Capacity Building in Local Communities

# Warning Dissemination Technologies

## for Tsunami Early Warning in Local Communities

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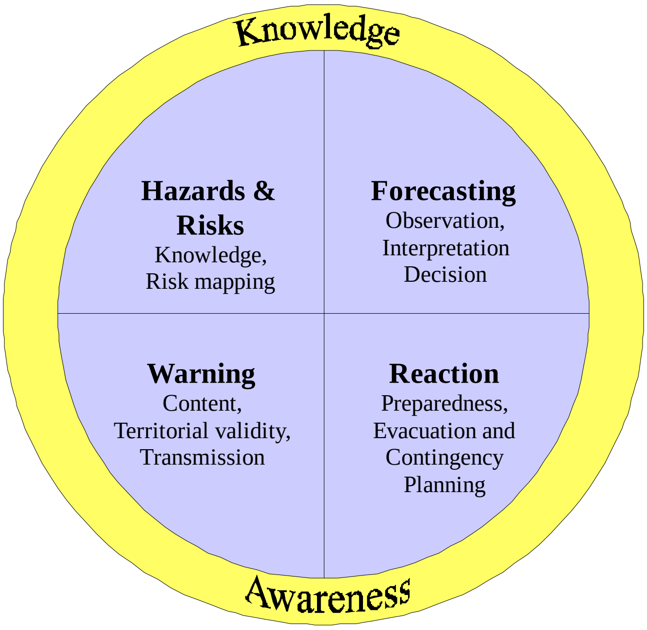
# Tsunami Early Warning Dissemination in Indonesia

Great progress has been made in the set-up of the Indonesian tsunami early warning system. Credible data is available to predict and detect tsunamis. To date official warnings are delivered to the public predominantly via the media (TV and radio).

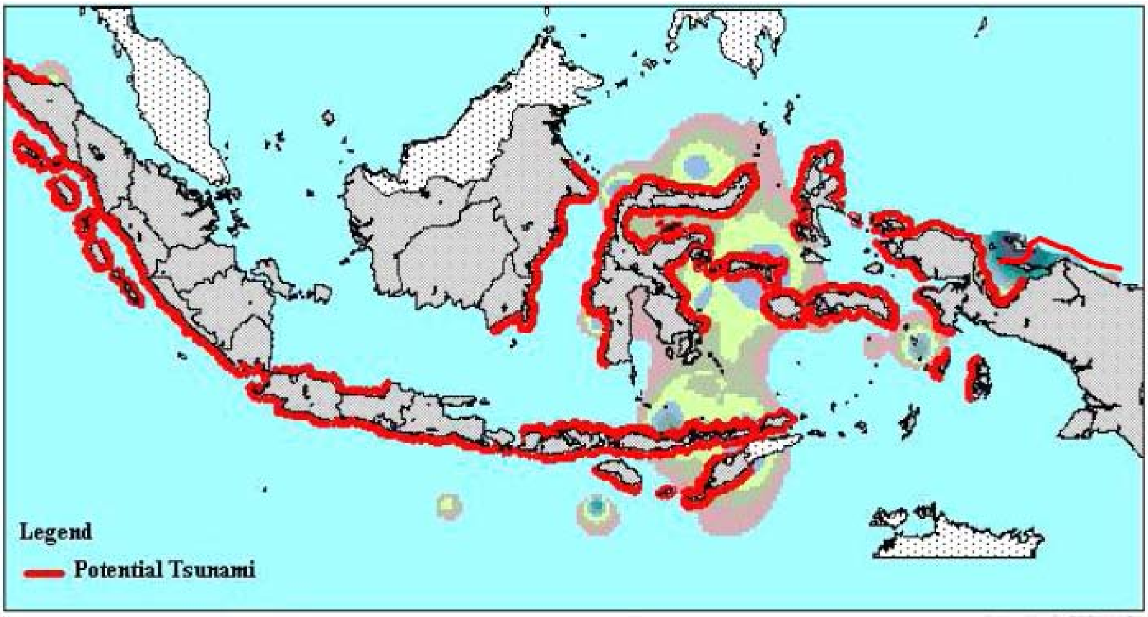
This guide is about tsunami early warning dissemination technologies and methods that can be applied on the last mile to inform and instruct the community at risk. The reader is designed to serve local decision makers with information and recommendations.




A complete and effective people centered early warning system comprises four inter-related elements: (1) risk knowledge; (2) technical monitoring and warning service; (3) communication and dissemination of warnings; and (4) community response capability. Best practice early warning systems also have strong inter-linkages and effective communication.

Source: GITEWS (2006): 'Implementation of Tsunami Early Warning in Indonesian Local Communities' Checklist for assessment, planning and monitoring, Jakarta

Nevertheless it is useful to have some background knowledge about the bigger picture of tsunami early warning in Indonesia, about where information is coming from, how information is gathered and processed, which roles and responsibilities are taken by which organisations and what the national warning scheme looks like.




Map I: Tsunami prone areas in Indonesia

Beside the technical aspects of tsunami early warning another great challenge lays in the clear manifestation of responsibilities and the creation of standard operational procedures (SOP's). Everything centres around the big question: "Who will in the end issue an evacuation order, based on which information and procedures and who will be responsible if the evacuation order was based on a false alarm?" Unless these vital questions are answered effective tsunami early warning in Indonesia will prove difficult.

## *Available Resources and General Conditions in Local Communities*

Available resources and the general conditions for tsunami early warning in local Indonesian communities vary greatly. That is why warning dissemination on the last mile requires tailor made solutions.

Development disparities between cities and rural areas are still vast. While most cities have access to a reasonable communications infrastructure with telephone and fax services, a mobile phone network, satellite receivers and VHF as well as HF radio infrastructure the majority of rural areas is much less developed. This has to be taken into consideration when thinking about an end to end tsunami early warning system. In cities a greater number of notification tools like sirens, loudspeakers mounted to fire or police cars, local radio stations etc. are available. FM-RDS technology for example makes good sense in areas within the vicinity of a FM-RDS repeater station with a reliable uninterruptible power supply (UPS). Non technical, social networks and traditional communication devices like the Kentongan become important in more traditional communities and/or communities that lack technological communication[1]. The education level in the countryside is also often lower than in the city. People with a wider education base and access to the media are mostly better informed about

[1] United Nations (2006): Global Survey of Early Warning Methods. p. 17

tsunamis, their cause, warning signs and the existence and utilization of early warning technologies and methods.

Target groups in rural areas are also different from city populations. While most people on the land are working in agriculture or as fishermen, spread out over a wide area, people in the city are usually dispersed over much lesser space. While people on the land work outside people in cities and towns are often working inside or in crowded places like markets or shopping streets. A siren located in a crowded city street will have more impact than in a rural area where a great part of the population is working on the fields, at least during the day. So people’s activities have an effect on how quickly they receive a warning and which technology to choose for early warning purposes.

Different groups have different information needs. Fishermen will require different escape routes and procedures than farmers on the fields or urban populations.

Once they receive a warning people in rural Indonesia might have a greater chance for escape than people in cities where even in non emergency situations traffic is often bad. On the other hand tsunami early warning information might be more easily available in urban areas.

In Indonesia just as everywhere else there is no ‘one size fits all’ solution. The choice of the applied warning technologies and methods depends on the target audience, its activities, location, available resources and the commitment of the community.

Indonesia is an earthquake and tsunami prone country with access to accurate and timely early warning information. The challenge is to forward this information to the communities at risk and to implement clear and efficient SOP’s on all levels to become ‘tsunami ready’!

## *National Warning Scheme*

The “mother of all tsunami warnings” in Indonesia is BMG (Badan Meteorologi dan Geofisika) www.bmg.go.id . BMG is a governmental institution with expertise in the fields of geophysics, meteorology and climatology. BMG is the official agency that issues tsunami warnings in Indonesia. Its head office is located in Jakarta. Branch offices are located in the provinces. Within BMG the “Tsunami Early Warning Center” (TEWC) is the entity responsible for the gathering, processing and evaluation of tsunami related information as well as for the issuance of tsunami warnings and advisories. TEWC is currently attached to BMG’s earthquake centre[2]. For information dissemination BMG draws from a wide range of options from satellite communication to the use of SMS services, telephone and fax. To communicate as efficiently as possible BMG is using a “5 in 1” communications system which will be explained later [p.9 Technology used by BMG for Information Dissemination].

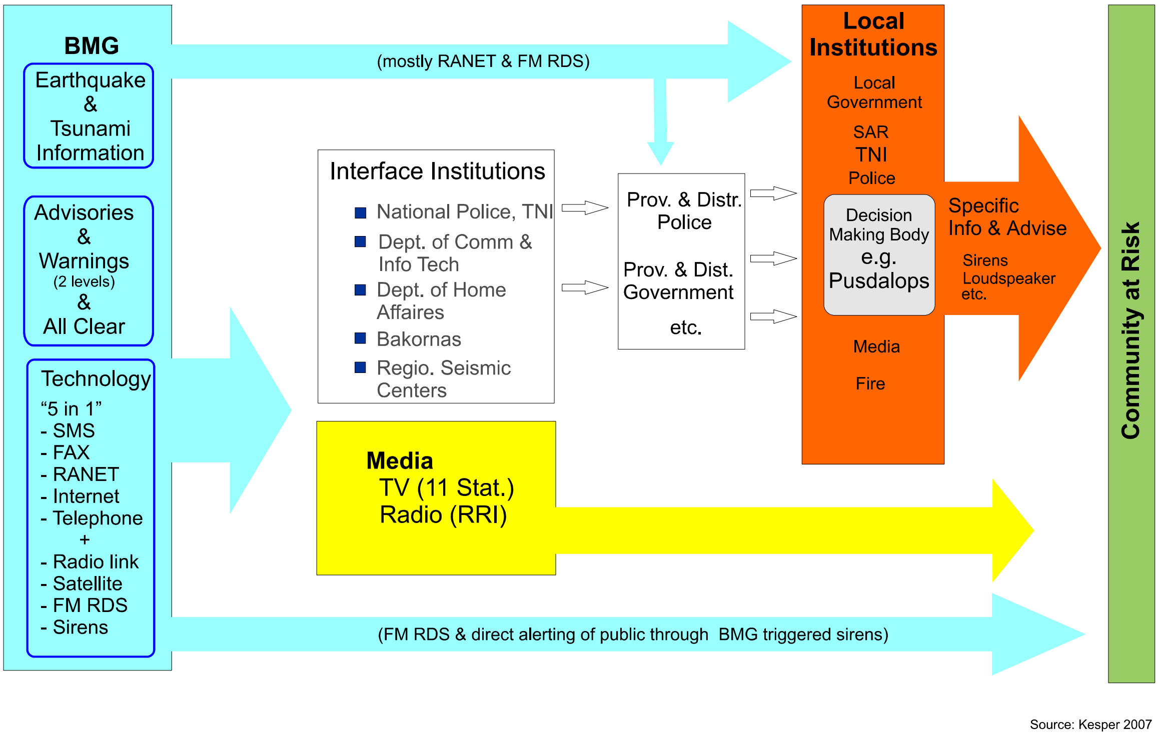
The national warning chain can be structured into four major components:

1. Communication from BMG to interface institutions

[2] GTZ IS (2006): Warning Chain Analysis. p. 12-16. Jakarta

2. Communication from interface institutions to other relevant institutions and public
3. Communication from BMG to local authorities/decision makers and public (Media)
4. Communication from local authorities/decision makers to population

Graphic 1 displays the flow of information from BMG to relevant stakeholders and the public.




Graphic 1: Current Flow of Information from BMG to Public

Interface institutions which are currently directly notified through BMG are:

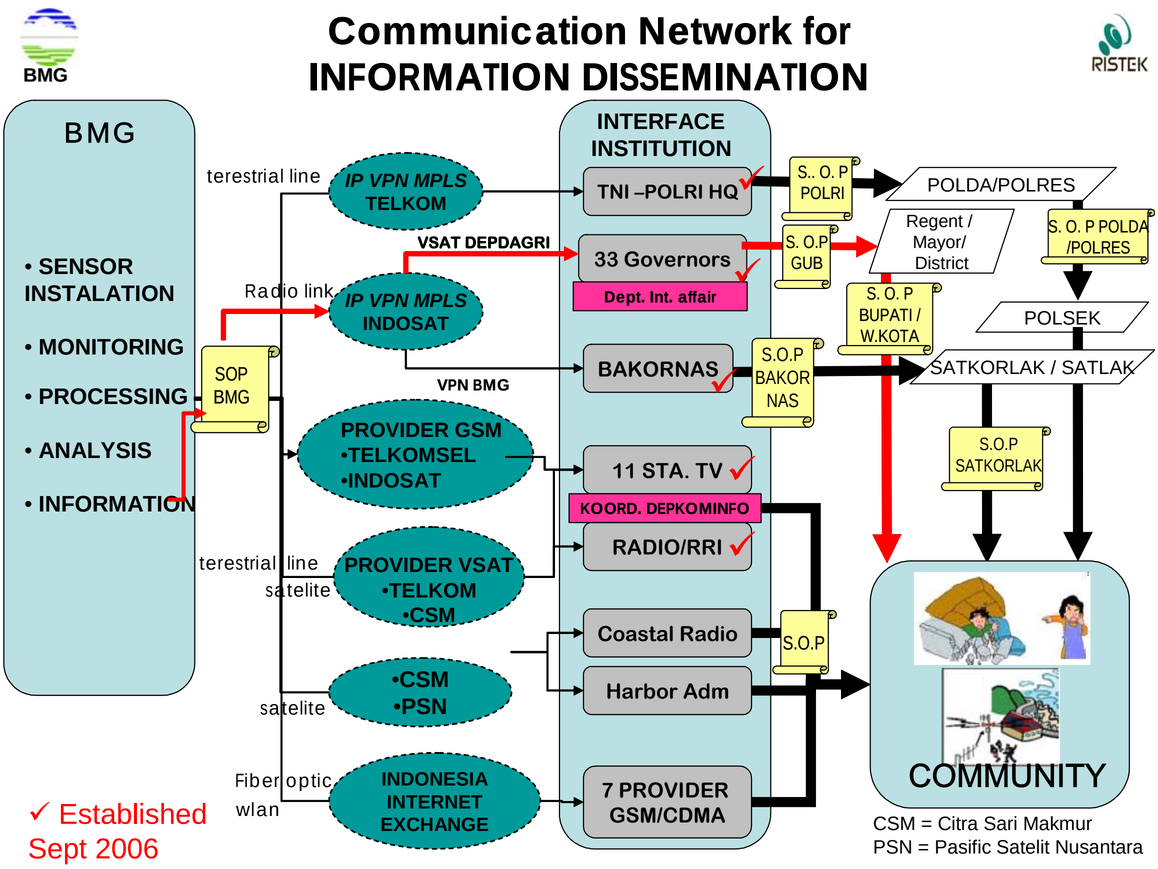
- National Police
- Indonesia's Armed Forces (TNI)
- Department of Communication and Information Technology (DEPKOMINFO)
- Media (11 TV Stations and Radio/RRI)
- Department of Home Affairs (DEPDAGRI)
- National Natural Disaster Management Coordinating Board (BAKORNAS)
- Regional Seismic Centers (RSC)

The Media plays an especially important role in the dissemination of BMG's warning messages to the public since BMG doesn't inform the public directly. The media (TV and radio) will broadcast BMG's tsunami warnings and advisories within minutes after a possible tsunami triggering earthquake.

In a few areas like certain parts of Bali, Aceh or Padang, BMG holds the option to alert the public via sirens. The technical infrastructure is already in place but up until now there was no training conducted for the local population in order to interpret the warning signals. It is planned to transfer the responsibility for the use of these sirens to the local authorities in the not so distant future[3].

Local authorities and decision makers play a crucial role in protecting the public from imminent threats. It is their responsibility to issue evacuation orders should the need arise. Most local authorities will probably receive BMG's warnings and advisories via RANET, SMS, HF, VHF or the media. In Padang city for example it is discussed to place the local decision making body at PUSDALOPS. PUSDALOPS Padang is using 24/7 RANET service with power back-up. PUSDALOPS will inform all relevant stakeholders and decision makers should the need arise. After the decision for evacuation is made PUSDALOPS will inform the public and initiate the necessary actions. Currently the local authority responsible for the issuance of evacuation orders is the mayors office.

The following diagram displays the communication network for the dissemination of early warning information as planned and in most parts already implemented by BMG. For the future BMG plans to also involve coastal radio and harbour administrations into the warning chains.




Graphic 2: The Tsunami Warning Dissemination System of BMG Source: BMG 2007

[3] Interview with Mr. Fauzi BMG (04.06.07)

## Technology used by BMG for Dissemination of Information

**"5 in 1"Technology:** Sends out information at the push of a button via FAX, SMS, Internet, Telephone and RANET.

BMG is sending out its messages to selected interface institutions using a "5 in 1" communications system. Means of communication are SMS, telephone, internet, fax, RANET and in the near future also FM-RDS. The general public will usually be informed via public media.

At the push of a button "5 in 1" transforms information into the appropriate format and distributes it via the above mentioned communication technologies. The "5 in 1" application software can be downloaded from www.meteo_indonesia.net and applied by emergency response centres throughout Indonesia[4].

Note that up until now the '5 in 1' system is not yet able to differentiate between regions. Warnings can not be sent out to predefined geographic areas[5].

## *Alert Levels*

BMG is giving out three different types of alerts, depending on urgency and threat level:

- **Advisory**
  is issued if there is the possibility of a minor tsunami with an expected wave height between 0.1 - 0.5m

- **Tsunami Warning** (level I)
  is given out for expected wave heights ranging from 0,5 - 3 m

- **Major Tsunami Warning** (level II)
  is issued for waves exceeding the height of > 3 m

When the danger is over BMG will send an **All Clear Message**.

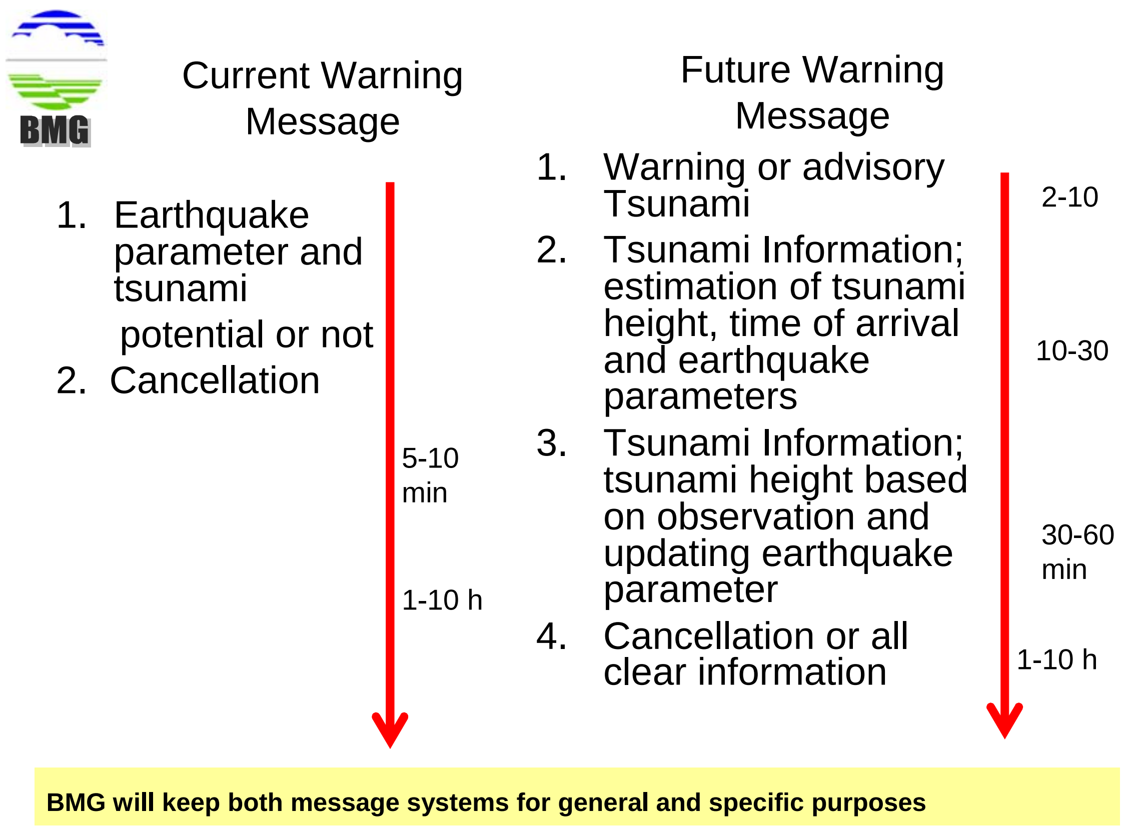
Message content will most likely consist of:

- Name of informing agency (BMG)
- Date and Time
- Advisory or Warning or All Clear
- Earthquake parameters: location, magnitude, depth
- Tsunami Parameters: effected areas, estimated tsunami arrival time, expected wave height etc.
- Advice for local decision makers

At the moment BMG is sending out a limited number of warnings or advisories per event. For the future BMG is planning a more refined warning scheme consisting of a succession of updated tsunami information bulletins. Also after the introduction of the more refined version BMG will keep both messaging systems to cater for general and

[4] Interview Fauzi BMG (04.06.2007)
[5] GITEWS (2006): FM-RDS Dissemination Technology – Manual for Pilot Project Bali. p. 5

more specific needs. The following BMG graphic illustrates the current and future set-up for the dissemination of BMG warning messages[6]:



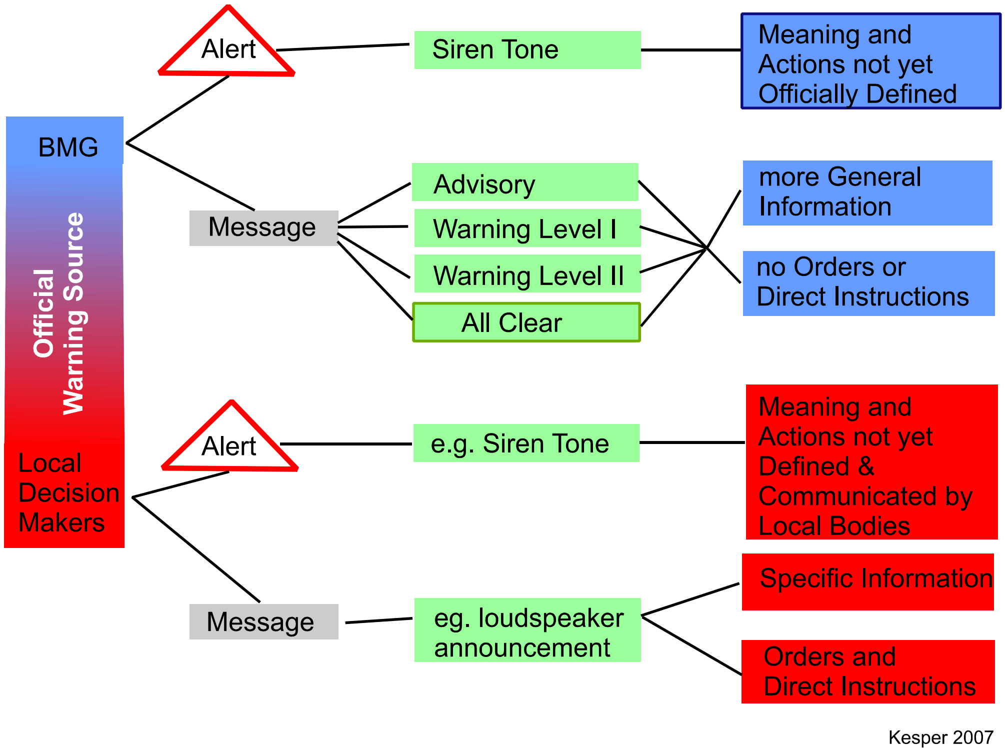

Graphic 3: Set-up for dissemination of current and future versions of BMG warning messages

## Official Information sources and what to expect from them

> Specific instructions like evacuation orders are only given out through local decision makers not through BMG!

In some places like Bali or Padang BMG can trigger its own sirens in order to alert the public. However no action procedures are in place on the ground yet and it is up to the public to interpret the warning sound. Note that BMG is not giving out evacuation orders. It is entirely up to the local decision makers to decide on a course of action after the reception of a warning message. This is also important to know for the local population. They may receive a BMG advisory or a warning through RANET, the media or FM-RDS but specific instructions will only be disseminated through local bodies. Graphic 4 provides an overview about what kind of information to expect from which official information source.

[6] InaTWES (2007): Tsunami Database Discussion 3rd Coordination meeting May 30, 2007 – Power Point Presentation. p. 19




Graphic 4: What kind of information to expect from which official warning source

## Example of BMG Warning SMS

On May 24, 2007 a magnitude 6,5 earthquake occurred off the coast of Sumba. Just a few minutes after the event BMG informed the public about a potential tsunami. The first sent out SMS red as follows:

1. SMS
   Info Gempa Mag:6,5 SR, 24-May-2007, 08:06:27 WIB, LOK: 9.92 LS-118.77 BT (161 km Tenggara Raba-NTB), Kedlmn:19 km, Potensi TSUNAMI utk dtrskn pd msyrkt: BMG

A second SMS was sent out when it became obvious that the earthquake didn't trigger a tsunami.

2. SMS
   Info Gempa Mag: 6,5 SR, 24-May-2007, 08:06:27 WIB, LOK: 9.92 LS-118.77 BT (161 km Tenggara Raba-NTB), Kedlmn:19 km. TIDAK MENIMBULKAN TSUNAMI utk dtrskn pd msyrkt: BMG

BMG will always inform the public if the warning level changes. BMG will also give an "All Clear" after the danger is over.

## Information dissemination from a local perspective

For the public it is not only important to know from which institution to expect what kind of message (e.g. with or without instructions) but also through which technologies those messages are delivered. Graphic 5 displays the origin, flow and type of information as well as the respective dissemination technologies, from a local perspective.

Note that some technologies like FM-RDS are only available if local decision makers create the technical preconditions for their utilization. In the case of FM-RDS it is not enough to just purchase and operate the receiver to obtain warning messages. Local institutions need to install and maintain their own FM-RDS transmitters. Currently BMG is the sole supplier of content for FM-RDS and RANET in Indonesia. That means that people will not receive local evacuation orders through FM-RDS and RANET but only official BMG advisories and warnings. RANET is independent from public technical infrastructure. The system only requires a satellite receiver, a computer and power to operate. Information received via RANET can theoretically be spread locally through FM-RDS which interfaces with some RANET functions. For the future it is envisaged to give local decision makers access to FM-RDS so they can use this technology to send out their own messages to the local public[7].

The media disseminates BMG 'Warnings' and 'All Clears' to the public!

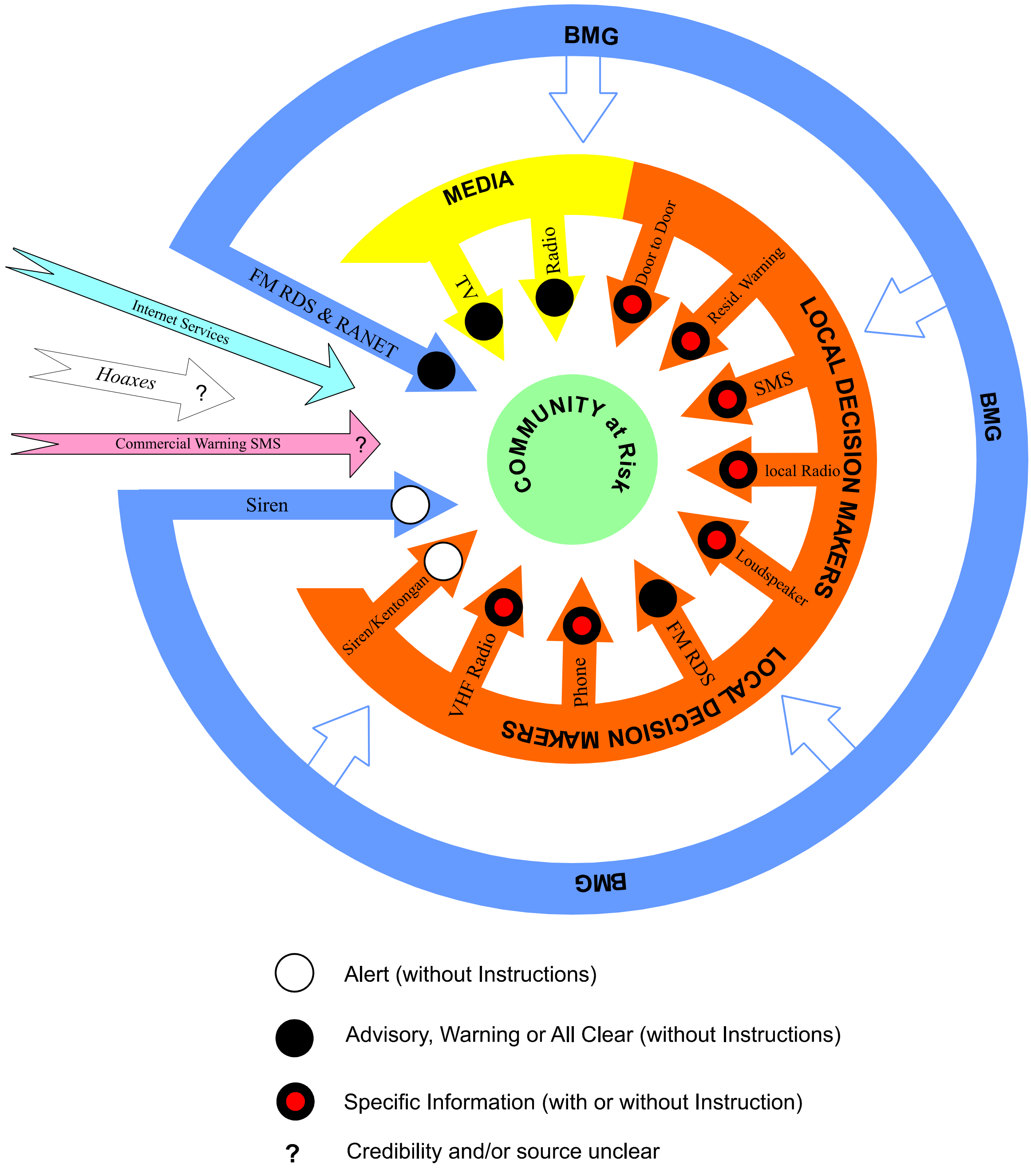
Advisories and Warnings broadcasted over national TV and radio (yellow) also originate from BMG and therefore will not give out evacuation orders. Exceptions are local radio stations (red) if they are involved into the evacuation notification process through local decision makers.

All devices and methods that are coloured red are operated and controlled through local decision makers. They can be used to give out evacuation orders and specific information relevant to a local community.

It is hard to evaluate the usefulness of commercial warning SMS (pink) since their reliability and credibility is questionable. Often it is unclear where the message provider is getting his information from. Commercial warning SMS might be a supplement for individuals who question the reliability and efficiency of official early warning methods.

Another source of (dis)information that the public is confronted with are hoaxes (white). Hoaxes have many faces. They might appear as unofficial SMS as happened in Indonesia in July 2007, as false TV announcements or else. Most have in common that their source is questionable and that they usually predict catastrophes of epic proportions. If unsure about early warning information it is advisable to check with the source if known, local authorities or directly with BMG.

[7] GTZ IS (2007): Results of FM-RDS Test in Bali 12/2006 and follow up activities




Graphic 5: Origin, flow and type of information and their respective dissemination technologies from a local perspective

## Further sources of Tsunami related Information

### Tsunami Information Bulletins

Tsunami "Information Bulletins" from the Pacific Tsunami Early Warning Center PWC operated by NOAA and the Japan Meteorological Agency (JMA) are available as email-service for the general public. To subscribe to this service visit
http://ioc3.unesco.org/indotsunami/subscribe_warning.htm

The bulletins are not a reliable early warning tool since nobody checks his e-mails all the time and messages might arrive late. However – the information bulletins are a good supplement and they are published in English.

### Example of an e-mail PWC Tsunami Warning Bulletin:

TSUNAMI BULLETIN NUMBER 001
PACIFIC TSUNAMI WARNING CENTER/NOAA/NWS
ISSUED AT 1135Z 12 SEP 2007

THIS BULLETIN APPLIES TO AREAS WITHIN AND BORDERING THE PACIFIC OCEAN AND ADJACENT SEAS...EXCEPT ALASKA...BRITISH COLUMBIA... WASHINGTON...OREGON AND CALIFORNIA.

... TSUNAMI INFORMATION BULLETIN ...

THIS BULLETIN IS FOR INFORMATION ONLY.

THIS BULLETIN IS ISSUED AS ADVICE TO GOVERNMENT AGENCIES. ONLY NATIONAL AND LOCAL GOVERNMENT AGENCIES HAVE THE AUTHORITY TO MAKE DECISIONS REGARDING THE OFFICIAL STATE OF ALERT IN THEIR AREA AND ANY ACTIONS TO BE TAKEN IN RESPONSE.

AN EARTHQUAKE HAS OCCURRED WITH THESE PRELIMINARY PARAMETERS

ORIGIN TIME - 1110Z 12 SEP 2007
COORDINATES - 4.5 SOUTH 101.3 EAST
DEPTH - SHALLOW
LOCATION - SOUTHERN SUMATERA INDONESIA
MAGNITUDE - 7.9

EVALUATION

THIS EARTHQUAKE IS LOCATED OUTSIDE THE PACIFIC. NO TSUNAMI THREAT EXISTS TO COASTLINES IN THE PACIFIC.

WARNING... THIS EARTHQUAKE HAS THE POTENTIAL TO GENERATE A WIDELY DESTRUCTIVE TSUNAMI IN THE OCEAN OR SEAS NEAR THE EARTHQUAKE. AUTHORITIES IN THOSE REGIONS SHOULD BE AWARE OF THIS POSSIBILITY AND TAKE IMMEDIATE ACTION. THIS ACTION SHOULD INCLUDE EVACUATION OF COASTS WITHIN A THOUSAND KILOMETERS OF THE EPICENTER AND CLOSE MONITORING TO DETERMINE THE NEED FOR EVACUATION FURTHER AWAY.

THIS CENTER MONITORS ONLY A LIMITED NUMBER OF SEA LEVEL GAUGES OUTSIDE THE PACIFIC SO IT MAY NOT BE ABLE TO QUICKLY DETECT OR MEASURE A TSUNAMI IF ONE WAS GENERATED. AUTHORITIES CAN ASSUME THE DANGER HAS PASSED IF NO TSUNAMI WAVES ARE OBSERVED IN THE REGION NEAR THE EPICENTER WITHIN THREE HOURS OF THE EARTHQUAKE.

THIS WILL BE THE ONLY BULLETIN ISSUED FOR THIS EVENT UNLESS ADDITIONAL INFORMATION BECOMES AVAILABLE.

THE JAPAN METEOROLOGICAL AGENCY MAY ALSO ISSUE TSUNAMI MESSAGES FOR THIS EVENT TO COUNTRIES IN THE NORTHWEST PACIFIC AND SOUTH CHINA SEA REGION. IN CASE OF CONFLICTING INFORMATION... THE MORE CONSERVATIVE INFORMATION SHOULD BE USED FOR SAFETY.

### Geoforschungszentrum Potsdam (GFZ)

Actual information on worldwide earthquakes can be found on the GFZ-Homepage http://www.gfz-potsdam.de/html/services/index-en.html . Recommendations on how to behave in situations of earthquake and tsunami are also available for download at http://www.gfz-potsdam.de/html/index-en.html .

### Earthquake Notification Service of Geofon/GFZ Potsdam

The GEOFON earthquake alert system is one of the fastest sources for earthquake information worldwide. The system is issuing alert emails, short messages for pager and SMS (for institutional users only!) and RSS feeds. For registration visit http://www.gfz-potsdam.de/geofon/new/amail.html .

### Earthquake Notification Service of the US Geologic Survey (UGS)

The service notifies about earthquakes via e-mail. Regions can be chosen. The service is quite fast and supplies additional information in the form of maps and tables.
To subscribe visit http://earthquake.usgs.gov/eqcenter/ens/ .

## Dissemination methods

The dissemination of warning messages is always a challenge, especially for emergency managers at the local level with limited resources. Fortunately there are multiple ways of how to deliver a message. However, there is no universal recipe. Dissemination technologies and methods have to be adapted to the local situation, requirements and capacities to be effective. There is no single best method of warning dissemination that fits all.

**Hardware & Procedures**
Successful early warning results from a combination of hardware and procedures. The hardware makes sure that the message comes across technically while procedures (SOP's) and protocols provide the organizational preconditions for successful and efficient early warning.

There are many factors and questions which need to be considered before the technical setup of a warning message dissemination system. Key factors and questions are:

- who needs to be informed
- where are recipients located
- what are they doing at what time of the day/night
- what specific needs do recipients have
- how will people understand and react to a warning
- season (e.g. fishing, harvesting, tourist season)
- what happens in the case of an electric power failure etc.
- do people have access to TV and radio[8]

[8] Anderson, P. Simon Fraser University Burnaby Canada. (2006): British Columbia Tsunami Warning Methods – 'A Toolkit for Community Planning'. Burnaby

### *Characteristics and Criteria of Warning Dissemination Systems*

The capability of warning dissemination systems results from a combination of methods and technologies. Reliability of applied early warning technologies is an issue, so is their optimal utilization. Coverage is of the essence as well as message design. The outcome should meet the following criteria:

| Criteria | Characteristics |
|---|---|
| Reliability | - Redundancy<br>- Security<br>- Availability in the absence of power<br>- Always operational and ready to warn<br>- Fast transmission with assured delivery and confirmation<br>- Easy to operate also in stressful situations<br>- SOP's for operation are in place and understood by relevant Stakeholders<br>- Accuracy<br>- Able to deliver an 'All Clear" message also after disaster struck |
| Coverage | - Reaches all people within a risk area<br>- Easy to expand in case a larger warning area needs to be covered<br>- Accessible to people with special needs (language requirements ?, disabled)<br>- Familiar, understood and accepted by population |
| Message features | Security & Reliability<br>- Enables only authorised persons to insert a message<br>- Hoax proof<br><br>Content<br>- Message content follows official rules and is explicit<br>- Message terminology is clearly understood by recipients<br>- Provides means for obtaining additional information<br>- Messages are geographically specific<br>- Warnings need to be specific about the nature of the threat and its impacts<br><br>Structure<br>- Message structure is standardized and officially communicated<br>- Recipients should be familiar with message structures and varieties (e.g. Advisories, Warnings, All Clear) |
| Other points to consider | - Supports multiple distribution technologies (eg. sirens, radio, TV, phones, RANET, FM-RDS etc.)<br>- Supports strategies for evacuation, response and recovery plans<br>- Applies to multiple types of hazards<br>- Doesn't put message provider or recipients at risk<br>- Cost effective<br>- Easily to maintain<br>- Optimal utilization of already existing infrastructure<br>- Clear and concise SOP's for the creation and dissemination of early warning messages are available |

Table 1: Important Characteristics of Early Warning Systems

Note that an effective warning system requires continuous maintenance, public awareness building and education as well as revision to make sure it is suited to the current situation. All groups involved in the notification process should be aware of each other and possess a general understanding about the general set up and what is required for the system to work.

**Alerts**
demand attention and alarm people.

**Messages**
provide further information.

## *Alerts and Messages*

Public notification should consist of two essential components:

1. an alert and
2. a message with instructions.

| | Objectives and Characteristics | Possible means of dissemination |
|---|---|---|
| Alert | - interrupts people from whatever they are doing<br>- demands attention<br>- can be received at any time of day or night<br>- can signal people to tune into local television or radio stations for further guidance<br>- is simple e.g. wailing siren tone<br>- can't carry complicated content<br>- can be delivered audibly, visually, physically (e.g. through vibrating devices) | - siren<br>- horn<br>- bell<br>- kentongan<br>- loudspeaker |
| Message | provides information about :<br>- what happens<br>- when<br>- severity of hazard<br>- likeliness of occurrence of hazard<br>- need for action<br>- can be delivered audibly, visually | - TV<br>- local radio<br>- loudspeakers<br>- Fax<br>- RANET<br>- FM-RDS |

Table 2: Objectives and Characteristics of Public Warning Alerts and Messages

Note that alerts and messages are not always delivered by the same method or technology. The delivery of messages usually requires a more advanced technology.

Messages as well as alerts can be delivered to:

- specific locations like the beach or certain parts of town
- specific list of recipients (e.g. all hospitals, public schools, mosques)
- specific list of recipients using multiple methods (eg. fax, FM-RDS, phone, HF radio etc.)
- general public

Some methods are specific to:

- the range of the transmitter
- an individual location
- a human determined geographic boundary (e.g. a municipality or regional district)
- outdoors
- indoors
- an individual facility (e.g. schools, hospitals, market place etc.)
- a specific authority, person or agency (e.g. PUSDALOPS)
- reliable availability of resources like electrical power

Some methods come with the ability to confirm that a message has been received or even offer means of more advanced two way communication.

## *Indoor and Outdoor Warning Methods*

Different audiences can be addressed through indoor and/or outdoor warning messages. The greater number of reliable outdoor warning methods is geared to address the general public. Some methods can be deployed indoors as well as outdoors, such as VHF-radios and mobile phones. Each method got its specific limitations and strengths which need to be taken into consideration.

### Outdoor Warning Systems

The most commonly used general mass outdoor notification devise is the siren. It can reach large segments of the population. However, sirens are usually not geared to deliver messages but they are formidable alerting devices. For their successful use it is crucial that the warning sound is clearly audible to the recipients and the listener is informed about the message/meaning of the tone. Another common outdoor warning device is the fixed or mobile loudspeaker.

### Indoor Warning Systems

The biggest challenge is to warn people who are situated indoors. Buildings can easily block out sound and visual warnings. Indoor warning systems rely upon technologies that are:

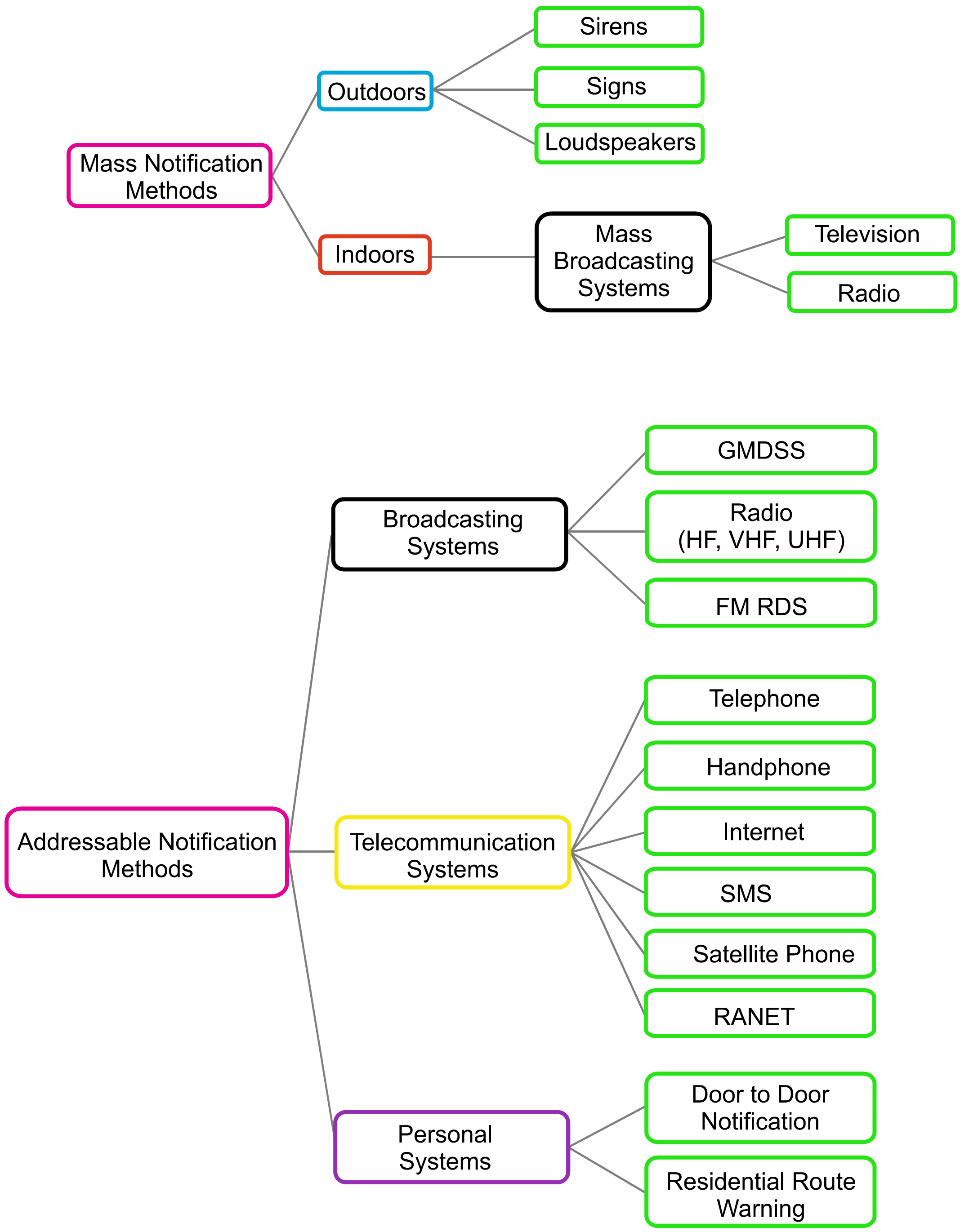
1. capable of penetrating inside spaces
2. wide spread enough to ensure that they can reach any space where people are residing
3. sufficiently disruptive to capture undivided attention
4. capable of disseminating messages at any time of day or night
5. preferably independent from external electrical power sources at least for a limited time

All indoor warning devises from the less to the most sophisticated rely on external sources as a trigger. Televisions and radios rely on functioning broadcasting systems and electrical power. Depending upon which kind of activity people are engaged in at the event of a warning it might be necessary to use different methods that cater to different senses (eg. hearing or sight). The special requirements of disabled persons (e.g. blind, deaf) should be taken into consideration as well. Some methods provide limited, one way delivery capacities; others support two way or interactive messaging (e.g. telephones or HF-radio). These features become important when an action like a confirmation of the reception of the warning message through the recipient is required. However, experience shows that common telecommunication systems tend to break down after earthquakes due to destruction of infrastructure and/or overload through increased communication needs.

### *Mass and Addressable Dissemination Methods*

Apart from whether they are deployed indoors or outdoors, dissemination methods can be further divided into mass and addressable dissemination methods. **General dissemination methods** (mass dissemination methods) are less targeted and mainly represented by the mass media while **specific methods** (addressable methods) can provide warnings to particular users of technologies, households, persons, neighbourhoods, predefined groups, agencies etc. In order to ensure that the intended message comes through the deployment of general as well as specific warning methods should be targeted. The greater the variety of deployed dissemination methods, the greater the likeliness that the message will reach the relevant stakeholders. Redundancies will prove useful should one technology or method fail.

The following graphic gives an overview of mass and addressable notification methods:




Source: Data Burnaby 2006 / Kesper 2007 [Graphic]

Graphic 6: Mass and Addressable Notification Technologies

### Dissemination Speed

Each method of dissemination may differ in the speed by which it delivers its messages. Speed is an important consideration since tsunamis in Indonesia will not leave much time for preparation. Looking at general warning dissemination methods sirens will alert people quicker than radio, television or for example internet websites. When it comes to specific dissemination methods FM RDS, RANET and two-way-radio group calls will be speedier than e-mails, fixed or mobile address systems, fax or door to door notification.

## Introduction & Evaluation of Early Warning Technologies

When it comes to the dissemination of warning messages to the public there are numerous communication technologies to choose from. The general goal for every community is to have the most effective and reliable coverage at the lowest cost. However, warning messages should be disseminated through a number of different redundant technologies. Messages need to be timely and understandable to make sure that as many people as possible can be saved. Therefore it is crucial to have local needs and the advantages and limitations of available technologies professionally evaluated. It is desirable to chose technologies that are not only suited for one purpose like tsunami early warning but which can be utilized for a greater number of tasks. Already existing technologies should be utilized as efficiently as possible.

Cost
Besides the technical aspects of early warning, cost plays a crucial role.
When calculating the budget for the purchase of early warning dissemination technologies one also needs to consider implementation and running costs which can be high. The warning system (e.g. sirens) might require supporting systems like costly power back ups and triggering mechanisms. Labour, maintenance and training costs must also be taken into account. However, the high expenses of purchasing a new system could be offset by higher maintenance outlay of old systems. The purchasing price of the system could also be reduced if several communities decide to acquire the same equipment.

The following gives an introduction to notification systems and technologies that can be used in an Indonesian context. The technologies are sorted into mass notification and addressable notification systems. The results are summed up in a table at the end of this chapter.

## *Outdoor Mass Notification Systems*

### Sirens

Sirens are amongst the most popular and widely used outdoor alerting devises. They can reach large parts of the population, also in more isolated areas. Sirens are especially an option when alerting people with limited access to other warning devices like telephones, hand phones or commercial TV and radio.

Sirens are ideal for alerting purposes. However, their messaging capacity is limited unless they are combined with an announcement function. Sirens can be used to advise people to turn to information sources like radios or TV sets to seek further instructions.

To be effective, populations need to be continually educated about the sirens purpose and their intended reaction. Without proper training sirens can cause confusion and panic amongst the local population, for example in the case of a false alarm. On Monday, June 4, 2007 a tsunami early warning siren in Aceh rang for 1 hour. It turned out to be a false alarm. Nevertheless thousands of people panicked because they were not educated about what to do in the case of a siren warning as well as about how to recognise the all clear signal. As a consequence siren infrastructure was destroyed by angry residents. This incident serves as an example that education of the local community is just as important as the technical set-up of the warning system.

**Aceh tsunami alarm shut down by locals**

Angry residents in Aceh province have disabled a tsunami warning system after a false alarm spread panic in a province still traumatized by the deadly 2004 Indian Ocean tsunami, an official said Thursday.

Residents cut power to a siren on a tsunami warning tower in the Lhoknga area near the provincial capital Banda Aceh by smashing an electricity box, said Syahnan Sobri, the head of the Meteorology and Geophysics Agency in Aceh.

A technical glitch prompted the siren to ring for about 30 minutes in Aceh Besar district on Monday, sending residents rushing out of their homes in panic.

"They cut the electricity connection but did not damage equipment," said Sobri, referring to the actual warning siren and tower.

"We are sending our technicians to the location to fix it. For the moment the warning system in Banda Aceh and Aceh Besar is still switched off," he told *Reuters*.

The Indian Ocean tsunami left some 170,000 people dead or missing in Aceh alone, inflicting deep psychological scars on many of the survivors.

Earthquakes, which sometimes cause tsunamis, are frequent in Indonesia, the world's fourth most populous country.

Its 17,000 islands sprawl along a belt of intense volcanic and seismic activity, part of what is called the "Pacific Ring of Fire".

In the wake of the 2004 tsunami, Indonesian officials have come under pressure to bring in a network of warning systems, but many vulnerable areas in the huge developing country remain excluded.

There have also been frequent technical glitches with the systems in place. —*Reuters*

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**'False' Alarm?**

If a tsunami alarm is triggered but a tsunami is not generated it is often called 'false' alarm. However the word 'false' can be misleading.

If an alarm is triggered unintentionally by technical malfunction or by manipulation, it should be considered a real 'false' alarm.

There are also cases where an alarm is intentionally triggered because all indicators suggest a tsunami but for whatever reason it doesn't materialize. There can be many reasons for this. Most tsunami alarms are based on predictions which are derived from information collected straight after a possible tsunami triggering event and experience. The prediction becomes safer the more information is available. To gather information takes time. If the official goal is to issue a tsunami warning fife minutes after an earthquake it could be that all available indicators suggest the potential of a tsunami and the alarm is triggered. Ten minutes later with additional data the alarm could become obsolete.
So was it really 'false' to trigger the alarm?

Antara/Ampelsa

# Tsunami alarm sparks panic in Aceh

A false tsunami alarm on Monday sparked a general panic in the capital of Aceh province, where people frantically scampered to higher ground (*see photo*), witnesses said.

Holy verses from the Koran were broadcast from mosque loudspeakers around Banda Aceh, which was devastated by the December 2004 Asian tsunami, before the all-clear sounded. Some schools were evacuated and many people fled in fear.

The head of the Meteorology and Geophysics Agency told ElShinta radio the alarm had gone off due to a "technical problem."

"We would like to apologize for causing the panic. The siren went off by itself," said Suhardjono, a scientist from the Geophysical and Meteorological Agency, which maintains the warning system.

"One explanation could be it was triggered by a short circuit," said Suhardjono.

"The alarm sounded for about one hour," said local resident Abdul Muthallib, 40, a survivor of the 2004 catastrophe.

He said that the sounding of the alarm coincided with the tide that usually accompanies the period around the full moon.

"The water in the bay near our house is indeed undergoing a quite high tide," he said.

"We immediately evacuated the children," said Juliani, a teacher at a state high school.

People began to return home around midday.

The 2004 tsunami killed over 168,000 people in Aceh alone. Indonesia was the nation worst hit by the tsunami, which also laid waste to other regions on the rim of the Indian Ocean. —*AFP/AP*

Jakarta Post, Monday, June 4, 2007: Tsunami Alarm Sparks Panic in Aceh

Critical factors when considering the setup of a siren system are:

- Purpose of siren
- Siren type
- Siren structure
- Coverage
- Voice Broadcasting
- Power source
- Testing and maintenance
- Siren Placement
- Cost

## Siren Types

There are two major types of sirens; electromechanical and electronic sirens.

### Electromechanical Sirens

Electromechanical sirens basically consists of a rotating disk with holes in it (rotor) and a casing which also features holes (stator). The rotor sucks air into the siren. As the holes in the rotating disk alternately prevent and allow air to flow, the different air pressures result in sound. Such sirens can consume large amounts of energy and are very heavy. Electromechanical sirens are also called pneumatic sirens. Electromechanical sirens can’t carry voice messages.

### Electronic Sirens

Electronic sirens are powerful loudspeaker systems that can generate a wide array of sound patterns. Some electronic sirens also offer public address functions. That means they also carry voice messages. This feature is valuable when a population needs to be supplied with instructions. These instructions can be given live or pre-recorded. Electronic sirens are reasonably priced and come with different power outputs. An advantage of electronic sirens is that some can be powered from a low voltage battery power supply. A community notification system based on electronic sirens powered from solar charged batteries can add additional reliability in emergency situations. On the other hand, electronic sirens require more maintenance than electromechanical devices, especially in coastal environments.

## Siren Structure

Sirens consist of three major elements, the siren itself, the controller and the actuator. The siren produces the noise, the controller controls signal type, duration, etc., and the actuator triggers the controller, either remote controlled or directly. Most fixed sirens are remote controlled by radio. To be radio controlled each siren requires a radio receiver and a decoder that translates the radio signal into the desired action. The sending of the signal requires energy and hardware as well so it is important to make sure that the remote trigger unit is situated in a place with its own power back up.

## Coverage

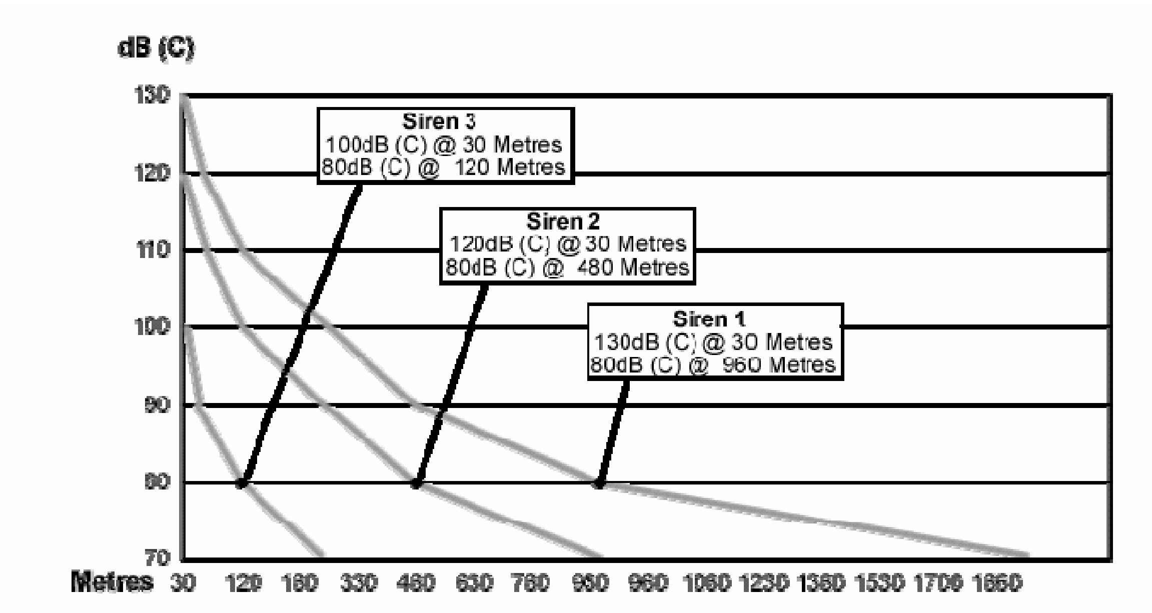
Some sirens are designed to project sound in a 360 degree pattern (omni directional). Others project sound in just one direction. Sirens can be mounted at a fixed location or mobile. Choosing an elevated mounting point can increase the sirens effectiveness. Rotating sirens have a greater reach than static sirens. For a stationary listener the sound of a rotating siren seems to oscillate.

The loudness of a siren is measured in decibel (db). A siren featuring 120 db will be heard louder from a distance of e.g. 30 meters than a siren with an output of 100 db. In terms of their sound output, sirens are rated in db at a distance of 30 m. When calculating the reach of a siren one subtracts 10 db for every doubling of distance, starting 30 m away from the source of sound. If a siren produces 120 db at a distance of 30 meters it will produce 110 db at 60 meters and 100 db at 90 meters distance. However these sound projections are theoretical and just rough estimates. When calculating the effective reach of a siren one needs to consider various other factors such as:

- shape of terrain (e.g. hills, outcrops etc.)
- vegetation (e.g. tall trees, dense foliage)
- surrounding building structures (the typical db loss in residential areas may be 10 db, in areas with high buildings such as business districts 12 db[2])
- wind patterns (e.g. if the prevailing wind is from the west, it may proof useful to install the siren towards the western edge of the area to be covered)
- air humidity and temperature (e.g. sounds travels upwards in hot weather)
- sound frequency (lower frequencies travel further than higher frequencies)
- background noise

The minimum sound level of the siren signal should be 10 db above background noise. Normal wind and surf produce a sound level of about 70 db, industrial districts 90 db, business districts 80 db and residential areas 68 db[9]. Note that about 80 db are needed to wake up people in insulated houses. As a rule of thumb the affectivity of a siren ends where the sound level drops below 80 db.

Graphic 7 illustrates the reach of three sirens under ideal conditions. Note the significantly greater range of alarm coverage by what might appear as only moderate increase of siren output power.




Graphic 7: Sound projection for three sirens with different output power

## Voice Broadcasting

Some electronic sirens come with a voice broadcasting function. Announcements can be stored on pre-recorded discs or chips. Most early warning sirens in the US and Japan use this additional feature. Messages can be broadcasted over the same loudspeaker as the warning tones. Broadcasting is a valuable feature to instruct the

[9] Federal Signal Corporation. (2005): Modular Series Speaker Arrays. Illinois

local population as well as groups like travellers who might not be familiar with the local situation. Note that whatever message is broadcasted it needs to be clear and concise.

**Power Source**

Sirens don't run without power. Should a local, tsunami triggering earthquake destroy the public power grid, a backup is required. That is why sirens should be equipped with batteries. They can be charged through the local power grid or even better, be independently powered through solar panels or even wind craft. Of course, solar technology will add to the price tag but in comparison to recent years prices came down considerably.

**BMG Siren in Padang**

Another advantage of battery powered sirens is that they are almost immune against power irregularities which are common in Indonesia and could damage the control system.

Batteries are also a good protection against overload caused by lightening. On the other hand, batteries need constant testing to keep their performance. Tests should draw as much power from the battery as would be required in a real warning situation. Negligence of battery testing and maintenance will result in suboptimal power outputs and a reduced life span. Experience shows that robust deep discharge, uninterrupted power supply (UPS), 6-volt batteries are more durable than 12-volt batteries. Also note that voice announcement functions require more power than simple warning tones.

Since the whole siren system depends on reliable 24/7 availability of power the choice and installation of the power and battery system should not be taken lightly but planed and executed by experts.

**Testing and Maintenance**

Sirens should be tested on a regular basis even though it might be causing some disturbance. On the other hand test runs can be used as a reminder to the community to be 'tsunami ready'. All manufactures recommend testing at least once a month and bi-annual maintenance.

**Placement and Installation**

Most sirens are installed 12 to 15 m above ground level. If the installation is located less than 15 m above the ground, the sound intensity at close range might increase, but at the same time the effective long range of the siren may be reduced. Conversely if the siren is located more than 15 m above the ground, its effective range might increase, but the sound might skip over areas closer to the siren. These variables make it desirable to test the sound coverage of the siren at several heights and locations whenever possible.

Some places might proof especially hazardous during earthquakes such as cliffs or buildings. When placing sirens in tsunami prone areas they should be placed well above the expected water line.

There are locations that put more strain on a siren system than others. Sirens installed on the beach will require more maintenance because they are subject to the corroding effects of salty spray and flying sand.

**Cost**

Sirens are costly and require a budget for set up, maintenance and supporting infrastructure like batteries or solar panels. Sirens can cost anywhere from 10.000 USD to way over 60.000 USD.

Example:

In Cannon Beach, Oregon, USA a Whelan siren system with public announcement component was installed. It runs on solar powered batteries, independent from the public power grid:

- Whelan Siren System: 27.000 USD
- Installation, testing: 6.300 USD
- Total per station: 33.000 USD
- Central triggering equipment 2.000 USD
- Site survey prior to installation 4.000 USD
- Maintenance/year 5.000 USD

## Mobile sirens

Mobile sirens can be quickly moved to different locations. They can be mounted on a fire or police car or set up on a trailer or even a bicycle. They are especially useful if a larger amount of time is available until disaster strikes. Combined with a voice broadcasting function they can supply supporting information to the public and be utilized to broadcast the ‘all clear’ signal. Mobile sirens can be transported to areas where they are most needed like evacuation routes or places with dense populations. Mobile sirens/speakers can also be equipped with an array of pre-recorded messages. On the other hand, vehicle mounted sirens might get stuck in traffic or get bogged down on bad or destroyed roads and it might take quite a while to move them to the desired location. Mobile sirens can be battery powered, just as their fixed counterparts.

## Signs

Signs can be set up on important strategic locations like beaches or busy roads and intersections. They can display that a tsunami is immanent and give instructions. People can be signalled that the tsunami warning sign is active through a strobe light and/or a siren on top. In Japan such warning signs are used e.g. on beaches.

Flashlights and sirens can be activated through remote control and powered by batteries.

## Flags

Flags can be raised to indicate that a tsunami warning was issued. Different flags can be assigned to different simple messages. Flags will only work if the public is educated about their meaning. Flags can only carry very limited information, like sirens without broadcasting function. Flags are only making sense where they can be seen, so their range is limited. Flags could be used on beaches that are frequented by tourists or locals. To be effectively recognised flags rely on daylight.

## Kites

Kites are a very uncommon communication tool. They are only effective under the right wind conditions and during bright daylight. In Indonesia however steady winds are not uncommon, especially on beaches. In Bali for example, kites are kept in the air day and night over weeks. Kites can be quite large and carry simple messages consisting of a few words. These messages should be prepared in advance. To be effective people need to be informed about the kites existence as a warning tool otherwise they will not be recognised as credible. If at all, kites are only a complementary warning tool.

## Kentongan & Kulkuls

**Kulkuls are a traditional Indonesian communications tool**

Kentongans and Kulkuls are traditional simple communication tools. Kentongans and Kulkuls are basically wooden or metal drums. When beaten they alert the public. In older times particular meanings where assigned to different signal patterns. This alerting device could be revived. Kentongans and Kulkuls could be placed in Poskos which are usually well known throughout their neighbourhood. However people need to be educated about the drums purpose and meaning of the signals. Since Kulkuls and Kentongans can be beaten by virtually everyone it will be vital to prevent misuse in order to insure the devices credibility.

## Electronic Signs

**Electronic Signs can be utilized for early warning purposes**

Electronic signs can be fixed or mobile. They are often installed on movable trailers and used for traffic warnings etc. along busy roads and highways. Existing electronic signs can be utilized for tsunami early warning purposes. Electronic signs are often equipped with pre-recorded messages and remote controlled, usually through LAN or WAN. Many electronic signs feature local/remote control switches, Ethernet ports and dial up modem capabilities. Where available electronic signs can also be linked to FM-RDS technology which is currently introduced by BMG. Electronic signs come solar and/or battery powered and can be managed from a central location.

Cost

The cost of mobile electronic signs is about 25.000 USD each while fixed units can cost up to 250.000 USD depending on the structure the unit is fixed on.

## *Indoor Mass Notification Systems*

### Radio and Television

Radio and television are among the most common mass media for the distribution of general information to a wide area but they are not suited for first level notification. For effective emergency broadcasting, alerting tools such as sirens are needed to signal people to turn on their TV or radio receivers. Note that there are considerable differences in the use patterns of radio and television at different times of day. During the day more people listen to the radio. In the late afternoon and in the evening the majority tunes into their TV sets.

**BMG broadcasts Advisories and Warning Messages via TV**

To utilize radio and TV as a means of early warning, standard operational procedures have to be worked out to make sure that information gets broadcasted when it is required and everybody understands the message. Standardized and pre-scripted messages should be stored and SOPs for the notification process of radio and TV stations in place. In an emergency case it may be difficult to contact especially local TV and radio stations since earthquakes and tsunamis often cause power outages and the breakdown of communication systems so that regular phones, fax machines or e-mail services fail.

In Indonesia the government has obligated all TV and radio stations to broadcast tsunami or other hazard related early warning information (Ministry of Communication and Information Regulation No. 20/P/M.Kominfo/8/2006). The content will be distributed by the Meteorology and Geophysics Board (BMG) or other governmental institutions. Upon reception of the broadcasting request, the respective media stations will activate a high tone alarm (1 khz) combined with a text message on TV and an announcement on the radio. Messages will be disseminated through TV and radio as long as necessary, until the 'all clear' is given. Furthermore broadcasters are obligated to perform a test run four times a year[10].

### Local radio stations

Local radio stations are a good option for the dissemination of more detailed and location specific messages. Local evacuation messages could be broadcasted via local radio. Almost every household and every car possesses a radio set. Battery powered receivers are cheap and widely used. The local radio station could be notified through

[10] Masyarakat Penanggulangan Bencana Indonesia (MPBI). (2006): Disaster Information in Indonesia. Volume 78. Jakarta

the official local tsunami mitigation body. For communication between the radio station and local officials means of communication which are independent from breakdowns and power failures like satellite phones or VHF radio need to be utilized. The radio station itself must feature a power back up to insure uninterrupted broadcasting. 24/7 emergency staff on site is necessary. Sirens will alert the public to switch on their receivers and tune into the right frequency. Beforehand people have to be informed about the role of radio broadcasts in case of an emergency and the frequency to tune into.

## Community FM Radio

Community FM radio stations are not much different from other FM broadcasting stations just simpler in set-up, cheaper to run and with limited reach. Community radio can be run by an NGO, a village or any other local institution. The ideal physical location for a local broadcasting station would be close to the local emergency mitigation body. In Padang for example a community radio station could be set up within the premises of PUSDALOPS to insure an uninterrupted flow of up to date information and 24/7 attendance. Local FM radio can also be very effective at involving local community members in larger education and awareness campaigns as well as developing local dialogue on various issues. FM radio is most effective when run by multiple interested parties, broadcasting a wider range of programmes. RANET amongst others is promoting community FM radio. The organisation recommends FM radio station sets from Wantok LTD ( http://www.wantokent.com/ ) because they are relatively cheap, easy to operate and robust. Another advantage of Wantok radio stations is that they can run on solar or battery power.

Some FM radio stations are so compact, they fit into a suitcase. These radios sets are ideal tools to inform the public about post tsunami recovery activities, for awareness building and evacuation training. They can also be used to transmit tsunami early warnings. A basic 30 Watt FM station costs about 4300 USD. If the antenna is installed at least 15 m. above ground and the terrain is unobstructed one can expect coverage in a radius of at least 18 - 24 km. Be aware that FM is a line of sight technology. The waves do not penetrate hills or mountains. It follows that the higher you put your antenna, the greater your cover will be because the visibility of the antenna is greater. If a coastline shall be covered, one alternative for coverage may be a repeater relay station. A small repeater that runs on solar power and is compatible to the 30 Watt radio station will cost about 1700 USD plus 300 USD for transmitting antenna, cables and connectors.

A community radio station was set up to assist the post-tsunami recovery of Pangandaran coastal area, West Java. The radio called Suara Pangandaran Darurat Recovery Ciamis Selatan (DRECS) (107.7 FM) is providing post-disaster information that is easily accessible by affected people. The radio station is in regular contact with the meteorology and geophysics agency BMG. It cooperated with the police and army[11]. The radio proofed especially helpful for massive trauma healing conducted in

[11] Muli's Commune (downloaded 18.06.07): http://communed.blogspot.com/2007_03_01_archive.html

the area. The Indonesian NGO Walhi Jabar ( http://www.walhi.or.id ) was a driving force behind the Pangandaran community radio.[12]

**Cost**

Direct station costs range from 4000 USD to 15.000 USD depending on the stations size, whether off-grid energy sources are required, a building needs to be constructed etc. One of the most significant variables, in terms of overall station cost, is the annual or other licensing fees. To run a radio station successfully significant training is needed. The organisation of workshops, travel expenses for the attendants etc. must be considered in the budget[13].

Price Example for a 30 Watt Radio Station

Standard Equipment Package
1 - SBS-1 Suitcase Broadcast Station c/w 30 Watt FM Stereo transmitter, stacked dipole antenna, 30m RG8/U Co-AX cable with all necessary connectors and mounting hardware. **USD 4,298.00**

Optional Recommended Equipment
1 - Extension Microphone c/w plastic prop stand holder **USD 55.00**
1 - 115 or 230 Volt AC to 13.8 Volt DC Switching Power Supply, 15 Amp **USD 165.00**

Cost
Sub Total Cost of Equipment FOB Winnipeg, Canada **USD 4,518.00**
Estimated Shipping/Handling/Insurance for transportation to Jakarta via Courier **USD 900.00**
Total cost of equipment listed, CIF Jakarta **USD 5,418.00**

In addition to the optional equipment listed above, each SBS-1 Standard Broadcast Station contains the following:
2 - Commercial Quality CD Players
2 - Commercial Quality Tape Cassette Recorder/Players
1 - Audio Mixer, 6 Channel c/w Cue, Control and Audio Level Display
1 - Power distribution board c/w all required cabling
1 - Set Stereo Earphones - Light commercial quality
1 - Gooseneck deck mounted microphone
1 - Audio Input/Output Board c/w Telephone interconnection (Standard RJ11)
1 - 3 Channel Microphone Mixer Box
1 - Console Tray
1 - Microphone, Tape cassette, switchable for local recording
1 - Sony to Sony Edit Cord
1 - Suitcase, composition, foam packed
Audio interconnect cables, studio to transmitter
Power connecting cables, studio and transmitter
1 – Operations/Transmitter Training Manual (English) (French)[14]

[12] WAHLI (2006): Solidarity in Adversity. p. 10
[13] RANET (2006): Information and Communication Technology (ICT) Crib. p. 1-2
[14] Wantok Enterprise (downloaded 19.06.2007): Pro Forma Invoice 30 Watt FM Stereo Transmitter. http://www.wantokent.com/PRO%20FORMA%2030.htm

**Radio Advantages**

- Instant communication to all effected people if tuned in
- Gives detailed and up to date  information
- Generally and universally available and affordable
- Accepted source of information, can have a very local focus
- Reaches people indoors and outdoors, in moving vehicles and on boats
- Battery powered receivers are immune to power outages

**Radio Disadvantages**

- Has to be tuned in to receive a warning
- Will reach people not effected by tsunami and may cause confusion
- Radio station needs to be ready to broadcast on a  24/7 basis
- Outlying areas might not be able to receive programme at all

**Television Advantages**

- Instant communication if turned on
- Gives detailed and up to date  information
- Reaches people indoors
- Widely available
- Respected source of information
- Very good tool for the dissemination of detailed information through graphics, maps etc.

**Television disadvantages**

- Access for many people limited during the day (work, school etc.)
- Not available outside
- Will reach people not effected by tsunami and may cause confusion
- Bad reception in outlying areas
- Not available during power outages

## *Addressable Notification Systems*

## *Broadcasting Systems*

### Radio Communication

Radio Communication, especially amateur radio (VHF), has got a proven track record in emergency communications.  After a disaster amateur radio is often the only remaining means of communication since most of its equipment is battery powered, portable and able to operate on a wide variety of frequencies.  Besides enabling verbal communication some systems are becoming increasingly interoperable with other communication systems like email, VoIP etc. Radio communication can be used for voice and data messaging, dispatch and surveillance as well as notification. There are three major radio communications systems, HF, VHF and UHF.

Frequency allocations for citizen band radio in Indonesia are regulated in a government decision called "Surat Keputusan Direktorat Jenderal Pos dan

Telekomunikasi No. 92/Dirjen/1994 tentang Ketentuan Pelaksanaan Komunikasi Radio Antar Penduduk (KRAP)". The regulation arranges frequency allocations for citizen band radio in Indonesia as follows:

**HF (High Frequency)**
26.960 - 27.415 MHz divided into 40 channels
27.065 MHz (channel 9) is used for emergency news

**VHF (Very High Frequency)**
142.0375 - 143.5375 MHz divided into 60 channels
142.2500 MHz (channel 9) is used for emergency news

**UHF (Ultra High Frequency)**
476.410 - 477.415 MHz divided into 40 channels
476.625 MHz (channel 9) is used for emergency news [15]

However, users have to register themselves and their equipment with either one of Indonesia's legal radio organisations, RAPI (Radio Antar Penduduk Indonesia) or ORARI (Organisasi Radio Amatir Indonesia) to obtain a call sign. A RAPI call sign begins with the letters JZ (Juliet Zulu). A call sign issued by OARI begins with the letter Y (Yankee).The registration fee is about 260.000 IDR for a 3 years period. RAPI is the more popular of Indonesia's radio organisation. Unlike with ORARI people can register without sitting for an exam. Both RAPI and ORARI are sending on a certain number of dedicated frequencies in HF, VHF and UHV. Both organisations are involved in disaster related communication and have developed their own SOPs. RAPI for example communicates periodically with organisations related to disaster management like SATKORLAK, BMG, SATLAK, fire brigade etc. RAPI also offers trainings seminars and workshops. Besides it operates a 24/7 standby for the case of emergencies. When disaster strikes RAPI works as a communication bridge between the disaster location and command centres on city, municipality, provincial and national level (BASARNAS, BAKORNAS, Departmen Sosial, BMG). Each province, region and city got its own disaster channel. Frequency 14.410.0 Mhz mode USB is reserved for communications with Jakarta. RAPI is also involved in the coordination of the radio communication network and data documentation.

## HF: High Frequency Radio:

HF radio is ideal for long-distance two-way communication. HF radio is a well established technology with a long tradition. The signal can travel great distances and over the horizon since under ideal conditions it gets reflected by the ionosphere. However there are a number of factors that can limit range such as sunspot cycles, polar aurora, humidity, season etc[16]. The set up of

**HF Radio Set**

[15] Idcx.or (20.06.2007): CB in Indonesia. http://cbradio.idxc.org/
[16] WIKIPEDIA (05.25.07): High Frequency Radio. http://en.wikipedia.org/wiki/High_frequency

a HF system requires some expertise but once set it is robust and can be operated even from a car battery (6 hours if fully charged). HF radio can be integrated with computer networking technologies to create text messages and e-mails. Since bandwidth with HF radio is limited, digital applications are best kept to text e-mails. The system is not powerful enough for a regular exchange of larger amounts of data like graphics or documents. Nevertheless RANET successfully installed a HF radio internet service between Tuvalu in the Pacific and New Zealand for the exchange of text based meteorological data. The service worked well because of the low volume exchange. The setup and running of HF systems requires technical expertise and regular maintenance through technicians. For the utilization of HF e-mail a laptop or PC is connected to a HF radio modem which in turn controls a HF radio transceiver[17]. RANET promotes HF e-mail systems that interface with applications like Outlook Express or Mstar weather station.

**Cost**

A standard HF node costs about 2000 USD. The development of a national or regional HF e-mail system will require the establishment of a central server system which comes at additional cost. Licensing fees for the commercial operation of HF radio have to be taken into consideration. A major advantage of HF is that it will prove as quite cost effective in the long run[18] since individual calls come free of charge.

## VHF: Very High Frequency Radio

VHF is also known as 2 meter band as its wave length ranges from one to two meters. It is the most common frequency used by amateur operators and official bodies like police, ambulance etc. VHF is lesser affected by atmospheric noise and interference from electrical equipment than lower frequencies but it can be blocked by land features like hills or mountains. As VHF signals travel in a straight line and don’t follow the earth’s curve the range of a hand held device hardly exceeds over the horizon (line-of-sight ca. 2 km). However range can be extended through the use of high antennas or repeaters.

**VHF Radio Recievers are inexpensive - some are even waterproof**

An approximation to calculate the line-of-sight horizon distance in kilometers is:

$\sqrt{12.7 \times A_m}$ where Am is the height of the antenna in meters.[19]

[17] World Meteorological Organization (2005): Working Group on Planning and Implementation of the WWW in Region V. Complementary systems, especially EMWIN and RANET. p. 4-5.
[18] RANET: Information and Communication Technology (ICT) Crib. p:2.
[19] WIKIPEDIA (05.24.07): Very High Frequency Radio. http://en.wikipedia.org/wiki/Very_high_frequency

So if a VHF antenna got a height of 3 meters its horizon/range will be a bit over 6 km.

However range can be extended to up to 100 km if a repeater is in close range. A repeater is an antenna that picks up VHF signals, strengthens them and sends them out again. The repeater system has to be placed in an elevated position like on a mountain top or on a high tower. If positioned ideally repeaters can pick up VHF signals from as far away as 20 km.  VHF radios are small enough to be carried and are usually battery powered. At close range they are formidable communication tools. If used for middle range emergency communications a reliable repeater system must be in place. Repeater systems don't run without power so they require an energy back-up.

VHF radio operates over an open master channel. Everybody can call this channel. For more private and undisturbed exchange of information callers can set a frequency over the master channel and then switch to a less frequented side frequency. In Indonesia users have access to 60 open user frequencies.

If VHF radio is used for emergency communications a repeater station is essential. Most cities like Padang are already equipped with repeater stations. However it is advisable to install an exclusive repeater channel to the public network for closed communication to ensure structured and efficient emergency communication amongst disaster reaction agencies. To add a repeater channel to an already existing network costs about 30 to 50 Mio IDR. Repeater stations require power to operate so reliable backup power in form of generators or batteries must be available. The instalment and maintenance of this technology can be costly.

**Cost**

The cost for VHF radio sets is quite low. In Indonesia prices start at 600.000 IDR. Talking time comes free of charge.

## UHF: Ultra High Frequency Radio

UHF operates at short range. UHV equipment is quite complicated and costly and not widely used by amateur operators in Indonesia. Cellular phones use UHV technology. Repeaters pick up the signals to carry them over longer distances. UHV is also popular with TV broadcasting.  An advantage of UHF is that it doesn't require large antennas to pick up the signal.

## FM-RDS

RDS stands for Radio Data System. It is a standard from the European Broadcasting Union for sending small amounts of digital information using conventional FM broadcasts. The RDS system standardizes several types of information transmitted, including time and station identification. RDS is standard in Europe since the early 90's.

**FM-RDS Receiver**

FM-RDS can be a powerful technology for tsunami early warning. A FM-RDS multi purpose early warning system was developed by the German company 2WCOM. It is currently tested and implemented in Indonesia through the Indonesian and German ministries of Research RISTEK and BMBF.

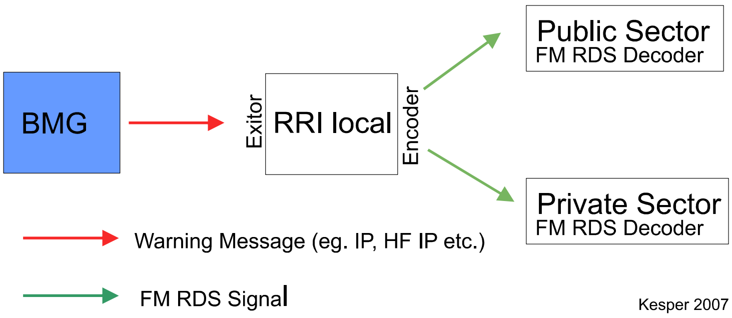
The receivers are radio/clock receivers which are active on a 24/7 basis. They spring to live when they receive a special radio signal, also when they are switched off or in standby mode. The same principle is used in car radios when they obtain a traffic warning and override the current programme to broadcast it. The 2WCOM receiver can also be used as an ordinary radio, receiving regular radio broadcasts.

In case of a warning initiated by BMG, an alert signal is broadcasted and the normal programme is interrupted. A loud audio tone and large flashing display provide the warning alert. The receiver display shows real-time text information.

The radio is equipped with a rechargeable backup battery that will power the receiver during power loss for at least 48 hours.

The receivers are triggered by signals which are broadcasted through local FM transmitters (Radio Data System (RDS) channel). The transmitters can be easily integrated into already existing radio broadcasting infrastructure. The Indonesian government (RISTEK) together with BMG is currently negotiating a nationwide integration of RDS transmitters into RII's existing infrastructure. This infrastructure should be operational on a 24/7 basis and connected to a reliable power back up. FM-RDS is also compatible with RANET. Information received through RANET can be further disseminated through FM-RDS. In Indonesia BMG plans to use FM-RDS technology to transmit warnings to local interface institutions as well as to the general public. Warnings can be issued either through national BMG headquarters or its regional offices.

Graphic 8 illustrates the ideal flow of information from BMG to local BMG to RRI and finally via FM-RDS to public and private receivers.

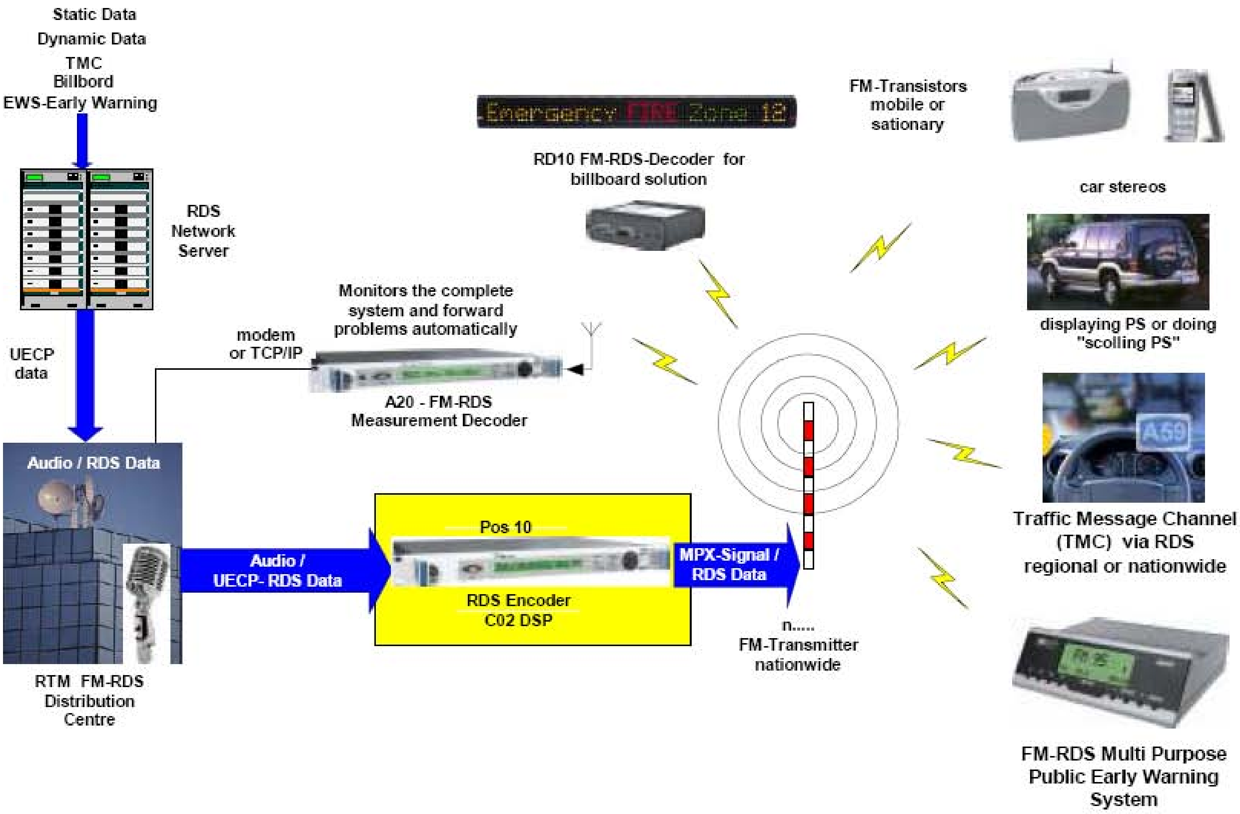



Graphic 8: Ideal Flow of BMG Warning Messages via FM-RDS

In addition to the dissemination of warnings through BMG, FM-RDS could also be utilized through local governments and emergency response bodies for the broadcasting of evacuation orders and instructions. However this still requires a major coordination effort[20].

In December 2006 FM-RDS technology was successfully tested in Bali. A message was sent out by BMG Jakarta through a direct fibre optic link to BMG Bali and forwarded to RRI Bali. Here the signal was encoded and transmitted as a FM-RDS signal through RRI to 37 2WCOM receivers. The test turned out to be successful.

Graphic 9 gives an overview about how FM-RDS technology works. After an early warning is sent out, for example via IP, it will be received at the local distribution centre, encoded into FM-RDS format and then transmitted. After reception the message can be displayed on a range of media from electronic signboards to car radios or the FM-RDS multi purpose public early warning system which is currently introduced to Indonesia.




Graphic 9: How FM-RDS works

[20] GTZ IS (2007): Results of FM-RDS Test in Bali 12/2006 and follow up activities

## GMDSS


Sunda Kelapa Harbour - Jakarta

GMDSS stands for 'Global Maritime Distress and Safety System'. It is an integrated communications system implemented by the International Maritime Organization (IMO) to ensue that no matter where a commercial ship is in distress, aid can be dispatched.

The system also ensures the provision of Maritime Safety Information (MSI) - both meteorological and navigational - on a global basis.

From February 1, 1999 all SOLAS vessels (passenger and cargo ships of 300 gross tonnage and upwards) have had to comply with the GMDSS, and be fitted with all applicable GMDSS communications equipment (international NAVTEX and-or SafetyNET Inmarsat), according to the sea areas in which the ship operates.

The Joint IOC-WMO (http://www.wmo.int/pages/index_en.html) Commission for Oceanography and Marine Meteorology (JCOMM) (http://weather.gmdss.org/index.html) is responsible for coordinating the provision of meteorological information within this framework. The provision of useful tsunami warnings for ships in ports or in coastal waters, both for SOLAS and non-SOLAS vessels, is clearly needed.

Since February 2005, the IMO has authorized the direct dissemination of tsunami warnings by tsunami warning centres through the SafetyNET communication system. SafetyNET is available to mariners and also, if needed and applicable, to local government offices in regions expected to be affected (COMSAR/Circ 36).

International marine organizations, the IOC, and a number of countries are working to establish protocols and content standards for tsunami warning bulletins to vessels, and on what training and guidance is needed, to promote vessel safety during tsunamis. To assure efficiency and consistency in the provision of the information through the GMDSS, coordination with the issuing meteorological services area will be essential[21].

GMDSS could be installed in harbour master offices throughout Indonesia. Since harbours are usually also equipped with VHF and HF radio they can play a role in informing local decision makers about possible tsunami threats. BMG could be linked to IMO and SafetyNET to broadcast Indonesia specific warning messages.

[21] UNESCO (2006): Tsunami Teacher – 3.3.6 Tsunami Mitigation: Alerting Vessels at Sea – SOLAS Vessels.

## *Telecommunication Systems*

### Telephone

Telephone notification systems are designed to ring a certain list of predefined numbers and play a pre-recorded message. Multiple numbers can be dialled simultaneously, dependable on how much ports are available on the server. If the target phones are not picked up the system will redial until the time-out limit is reached. The system can be triggered through any predefined emergency operation centre. Telephone notification systems are effective mostly for distant tsunami warnings since they require at least 20 to 30 minutes to become effective. Some systems can be equipped with GIS (Geo Information System) capabilities which make them more flexible. Through GIS it is for example possible to select a certain area on an electronic map and place a call to telephones within the selected area. A major advantage of telephone notification systems is that they can be used for multiple hazard notification.

Telephone notification systems are usually offered by service companies. These companies should offer a 24/7 service and be experienced. The maintenance of the outbound calling database should be easy and secure. To avoid breakdowns the system should feature redundancies. BMG for example contracted a commercial SMS service for the dissemination of its warning messages. However BMG also set up its own powerful SMS server at its headquarters in Jakarta in case it needs to send out messages by itself.

Before the setup of an own telephone notification system the local telephone network's engineers should be consulted to make sure it can handle the required calling rate. The possibility to place priority calls needs to be checked.

**Speed and Calling Capacity**
The number of calls a system can place within a given period of time is determined by the call completion time (dialling and connection to called number) and the number of available outgoing phone lines. Most telephone systems require 20 seconds for the placement of the call until it is answered (3-4 ringing cycles). So the delivery of a 30 second message would take about 50 seconds to be completed. This time could even be stretched out should the system deploy interactive functions. It is crucial that the telephone server is equipped with sufficient outgoing lines to become effective.

The following table illustrates the number of calls that a system with different calling capacities can place within a 30 minute time frame. For the completion of one call 60 seconds were estimated:

| Number of lines | Potential number of calls |
|---|---|
| 10 | 300 |
| 100 | 3000 |
| 1000 | 30.000 |
| 10.000 | 300.000 |

Table 3: Relation between number of lines and possible calls

The number of calls successfully completed depends on whether phones are picked up, the lines are busy, network congestion etc.

**GIS Capabilities**
Some telephone notification systems can be linked to electronic maps (GIS). In the case of an emergency certain areas on the map can be selected and messages sent out to the people living there. GIS functions provide emergency operation centres with increased flexibility. Recipient lists can be changed quickly according to need. In order to make GIS systems work a lot of preparation is needed which is costly.

**Cost**
Prices for telephone notification systems range widely, depending on the desired features like GIS, number of lines and capacity of the dial out system as well as the extend to which subscribers will maintain their own database. Annual contracts for basic non-GIS Systems start at about 2000 USD. GIS based systems are more expensive. Small systems are not effective for community wide notification but might be useful for limited emergency personnel notification. Basic prices for community-wide notification systems typically start at 30.000 USD and rise quickly when it comes to additional dial-out power, redundant capacities and out-of-area back-up systems.

**Advantages of telephone notification systems**
- multi purpose use
- predefined groups or organizations can be supplied with targeted information
- can be configured to target specific geographic locations
- called parties can be logged
- messages can be pre-recorded
- system can be supplemented with cellular and satellite phones
- can operate 24/7
- can be linked to GIS
- can be modified quickly to address changing conditions

**Disadvantages of telephone notification systems**
- can't reach people without phones
- can't reach people outdoors unless they are carrying hand or satellite phones
- people have to answer the phone to receive message
- not available during phone outages
- trade-of between content and speed may become necessary to get as many messages across as possible
- effectiveness decreases rapidly as public phone networks become congested
- Telephone notification systems are vulnerable to earthquakes due to related power failures and destruction of infrastructure like cables etc.
-

## Cellular Phones

Cellular phones are not recommended for the dissemination of voice-based warning messages. Unlike 2-way radios, cell phones require external infrastructure (repeater antennas) and cannot communicate directly with each other. Damage to the external infrastructure through earthquakes for example can directly impact service quality and availability. The cost of creating cellular networks is quite high and so they tend to exist only in more populated areas. The area covered by a network is divided into cells. Each cell site has a limited number of calling frequencies available. In emergencies it is very likely that a cells capacity gets exceeded and the system breaks down. In Indonesia temporary failures of the cellular phone systems are quite common, even in non-emergency situations. Because of its limited coverage and questionable reliability cellular phones should not be utilized to deliver time sensitive and life critical voice-based warnings.

## SMS (Short Message Service)

The use of SMS as a complementary method for tsunami early warning can be an option. A great number of people, especially in urban and densely populated areas are using hand phones and are familiar with SMS. SMS is more reliable than cellular voice transmission. During 9/11 mobile phone networks in New York lost most of their voice transmitting ability but SMS still came through. The Tourism Authority of Thailand claims to be able to submit warning messages to 20 Mio. cellular phone users should the need arise[22]. BMG notifies 400 people via SMS in the case of emergency. Every computer with internet access can theoretically initiate the sending of a SMS.

**Private SMS banks**

Local emergency centres can set up their own data bank and send out their own SMS to predefined groups as long as their PC's, are operating and the software and GSM modems are capable to carry out the task on a big scale. Recipient lists can be prepared in advance. However it might prove quite costly to maintain and operate a larger scale SMS service since you need a backup computer, several modems including SIM cards and contracts. The more modems you deploy, the greater the speed of sending out messages. The set up of your own SMS bank might be technically challenging and special software is needed to interface computers and modems. 24/7 power backup as well as trained operating personnel is essential. If you expect high volume use of messages it might be easier and saver to hire a commercial SMS provider. If you are a low volume user a private SMS bank might prove cheaper in the long run.

**Tsunami Early Warning via SMS is controversial**

**Cost for private SMS banks**

Estimated Capital Cost
Computers: 1000 USD – 2000 USD
GSM Modems: ca. 500 USD each, additional modems might be cheaper
Modem Interface Software: 500 – 1000 USD

Monthly maintenance
SIM Card: 40 USD each/month for each modem
Messaging cost: depend on service plan

[22] Tourism Authority of Thailand: How Thailand's Early Warning System Works. http://www.tourismthailand.org/content/detail.aspx?id=28 (05.19.07)

**Commercial SMS service providers**
Commercial SMS providers can be hired to send out almost unlimited numbers of SMS fast. The message text can be sent to the provider via the internet. Commercial SMS providers can also be scaled quickly in terms of the area of their coverage. Note that some providers may not be able to send messages to certain networks, even though they claim they can. Tests are necessary.

**Cost for commercial SMS service**
Cost for a commercial gateway comprises of a monthly maintenance fee which can amount to a few hundred USD as well as the cost for sending messages. Message cost ranges from 0,06 USD to 0,25 USD a message, depending on the country. If two-way messaging capacity is required the monthly service fee will probably double. In order to contact the service provider in time a reliable computer with the necessary software, internet access and power backups as well as qualified operators must be in place and ready on a 24/7 basis. That might add additional cost[23].

**Commercial SMS Tsunami Early Warning**
Some companies offer commercial tsunami early warning via SMS. They claim to be 100% reliable in their predictions. However, this claim is questioned by numerous seismic and geological experts. Since these service companies are reluctant to disclose the sources of their information it is difficult to asses them. Common sense is asking why countries set up their own tsunami early warning and monitoring systems if they could just as well subscribe to a commercial warning provider. However one should keep in mind that SMS is not 100 % reliable and that systems can easily fail because of damage to the infrastructure or overload.

**Cost for Commercial SMS Tsunami Early Warning**
Subscription prices start at about 12 USD for a month. A year long service contract costs starts at ca. 33 USD.

**Advantages of SMS**
- More reliable than cellular voice transmission
- Can target specific groups
- Most people are familiar with technology
- Messages can be sent via internet
- Relatively cheap
- Works indoors and outdoors
- Usually people keep their hand phones close by
- Cell phones are battery powered and so immune to power outages

**Disadvantages of SMS**
- Message content is usually limited to 160 characters
- Delivery of messages can be delayed due to congested systems
- Limited coverage
- Transmitting infrastructure vulnerable to earthquakes
- Pre-registration of phone numbers is necessary
- SMS might not be opened after delivery
- Geographically targeted mass delivery is difficult

[23] RANET: Information and Communication Technology (ICT) Crib. p. 7-10

- No priority access for SMS warnings
- Not everybody uses a cellular phone
- Method is not hoax proof[24]

  In the beginning of June 2007 people in Indonesia received SMS predicting an earthquake with the possibility for a devastating tsunami for June 7, 2007. The SMS referred to an alleged CNN story. Various versions of that SMS were circulated. One red as follows:

> **Example of Hoax Warning SMS**
>
> "*'CNN aired 3 days ago that the earth's plate in Australia is moving to the north of Asia. It is predicted that it could collide with the earth plate of southern Indonesia. It is predicted that 11 days after the high tides, on wed 7 June, there will be a big earthquake and it might be followed by a tsunami'. Please forward this to your friends - Don't keep it to yourself*" (translation from Bahasa Indonesia)

Of course this SMS was a hoax. Earthquakes and tsunamis can not be predicted like the weather. Predictions can be made in geological time frames and these are very inaccurate in the short run. Reliable predictions about tectonic movements even in the range of years are quite impossible, especially in Indonesia. Since the source of the SMS could not be traced and verified people who were already traumatized through the 2004 Asian tsunami panicked when the malfunction of a tsunami early warning siren in Aceh coincided with this SMS hoax. (see p. 42 "Tsunami alarm sparks panic in Aceh").

## Internet

## Email

**Advantages of Email**

- Email is an easy way to disseminate information, ranging from text files to maps, sound and video files.
- Every computer with internet access features usually also an email programme
- Large amounts of information can be sent out to a large number of people in a very short time if bandwidth is sufficient.
- Distribution lists can be predefined.
- Email can also be used to send messages to hand phones in SMS format.
- Email is widely supported on all computer operating systems and can be easily interfaced with other warning systems.
- It is easy to track whether a mail has been opened or not.
- Very low cost
- Can be sent and received via HF radio

**Disadvantages of Email**

- Email it is not an alerting device, it needs the recipient to become active (open the mail and read it).

[24] UNESCO (2006): Tsunami Trainer. p. 325

- It only functions if power is available to run the computer and communication infrastructure (e.g. telephone cables)
- There is no guaranty for timely delivery of messages.
- If large numbers of mails are sent out boosted server performance might be needed.
- Not everybody got constant access to Email

## Websites

Websites can be quickly updated and supply an almost unlimited number of users with a large variety of information but they don't function as an efficient alerting or notification tool. Websites can only be categorized as supplementary. Users have to actively open the website. To do so they have to know the web address. To change the content of a website requires expert knowledge. Websites are merely useful as long as a computer is running and connected to the internet. Websites can be useful information sources during the response phase of a catastrophe. Information can be centrally stored and access rights for restricted information given to relevant stakeholders like fire-fighters or emergency operation centres.

## RANET

RANET is an international collaboration to make weather, climate, and related information more accessible to remote and resource poor populations to aid day-to-day resource decisions and prepare against natural hazards[25].

RANET is often associated with the use of the WorldSpace digital satellite system, which enables audio and one-way multimedia (dta) transfers to anywhere in Africa, Asia and the western Pacific via satellite receiver systems which are not more expensive than a quality FM stereo.

The networks RANET develops are not limited to satellite systems. The programme works with a variety of partners to utilize FM community radio equipment, HF radio systems, SMS systems, community building and even energy solutions such as solar and wind power[26].

In Indonesia RANET collaborates with BMG[27] . BMG is using RANET satellite technology to disseminate its warning bulletins. Through RANET BMG in cooperation with WMO broadcasts almost real time information about earthquakes and tsunami hazards. The service is called EMWIN (Emergency Manager's Weather Info Network). Information is broadcasted as a map and text on a computer screen. Epicentres are displayed together with more detailed earthquake data and indicators of distance from the epicentre to important surrounding cities. In case of an earthquake

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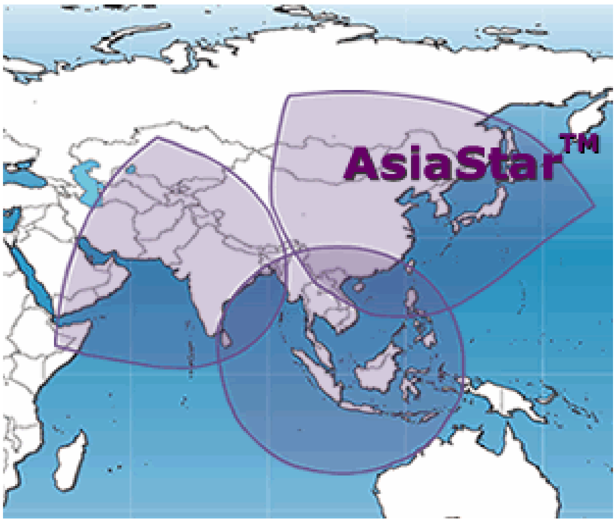
25 World Meteorological Organization (2005): Complementary Systems, Especially EMWIN and RANET. Samoa
26 UNESCO (2006): Tsunami Teacher: Delivery of environmental Information through RANET. p. 320
27 Weniza, Suhardjono BMG (2007): Development of Seismic Network for Indonesia (ppt Presentation Yokohama)




Coverage of AsiaStar Satellite

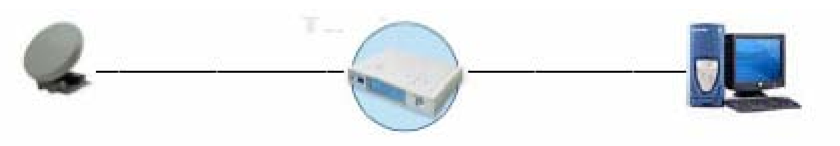
that could trigger a tsunami the system will sound a warning tone and display a warning message.

The information is sent via AsiaStar satellite to low cost receivers and computer terminals which can be placed almost anywhere. RANET should be installed on computers which are merely reserved for early warning purposes, with a power back-up and 24/7 supervision. Currently the receivers can be obtained from BMG. RANET is an inexpensive means of receiving reliable tsunami early warning information in Indonesia. However some users suspect RANET to be effected by bad weather conditions. Receivers should be placed in local emergency response offices as well as in households as soon as RANET receivers are easily available to the public.

RANET interfaces with e.g. SMS, e-mail, HF e-mail and VHF. The organisation offers advice, resources like software and manuals as well as customised expertise[28]. Further information on RANET can be obtained from www.ranetproject.net .

**Cost**

- RANET receiver: ca. 160 USD. Once installed reception of information comes free of charge.
- Computer exclusively reserved for RANET: ca. 500 USD
- 24/7 surveillance and power back ups are strongly recommended



**Graphic 10: Equipment needed to receive RANET within the Footprint of the AsiaStar Satellite**

[28] RANET (2006): Information and Communication Technology (ICT) Crib.

## *Personal Warning Systems*

### Door-to-Door

Door-to-door warning can be carried out by trained groups of people. The advantage is that in a personal encounter very specific information can be exchanged. Personal warning can also be more convincing especially when carried out by people who are already known throughout the neighbourhood. This notification method can make sure that everyone in an area receives the warning. In some areas door-to-door warning might be the only working option.

On the other hand door-to-door warning can be very time and resources consuming. Door-knocking can only be used when a lot of time is available to ensure the knockers safety.

The visits should be supported by a delivery of printed material including information on evacuation routes and procedures. The papers should also specify what people should do before they leave their homes and what they should take with them. For the notification of small areas one can deploy local volunteers which should be trained and introduced to the residents beforehand. If the area is larger much planning will be required. When considering door-knocking as an option also bear in mind how long it takes to assemble, equip and brief your personnel and how long door-knockers can remain in the area before they endanger their own safety.

Experience shows that it takes four to six minutes to complete the notification of one single house. Ten two man teams (20 people) will require at least 1 hour to notify 100 homes. This rate can vary considerably depending of the time of day/night, weekday (on weekends people tend to be more at home than during the week) and how densely the area is populated.

Door to door notification might not be a good option for tsunami early warning in Indonesia because the country is more likely to be hit by local tsunamis which don't allow much preparation time.

### Residential Route Warning

Residential route warning is a very efficient warning method, especially in densely populated areas like cities or villages and much faster than door-to-door warning. Residential route warning uses public address systems which are mounted on a vehicle. Most police and fire cars as well as ambulances are already equipped with such a system. Mobile public address systems comprise of a controller, an amplifier, a microphone and a siren/speaker. The speaker is necessary for voice notification. Announcements can be pre-recorded or life. In areas where financial resources are limited or which are densely populated but not accessible by car because of narrow roads which is still the case in some parts of many Asian cities, bicycles equipped with a simple speaker system might also be an option. For residential route warning the following factors need to be considered:

**Range of warning**

The average public announcement system got a range of about 300 m. Behind that range the message might quickly become incomprehensible. The announcement vehicle must travel at a low speed and at least every 300 meters the message must be repeated.

**Message type**
To cover an area as large as possible the message should be kept simple and be as brief as possible. The message should advice people to turn to other sources for further information like TV or radio. If there is just very short time available the main message should point out evacuation routes and emergency centres.

**Warning routes**
Warning routes can be planned in advance but should be flexible due to possible destruction or blocking of traffic infrastructure like roads e.g. through crumbled buildings or traffic jams.

**Advantages of residential route warning:**

- method is highly credible, especially if carried out through emergency vehicles like fire or police cars
- very flexible, can change routes and announcements quickly
- can notify very targeted
- can reach people indoors if loud enough
- easy to install on different types of vehicles
- system usually already installed in emergency vehicles like police or fire cars
- cost effective for large areas like public beaches, markets or parks
- relatively cheap

**Disadvantages of residential route warning:**

- requires personnel and equipment which could be endangered during the event
- road damage and traffic jams can hinder warning message dissemination
- area covered is limited to a radius of about 300 m from the loudspeaker
- sound might be blocked off by big buildings

**Cost**
The entire system is relatively cheap. Prices range from 1.000 USD to 2.000 USD per unit.

## Natural Warnings

Most tsunamis in Indonesia are triggered by local earthquakes which can often be felt on land. So earthquakes are a natural warning sign for the possibility of a tsunami. If you are in a coastal area and feel an earthquake better move to higher grounds immediately. Of course there is no way to predict that there is really a tsunami developing just by sensing that the earth is moving but there is an old saying: better be safe than sorry. Whether an earthquake triggers a tsunami depends on many factors such as magnitude, depth and location. However, the possibility that a felt earthquake could have triggered a tsunami is real.

There are further natural warning signs which are quite specific, especially in the combination with a felt earthquake. In many cases the waterline on the beach will recline far and rapidly prior to the arrival of a tsunami. If this sign is observed it is recommended to leave the beach as quick as possible and move to higher grounds. Other signs are strong and sudden, gusty winds or unusual sounds coming from the sea.

A tsunami is not a single wave, but a series of waves that can come ashore for hours. The first wave may not be the largest. Stay out of danger areas until an "all-clear" is issued by a recognized authority.

## *Conclusion*

There are additional notification technologies and methods to the ones illustrated in this reader. Nevertheless the methods and technologies described here are means that are available in Indonesia. Other parts of the world with different technical infrastructure may well use different notification systems. However, warning messages should be disseminated through a variety of different technologies to ensure reliability. They should be delivered as fast as possible as 'time is life'. Message content should be clear and explicit to make sure that as many people as possible can be saved. Existing communication systems should be utilized to their full potential and integrated into the early warning scheme. The creation of multi-hazard and multi-purpose communication systems is desirable.

There is no single early warning method that fits all requirements. Especially on the 'last mile' tailor made communications solutions are required considering the special needs of the local population. To do so one needs to research the specific needs of that particular community. Before designing the system one needs to know the audience, of which different groups it consists and what these groups might be doing at which time of the day.

Cost is a major, possibly limiting factor. Each place has different budgets and priorities. Cost could be the reason why the best solution can't be installed at certain communities.

Another important factor is size and layout of the area that has to be notified. A large, spread out community might require an interdependent multiple notification system like RANET, FM-RDS, loudspeaker and sires. While FM-RDS is ideal for inside warnings, sirens and loudspeakers are a better solution for beaches or markets.

Effective notification systems and procedures require clear, concise and consistent signals and messages. Redundancies can give people extra assurance and the decision to evacuate is positively enforced. The various information sources must not provide conflicting information and so undermine the credibility of the whole system. Planning and education are required to ensure efficient and timely evacuation[29].

A uniform notification system for the whole of Indonesia on all levels would be useful but probably unrealistic. At least the initial advisories and warnings given out through BMG all follow the same format. It is up to the local decision makers how to interpret and use this standardized information. It would be helpful if for example special siren signals would be dedicated to tsunami early warning all over Indonesia and signs for evacuation routes would follow the same design and principles nationwide.

All clear signals should be easily recognizable and familiar to the local population. A clear distinction between all clears from BMG and all clears from the local decision making body is advisable.

[29] Oregon Department for Geology and Mineral Industries (2001): Special Paper 35 – Tsunami Warning Systems and Procedures. p. 27-30

Note that even the best system doesn't work without education, no matter how sophisticated or expensive. Whatever system is chosen, all groups that are part of the notification process (emergency managers, media, local NGOs, etc.) should be involved in the planning and implementation of their system. If a feeling of ownership and personal responsibility can be achieved the system will work even better and adapt to changing requirements and situations with greater ease.

Annex I provides an overview of the technologies and their individual characteristics as discussed in this reader.

The GITEWS publication *'Implementation of Tsunami Early Warning in Indonesian Local Communities - Checklist for assessment, planning and monitoring'* serves as a simple tool for local decision makers and stakeholders involved in the implementation of Tsunami Early Warning. It considers many of the above mentioned elements and is highly recommended. The publication names three major preconditions for successful dissemination and communication of early warning messages on the local level:

1. **Organizational and decision making processes are institutionalized**
   Each community has to define, where, how and by whom the warning from BMG will be received and what kind of procedures will be started upon receiving an advisory or warning message. All local actors involved in warning dissemination have to be identified and roles and responsibilities as well as coordinating mechanism have to be agreed upon. All procedures should be documented in form of SOP.

2. **Effective local communication systems and equipment are installed.**
   The use of multiple communication channels is necessary to ensure that as many people as possible are warned, to avoid problems in case of failure of any one of the used channels, and to reinforce the warning message. Every community will have distinct characteristics and needs regarding warning dissemination. Factors to be considered are (1) size and layout of the area; (2) make up and activities of the population; (3) financial resources of the community and (4) existing communication systems.

3. **Warning messages are recognized and understood.**
   Clear messages containing simple, useful information are critical to enable proper responses that will help safeguard lives and livelihoods. It has to be assured that warning and instruction messages from the different levels and institutions are consistent in content and time[30].

[30] GITEWS (2006): 'Implementation of Tsunami Early Warning in Indonesian Local Communities' Checklist for assessment, planning and monitoring, Jakarta

# Case Study Padang

Padang is one of the most proactive cities in Indonesia to prepare for tsunami hazard and the establishment of a tsunami early warning system. There are already initiatives on the way to establish local warning chains and set up technologies for early warning. A working group from Padang participated in a series of trainings facilitated by a consortium of several national and international organizations between 2006/2007.

Padang is also one of the selected Pilot Areas for the German–Indonesian Cooperation for Tsunami Early Warning System (GITEWS). As part of GITEWS the project “Capacity Building in Local Communities” cooperates with Local Governments and other stakeholders (including private sector) to develop warning and preparedness mechanism also in Bali and southern Java.

Cooperation between GTZ-IS in the Pilot Areas comprises the identification of local tsunami risk, the establishment of the warning chain on local level and the preparation for appropriate reaction to the warning. The results from this project shall enable other coastal communities to link themselves to the Indonesian Tsunami Early Warning System and to prepare better for future Tsunamis. The project started in June 2006 and is scheduled up to the end of 2008.

As part of the GITEWS cooperation a Warning Chain Analysis for Padang was realized in late 2006 to get a better understanding about the roles and responsibilities of the involved institutions and procedures already in place.

A complementary initiative funded by State Ministry of Research and Technology (RISTEK) and its German partners, Ministry of Education and Research (BMBF) and the German Company 2WCOM introduces in cooperation with RRI the FM-RDS technology for early warning dissemination in Padang. With support from the US the RANET technology was implemented to link the city with BMG in Jakarta.

The following Case Study spotlight the current state of tsunami early warning on the local level in Padang.

## *Official Stakeholders involved in Tsunami Early Warning and Disaster Management in Padang*

A great number of organisations and agencies are involved in Tsunami early warning and disaster management in Padang. These organisations and agencies need to be coordinated in order to react to a tsunami threat in the best possible way. At the same time the right technologies have to be utilized to communicate with the general public. Table 6 introduces the main official stakeholders in tsunami early warning and disaster management in Padang.

| Agency | Task/Role | Current state of preparedness |
|---|---|---|
| **Provincial Level Agencies and Organisations** | | |
| **SATKORLAK* PB** West Sumatra Province | - non structural board organization<br>- forum for coordination and controlling of disaster management activities in the province of West Sumatra<br>- Chaired by provincial governor<br>- Members are representatives from different provincial level agencies as well as NGOs<br>- Reports to BAKORNAS PB on national level<br>- Responsible body for information dissemination within SATKORLAK is 'Bidang Data, Dokumentasi, Informasi dan Publikasi".<br>- This body handles all aspects of information dissemination connected to disaster management including early warning<br>- Delivers information directly to SATLAK PB<br>- Collects and receives disaster related news<br>- Validates information<br>- Records all messages received and sent | - SOPs from Governor<br>- Means of communication: phone, fax, courier |
| **Badan KESBANGLIMAS** West Sumatra Province | - Secretariat Office of SATKORLAK PB<br>- Dissemination of disaster information<br>- Receives information from BMG through 24/7 standby communication centre<br>- Information distributor to next lower government level (district and city KESBANGLIMAS) | - No special SOPs regarding the dissemination of early warning but refers to SOPs established by SATKORLAK PB<br>- Dissemination of information to local level might prove difficult since not all districts and cities have KESBANGLIMAS<br>- Not all districts and cities have 24/7 communication centres<br>- Relies on RAPI<br>- Main means of communication are phone and radio which might be useless without power back up<br>- Very limited budget<br>- Plans to install a repeater network reserved to disaster related communication on local government level to become independent from |

| | | |
|---|---|---|
| | | RAPI |
| **BMG** (Regional Office Padang Pajang) | - supplies disaster information, both for the regional stakeholders and BMG Jakarta<br>- Disseminates early disaster information as soon as disaster potency is detected via VHF radio and telephone.<br>- Disseminates official BMG advisories, warnings and all clears, mainly via VHF and telephone.<br>- Receives most information via RANET | - No comprehensive SOPs on warning information dissemination, informs the governor via phone and VHF radio (RAPI)<br>- Limited means of communication (telephone, fax, RAPI)<br>- Communication with BMG Jakarta via V-sat and phone |
| **POLDA** West Sumatra Province | - disaster preparedness and response at all stages<br>- dissemination of information | - developed an SOP for disaster preparedness and response at all stages<br>- Communication means: MIS on line, Alkom (communication equipment), VHF, loudspeakers, sirens, bells, phone, cellular phones etc.<br>- Public announcements are done in Bahasa Indonesia and Bahasa Minang |
| **District/City (Kabupaten/Kota) Level Agencies and Organisations** | | |
| **SATLAK*** PB Kota Padang | - Non structural organization, established under mayors decree<br>- Coordination board for disaster management in Kota Padang<br>- Members are representatives from different city level organizations including NGOs<br>- Prepare guidelines on the implementation of disaster management in accordance to local conditions<br>- Conducting disaster management activities in a planned and coordinated way together with neighbouring SATLAK<br>- Reports disaster occurrence to SATKORLAK PB West Sumatra and BAKORNAS PB with cc to relevant agencies<br>- Reports the implementation of disaster management activities to SATKORLAK PB West Sumatra and BAKORNAS PB<br>- Responsible to coordinate its entire government elements related to disaster | - no SOPs concerning disaster management or early warning in place<br>- Drafting a general disaster SOP focused on emergency response together with KOGAMI<br>- so far played no major role in disaster preparedness and reaction in Padang |
| **DINAS KESSOS** PBB Kota Padang | - Department for Social Welfare, Flood and Disaster Response<br>- Assigned secretariat office of SATLAK PB Kota Padang | - No specific section concerned with early warning and disaster information |

| | | |
|---|---|---|
| | - Handles most of disaster management activities in Kota Padang<br>- Conducts training/education<br>- Disseminates Information<br>- Emergency response and evacuation<br>- Consists of four sections: social welfare, social rehabilitation, facilities and infrastructure, disaster<br>- Disaster section subdivided into disaster prevention and response + flood and disaster relief section | - means of communication: mobile phone, RAPI, mosque loudspeakers |
| **PUSDALOPS** Padang | - early warning and disaster response in Padang<br>- Chief of PUSDALOPS might be authorized to order local evacuation on behalf of mayor at a later stage<br>- Disseminates warnings and orders to local community<br>- same members as SATLAK<br>- situated at fire department | - formulation of SOPs ongoing<br>- equipped with UPS<br>- Communication tools: HF radio, VHF, phone, fax, RANET, SMS server, e-mail, mobile phones<br>- 24/7 readiness |
| **SATPOL** PP Kota Padang | - local government police unit under responsibility of mayor<br>- mandate to enforce the implementation of local government regulations<br>- warning dissemination to: kecamatan, lurah, mosque and mushola | - does not have own SOPs<br>- refers to SOPs of SATLAK PB (which are not in place yet)<br>- warning dissemination through patrol car and mobile phone<br>- communication tools insufficient for task |
| **Badan INFOKOM** Padang | - City office for information and communication<br>- Helps top level to disseminate information, including early warning information | - no SOPs |
| **POLTABES** Padang | - Police Force Unit at city level<br>- Similar tasks to POLDA | - SOPs in place<br>- Information dissemination problematic because of unreliable communication tools |
| **KODIM 0312** Padang | - Territorial Military Command at District Level<br>- Main role in disaster response as evacuator | - no mandate to disseminate information<br>- general but confidential disaster management SOPs in place<br>- flexible to provide support and aid when needed<br>- no reliable communication tools and no back ups |
| **Non Governmental Organizations (NGOs)** | | |
| **KOGAMI** Kota Padang | - works as a catalyst in developing community disaster preparedness<br>- supporting community | - no official mandate in warning dissemination |

| | | |
|---|---|---|
| | organizations especially in stakeholder capacity building in terms of preparedness<br>- assisting local government in the draft of regulations and decrees related to disaster preparedness | |
| **RAPI & ORARI** Kota Padang | - important radio organizations<br>- supports government in dissemination of disaster related information via HF and VHF radio | |

**Table 4: Important Padang Organizations involved in Tsunami Early Warning[31]**

(* BAKORNAS, SATKORLAK and SATLAK will be replaced by new agencies by 2008 called Badan Nasional Penangulanan Bencana [National Body for Disaster Management] or Badan Penangulanan Bencana Daerah)

The table suggests that currently no effective, unified early warning chain and disaster response plan which involves and coordinates all relevant stakeholders on all levels is in place. No comprehensive SOPs are worked out. The organizational structures and SOPs which are already existent have never been fully tested. A lack of qualified personnel, facilities and communications equipment could hamper effective tsunami early warning and response[32]. However, serious efforts to overcome the shortcomings are undertaken, especially by PUSDALOPS Padang and its members.

## *PUSDALOPS Padang*

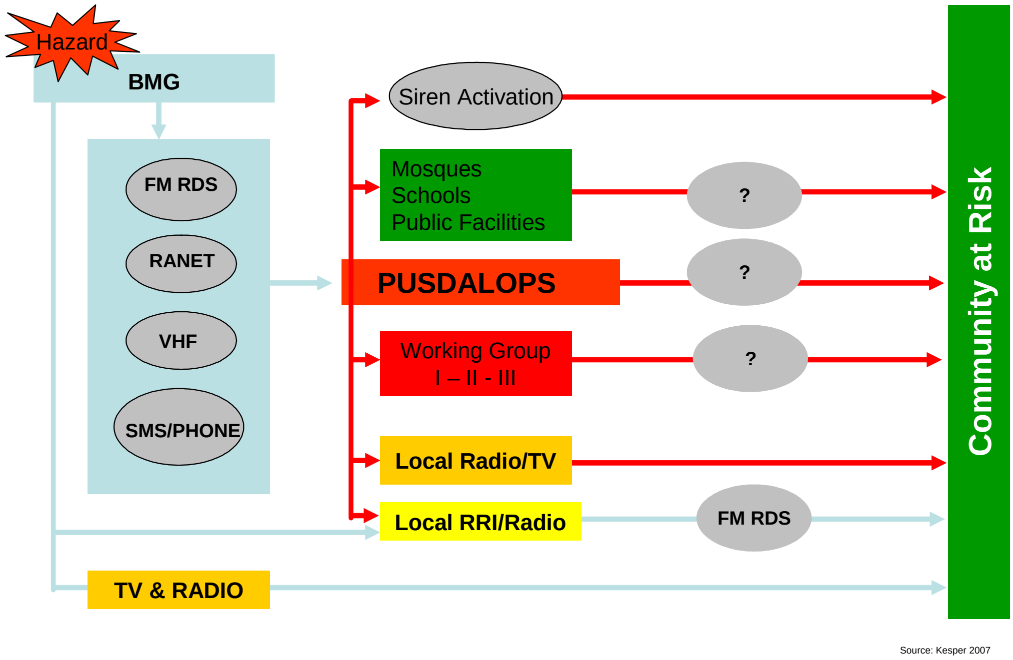
An important organisational body for tsunami early warning and disaster response in Padang is PUSDALOPS (Pusat Pengendali dan Operasi). It is located at the headquarters of the Padang fire brigade. PUSDALOPS acts as the cities centre for disaster related coordination, command and operation. In the future PUSDALOPS might be charged with the issuing of tsunami evacuation orders and the coordination of the last segment of the early warning chain on behalf of the mayor of Padang. The final structure and legal status of PUSDALOPS is still under discussion because the relevant law on disaster management (Peraturan Pemerintah PP) still needs to be endorsed. A strategic plan for disaster management in Padang (RENSTRA) is in the making. However, the Padang Working Group (PWG) which is organized in PUSDALOPS has decided to go ahead. The current members of PUSDALOPS are identical with SATLAK. Main actors at the moment are the fire brigade, police, military, navy, PMI, Kogami, RAPI, Dinas Pekerjaan Umum (Public Works), PMI (Palang Merah Indonesia) and Tagana.

PUSDALOPS is headed by the mayor of Padang and representatives of the district army and district police. The appointed chief of PUSDALOPS is responsible for operations and decision making. By law, the chief holds the authority to command and activate the members of the three groups which are experts in the fields of 'Evacuation & SAR', "Infrastructure' and 'Health & Logistics'.

The following flowchart displays the envisaged early warning chain for Padang as planed by PUSDALOPS. PUSDALOPS will receive early warning information directly from BMG and forward it to its local interface institutions as well as directly

[31] Data taken from: GTZ IS (2006): Warning Chain Analysis. p. 26 - 48. Jakarta (adjusted)
[32] GTZ IS (2006): Warning Chain Analysis. p. 26 - 48. Jakarta

to the local community. So far there are no SOPs for the direct notification of the local community and the interface institutions in place. In the near future FM-RDS technology will be introduced in cooperation with RRI and a commercial radio station as a back up.




Graphic 11: Intended Flow of Information according to PUSDALOPS Padang[33]

## Technical Equipment of PUSDALOPS Padang

Currently PUSDALOPS is equipped with personal computers, internet connection, fax, telephone and a radio communication system comprising of:

- 1 VHF Repeater System
- 1 VHF Radio
- 1 HF Radio Vertec System

One computer is exclusively dedicated to RANET for the reception of BMG early warning messages. PUSDALOPS is staffed 24/7. The agency is equipped with an old power generator that is started manually. For reliable UPS a new, automatic power generator is required but up until now no funds could be allocated.

[33] Graphic from PUSDALOPS Power Point Presentation (adjusted)

## *Introduction of FM-RDS to Padang*

For the near future the introduction of FM-RDS early warning technology to Padang is planned. BMG Jakarta will forward its early warning information to RRI Padang via Internet (Speedy). A satellite connection would be more reliable but is currently unrealistic due to financial restraints. RRI will broadcast the message in FM-RDS format. The private radio station PRONEWS FM in Padang might serve as a back up for the case that RRI is not able to receive the BMG bulletin and/or transmit the RDS signal. PRONEWS seems to be a good choice because it disposes of a better coverage than RRI. Both broadcasting stations require an uninterruptible connection to BMG and a reliable power back up. To ensure reliability the power back up needs to be checked and tested on a regular basis under realistic conditions. One of the main goals for public notification of PUSDALOPS in Padang is the utilization of mosque loudspeakers. The loudspeakers could be simultaneously triggered through FM-RDS as well. The following table compares the signal strengths of PRONEWS and IRR.

| | AREA | RRI 90.8 FM | PRONEWS 90 FM | | AREA | RRI 90.8 FM | PRONEWS 90 FM |
|---|---|---|---|---|---|---|---|
| 1 | Pasir Jambak | High | Low | 17 | Jl. KH. A. Dahlan | High | High |
| 2 | Lubuk Buaya | No Signal | No Signal | 18 | Lubuk Lintah | High | High |
| 3 | Sungai Bangek | No Signal | Medium | 19 | Lambung Bukit | High | High |
| 4 | Tanjung Aur | Low | Low | 20 | UNAND/Koto Panjang | High | High |
| 5 | Air Dingin | No Signal | Medium | 21 | Jl. Samudra | High | High |
| 6 | Sungai lareh | No Signal | No Signal | 22 | Simpang Haru | High | High |
| 7 | Ps. Sebelah | No Signal | High | 23 | Lubuk Begalung | Low | Medium |
| 8 | Bandara Tabing | High | High | 24 | Cengkeh | High | High |
| 9 | By Pass | Medium | High | 25 | Padang Besi | No Signal | High |
| 10 | X | High | Medium | 26 | Cement Indarung | No Signal | High |
| 11 | Ujung Karang | High | High | 27 | Air Manis | No Signal | No Signal |
| 12 | Gurun Lawas | High | High | 28 | Rawang Timur | No Signal | No Signal |
| 13 | Gunung Sarik | No Signal | No Signal | 29 | Tl. Bayur Utara | Low | Low |
| 14 | Gn. Sarik Kelok | No Signal | No Signal | 30 | Sungai Beremas | No Signal | High |
| 15 | Jl. Juanda | High | High | 31 | Bukit Lampu | Medium | Medium |
| 16 | Pantai Carolina | Low | Low | 32 | Pasar Laban | High | Medium |

Table 5: Comparison of FM Signal Strengths RII and PRONEWS Padang

The pilot project is funded by RISTEK, BMBF and 2WCOM. The following equipment will be used:

- 3 RDS encoders
- 3 FM-RDS monitoring and measuring decoders
- 30 early warning receivers

GTZ IS will coordinate the implementation and testing phase. Additional RDS receivers will be provided after successful testing.

So far the following bottlenecks and problems in the introduction of FM-RDS to Padang have been identified:

- Currently RRI can't make an extra budget for the implementation of FM-RDS available.
- RRI lacks an automatic power generator. Funding for the new generator is still in question (ca. 8000 – 10.000 USD).
- RRI can't operate on a 24/7 basis because they only dispose of one transmitter. This transmitter can't be operated full time because it would reduce its life span dramatically. To ensure 24/7 transmissions a second 2 KW FM transmitter needs to be installed (ca. 15.000 USD).
- A plan of action between the main stakeholders BMG, RISTEK, RRI and 2WCOM with clearly defined responsibilities needs still to be created.

After successful testing FM-RDS receivers should be given out to all relevant emergency stakeholders like government agencies, police stations, fire stations and hospitals. Public facilities like schools and universities, markets or big shopping centers should also be connected. Private households throughout Padang should be given the opportunity to purchase their own receivers.

## *Effective Early Warning Technologies Currently Available in Padang*

In May 2007 PUSDALOPS reviewed technologies for last mile tsunami early warning in Padang. The outcome is displayed in appendix II.

It turned out that at the moment the only reliable technologies that are ready to use are mobile speakers and VHF radio but VHF radio is not a device to alert the general public. It is used by the members of RAPI, ORARI or/and the members of PUSDALOPS.

In Padang mobile speakers are fixed to police and fire cars. However, no SOPs for their use are in place yet and nobody researched how many mobile speakers are available at all. It is an advantage that PUSDALOPS is located at the fire department so that fire cars can be utilized for the dissemination of early warning messages with little delay. Since PUSDALOPS is connected to RANET and uses HF as well as VHF radio it can communicate with other disaster management organizations like the police department and initiate the deployment of police car loudspeakers and sirens.

Mosque speakers could serve as a great early warning device since they are widely available but it is not easy to utilize them. To be reliable they require a power back up which is costly. The operators have to be notified and SOPs and standard messages have to be developed to ensure credibility and unambiguousness of the broadcasts. First steps have already been undertaken in the endeavor to integrate mosques into an efficient early warning system for the last mile. The utilization of mosque speakers will be integrated into RENSTRA, the government's strategic plan for disaster management in Padang. A local initiative already committed itself to the development of a triggering system to utilize mosque speakers for early warning purposes [see: The 'Rabab' Early Warning Notification System'].

A group that is mobile and connected to VHF are taxi drivers. Taxis are usually located in most parts of the city. Taxi drivers could be used to spread information if an appropriate plan and SOPs are worked out. Taxi drivers could for example be asked to inform the nearest mosque about imminent danger, trigger warning devices like sirens or just beat the kentongan or kulkul at a Posko.

Private radio stations are another useful means for the dissemination of early warning information in Padang. The city is home to 18 private broadcasters. For the near future a workshop is planned to assess how these radio stations, RAPI and ORARI can be involved into the cities tsunami early warning scheme. According to the broadcasters reliable power back up is the major technical issue.

BMG installed one big siren with voice function in Padang. It can be triggered through BMG Jakarta and through local decision makers. The ministry of social affaires allocated a budget for the purchase an additional 7 sirens. The equipment needs to be installed until the end of 2007 otherwise the allocation will be lost.

Padang airport and Padang harbor are both located well outside the city. The surrounding of both locations is not densely populated. It would be recommended to install RANET as well as FM-RDS at both facilities. Since the airport is located in direct vicinity of the beach it is vulnerable to tsunamis. Both airport and harbor are equipped with VHF and UHF technology. However during the big September 2007 earthquakes which triggered high priority tsunami warnings no evacuation orders were issued. The airport fire fighters are equipped with siren cars. The tower is equipped with a siren as well. These devices could be utilized for tsunami early warning within the direct surrounding of the airport. However Padang Airport has not developed any tsunami related SOP’s yet.

Because Padang is likely to be struck by a local tsunami with short warning times notification methods like telephone cascades or door to door warning are probably rather inefficient. Residential route warning might loose some of its effectiveness due to time constraints. The possibility of destroyed or blocked traffic infrastructure should always be kept in mind. The solution for tsunami early warning in Padang needs to be quick, redundant and efficient. FM-RDS technology seems like an ideal solution. In combination with sirens, loudspeakers and the national as well as local media it could inform people without much delay.

After successful notification the evacuation of the population is the next challenge. Ideally evacuation should be carried out in a planned and orderly way to prevent unnecessary bottlenecks like traffic jams and accidents. This will only work if people are informed about emergency procedures before an evacuation order is given. Local TV and radio stations such as PRONEWS as well as newspapers can play an important role in awareness building and evacuation training. Government agencies, public facilities, the local media as well as neighborhoods, clubs and any other organized body can participate in tsunami early warning and evacuation training. However, to be most effective tsunami early warning and preparedness needs to be steered, supported and supervised by a central body like PUSDALOPS.

During the September 2007 quakes the mayor of Padang suggested to the people of Padang to evacuate to higher ground via radio. People reacted in a surprisingly orderly way. However official evacuation routes are still in the making by a panel of experts. Street signs marking evacuation routes will probably be installed by 2009.

## The "Rabab" Early Warning Notification System

**The Rabab - a traditional Indonesian musical instrument**

During a number of GITEWS tsunami early warning workshops participants suggested using the system of mosque speakers for tsunami early warning dissemination. Mosques are dispersed throughout the whole area of Padang and usually of taller structure. They are ideally suited for notification.

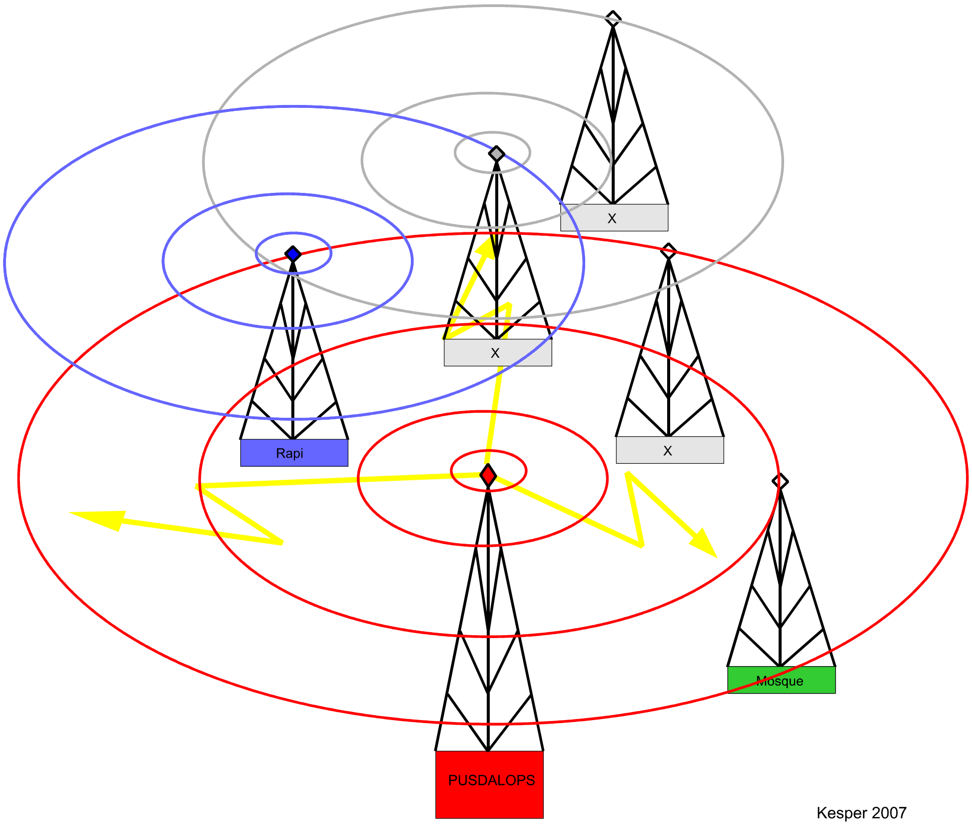
During the last GITEWS workshop at the Pangeran Beach Hotel in Padang on September 20, 2007 a communications working group was formed. Members come from a wide range of backgrounds. Involved are members of Padang's administration, the business community as well as local NGOs and other stakeholders. One of the members presented his self developed invention of a VHF triggering mechanism for mosque loudspeakers. The mechanism allows the use of mosque speakers as a siren or remote broadcasting device, controlled from a central location. Many mosque speakers can be hooked up to a car battery which provides sufficient power for emergency use. Additional battery powered and Rabab triggered small sirens can be installed on the towers as well. Sound patterns will be stored on a small chip.

The members of the working group signed a memorandum of understanding in which they commit themselves to the development and implementation of that triggering devise. The trigger is very versatile and can be used for a wide range of purposes. The system was called 'Rabab System'. The Rabab is a traditional Sumatran music instrument which is still used by story tellers today. The members of the working group committed themselves to the technical development and testing of the system. The commitment involved also the creation of a user's guide, training for operators and an information campaign for the community at risk.

Expected outcomes were:

1. Padang's community at risk can be alarmed and instructed on a 24/7 basis from a centralized location.
2. Timely delivery of BMG warning messages to population of Padang
3. Timely notification and instruction of population through local decision making body
4. System is cheap
5. In the long run the technology should be transferable to other locations throughout Indonesia for early warning purposes

For the testing phase it was planned to place the master control at PUSDALOPS and to install two speaker units on a mosque and on an amateur radio tower (RAPI Padang office/close to beach). The system was designed in a way that access points can also act as repeater stations if the original signal from master control can not be received. This allows the establishment of a decentralized network with redundancies and the option of easy extension. The trigger signal is a DTMF tone for which a dedicated frequency will be blocked. The inventors saw Rabab as an addition to FM-RDS since up to date FM-RDS input is solely distributed by BMG Jakarta. With the Rabab system one can distribute BMG warning messages as well as locally generated information and instructions which makes the device more versatile.




Graphic 12: Rabab access points can also act as repeater stations. That makes the system easily extendable.

A concern of the inventors was maintenance of the system. That is why they aimed at installing a number of units on private radio towers since the members of RAPI and ORARI understand the technology and its requirements. The downside was that private radio towers are not equipped with loudspeakers and sirens which will have to be purchased.

Telkomsel committed itself to support the initiative as well. They allow the use of their towers to install equipment as long as it doesn't interfere with their own operations. Since the towers are strong, powerful speakers can be installed and UPS is also not an issue.
One Rabab unit will cost about 5 Mio. IDR.
However the members of the Padang working group found out that a very similar system is already in use in Bantul, D.I. Yogyakarta. Now the Padang working group considers the implementation of the Bantul system in their own city.

# Examples of Early Warning Measures from other Countries

## *Bangladesh*

Bangladesh is threatened by cyclones on a regular basis. These storms pose a serious danger to low lying areas. Since 1775 an estimated 775.000 people have died in the countries coastal flats and offshore islands due to an inadequate early warning and preparedness system.

After a major cyclone catastrophe in 1970 Bangladesh has continuously improved its Cyclone Preparedness Programme (CCP) and early warning system with mounting success. When another big cyclone struck in 1997 a million people were evacuated - casualties could be limited to 193.

The current early warning system focuses on the use of an advanced weather forecast and cyclone detection system. Cyclone warnings are frequently issued to communities and vulnerable citizens through radio and television. Local alerting is carried out through trained CPP volunteers on bicycles with mounted loudspeakers, fixed loudspeakers and through the utilization of the local mosque speaker infrastructure. .

Presently, the CPP covers 11 districts reaching about eight million people through more than 140 wireless stations.

More than 1600 cyclone shelters have been built to accommodate 1.3 million people, with a further 2.3 million people taking refuge in school and office buildings – and these measures are still considered a minimum since more than 15 million people are potentially at risk.

Cyclone reports are issued through High-Frequency Radio Stations operated by volunteers along the coast. More than 35,000 trained volunteers are ultimately notified to take action in local villages using megaphones and hand-cranked sirens.

The coordinated dissemination and response system under the Ministry of Food and Disaster Management is triggered by warnings issued by a forecasting centre operated by the Bangladesh Meteorological Department. The early warning response involves local administrations, port authorities, the armed forces, the Disaster Management Bureau, the Directorate of Relief and Rehabilitation, other responsible ministries and departments, as well as the CPP and Bangladesh Red Crescent Society[34].

Indonesia could learn from Bangladesh especially in the areas of community activation and motivation as well as low cost notification devices like bicycle mounted loudspeakers and hand cranked sirens.

[34] UNESCO (2006): Tsunami Teacher. p. 318

## India’s Village Knowledge Centers

Since 1992, the MS Swaminathan Research Foundation has been working in Tamil Nadu and Pondicherry to establish Village Knowledge Centers (VKC) as focal points for the provision of information and knowledge to villagers on various issues such as fish movement, height of waves, weather forecasts, health, education, agriculture and other community activities.

The VKCs provide resources such as computers, printers, telephones, high-frequency radio services, internet access and other communication devices, for villagers to use. Training is provided on basic skills such as operating computers, dissemination of local information to other centers, and transfer of voice from the hub to a Public Address System. Every interested villager may participate and use the technology to build and share knowledge.

An example of how technology is building capacity and empowerment at the community level was provided by the 2004 Indian Ocean tsunami.

In Verampattinam village in Tamil Nadu, fishermen who noticed abnormal sea behaviour ran to the Village Knowledge Centre, broke the lock on the door, and without delay used the Public Address System to warn everyone to evacuate and run from the sea. Only five people died from the tsunami. The actions by the fishermen, and the ability to broadcast information through the VKC, were credited for saving many lives.

Information hubs or focal centers linking three to four villages along the coast of Tamil Nadu are now being established to achieve greater awareness for disaster preparedness among community members. The initiative is an excellent example of how technology and access to information can make life saver in the face of natural hazards like tsunamis[35].

## High Tech in Japan

Japan got a very advanced tsunami early warning system that makes use of satellites, deep sea sensors, buoys etc. The Japanese system is specialized in near off-shore tsunami events. Its goal is to broadcast tsunami warnings less than three minutes from the actual sensing of an earthquake. Warning messages are disseminated from the observatories through the Local Automatic Data Editing and Switching System (L-ADESS) to relevant government agencies and the prefectures (cities, towns). The prefectures submit the warnings to the local governments for action. On the national level the Central Emergency Communications Network (CEMCN) links ministries and agencies. Members of CEMNC include bodies like Tokyo Electric Power and the Nippon Broadcasting Cooperation. Japan is using a wide range of local notification methods:

SAWS (Simultaneous Announcement Wireless System) is a system of transmitters and receivers installed by communities for all types of messages. Transmitters are

[35] UNESCO (2006): Tsunami Teacher. p. 324

installed at local government offices, receivers in public places like hospitals, schools, fire stations, emergency management agencies and other locations. Receivers connected to loudspeakers are also mounted on tall buildings and along busy streets. People can purchase private receivers which activate themselves automatically when a message like a tsunami warning bulletin is coming through.  Special receivers can be connected to the telephone. When they receive a signal they activate the loudspeaker and the SAWS message can be heard. SAWS is known as tone alert radio in the USA and Canada.

Mobile announcement systems are used where SAWS is not applicable. The public receives information through loudspeakers which are mounted to fire trucks.

Television and radio stations in Japan are obliged to broadcast tsunami early warning information just like in Indonesia. Stations receive tsunami bulletins from the main and regional observatories through ADESS. On TV the message consists either of a subtitle running on the bottom of the screen or a window displaying a map where the warning applies. However a map can not be shown in the case of a local tsunami.

The use of sirens and bells is also common in Japan. The sounds are a signal to turn to radios or TV sets for further information.

Some communities have formed telephone networks to spread important information. In some communities, the only way to inform people is going from house to house. Both methods are time consuming but considered necessary to reach populations that lack other systems.

Even though the Japanese early warning system is very advanced it doesn’t just stop there. Strict building laws protect against tsunamis and earthquakes. Hundreds of tsunami and earthquake resistant shelters have been built in endangered regions. Some towns have build seawalls or floodgates to protect themselves.

Tsunami awareness became part of the Japanese culture. Most coastal communities conduct extensive trainings on a regular basis.  Most Japanese are so ‘tsunami ready’ that evacuations, even at night, are often carried out in record speed[36].

[36] Anderson, Peter (2006): BC Tsunami Warning Methods ‘A toolkit for community planning’, Burnaby

Appendix I

## <u>Table of Early Warning Dissemination Technologies</u>

| Technology | Direction of Communication | Audience | Availability | Independence from public power supply[37] | Speed | Durability | Maintenance | 24/7 | Purpose | Communication Type | Range | Level of Technology | Reception | mobility | Knowledge to Operate | Multipurpose | Trigger | Price | Comment |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Community FM Radio | ↑ | | available in some places | X | ○○○ | ○○ | ○○ | depends on staff availability | ! i | | 20-30 km | ○○○ | | X | ○○○ | ✓ | | starts at 3500 USD | great device for the dissemination of warning messages, evacuation orders and disaster management, best in combination with sirens to indicate public to tune into radio programme, multi purpose |
| E-mail | ↕ | | widely available and in use | X | ○○○ | ○○ | ○○ | ✓ | i | | worldwide | ○○○ | | X | ○○ | ✓ | | ○ | only complementary |
| Flags | ↑ | | need to be installed | ✓ | ○ | ○○○ | ○ | for daytime use only | ! | | | ○ | | X | ○ | X | | ○ | only make sense where many people gather like e.g. on beaches |
| FM RDS | ↑ | | will be introduced in the near future, general availability targeted | ✓ | ○○○ | ○○○ | ○ | ✓ | ! i | | medium - within range of FM RDS transmitter | ○○○ | | ✓ | ○○ | ✓ | | ca. 70 USD for receiver | requires installation of FM RDS transmitter with UPS, FM is line of sight technology so signal can be obstructed by physical obstacles like massive buildings or mountains |
| GMDSS | ↕ | | on all SOLAS class vessels | ✓ | ○○○ | ○○○ | ○○ | ✓ | ! i | | worldwide | ○○○ | | ✓ | ○○ | ✓ | | ? | utilization for early warning on local level still under discussion |

37 Some devices can be run on solar or battery power. Please refer to relevant chapter.

| | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **HF Radio** | | | usually available at police, fire and some government institutions, harbors, airports etc. | X | | | | ✓ | | | very long range | | | X | | ✓ | | starts at 2000 USD | very useful for long range communication, can replace e-mail if messages are kept simple due to low bandwidth |
| **Kentongan** | | | available in some places like poskos | ✓ | | | | ✓ | | | very limited range | | | X | | X | | | not hoax proof, trigger difficult since it requires communication and 24/7 readiness |
| **Kites** | | | only useful if wind is right | ✓ | | | | for daytime use only | | | | | | ✓ | | X | | | kites are a very unreliable early warning tool since they depend on wind and they require some skill to rise |
| **Mobile Phone** | | | widely available and in use | ✓ | | | | ✓ | | | almost worldwide but limited in remote areas | | | ✓ | | ✓ | | | not recommended for tsunami early warning due to high vulnerability of GSM network to overload and earthquakes |
| **RANET** | | | receivers need to be purchased, not quite clear where (BMG?) | X | | | | ✓ | | | Very long range | | | X | | ✓ | | | very useful for early warning purposes since wide range of data can be submitted, ideal for interface institutions, totally independent from conventional communications infrastructure, can be interfaced with FM RDS and 5 in 1 technology |
| **Signs** | | | need to be installed | ✓ | - | | | ✓ | | | | | | X | | X | | | signs can be used to indicate evacuation routes or for tsunami warning - in that case activation device is required (electricity needed?), might be subject to vandalism |
| **Signs (Electronic)** | | | available in some places like toll roads | X | | | | ✓ | | | | | | X ✓ | | ✓ | | | messages can be managed from a remote location, signs can be mounted on trailer and installed where needed |

| | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Sirens (fixed)** | ↑ | | needs to be installed in most places | X | ○○○ | ○○○ | ○○ | ✓ | ! i[38] | | medium area of coverage | ○○○ | | X | ○ | X | ● | ○○○ | widely recognized and accepted as alerting device, testing could be irritating to public, some sirens come with voice broadcasting function, sound sensitive to sensitive to high winds and structural barriers |
| **Sirens (mobile)** | ↑ | | on most police, fire and ambulance cars | ✓ | ○○ | ○○○ | ○○ | depends on staff availability | ! i[39] | | medium area of coverage, | ○○ | | ✓ | ○ | X | ● | medium | high flexibility makes it very useful early warning device especially in combination with voice broadcasting, limited usefulness if traffic infrastructure damaged or choked, sensitive to high winds and structural barriers, can be deployed where needed most |
| **SMS** | ↑ | | widely available and in use | ✓ | ○○○ | ○○ | ○○ | ✓ | ! i | | almost worldwide | ○○○ | | ✓ | ○○ | ✓ | | range widely | not 100 % reliable due to vulnerability of GMS transmitters to earthquakes, mobile phone networks tend to break down during emergency due to overload, not hoax proof, limited or no signal in remote areas |
| **Telephone** | ↑ (prerecorded messages) | | widely available and in use | X | ○ | ○○ | ○○ | ✓ | ! i | | worldwide | ○○ | | X | ○○ | ✓ | | range widely, start at 2000 USD | sensible to earthquakes, to serve large populations take time |
| **VHF Radio** | ↕ | | widely available | ✓ | ○○○ | ○○○ | ○ | ✓ | ! i | | ~ 5 km - much further if repeater station in range | ○○ | | ✓ | ○○ | ✓ | ● | starts at 50 USD | can be on standby on a 24/7 basis, can easily be carried around, major communications device during disasters, for repeater station UPS is required, widely used by police, fire brigades etc. , users have to register with RAPI, ORARI |
| **Websites** | ↑ | | widely available and in use | X | ○○ | ○○ | ○○ | ✓ | i | | worldwide | ○○○ | | X | ○○ | ✓ | | low | only complementary |

[38] If voice function
[39] If voice function

## Legend Appendix I

| | | |
|---|---|---|
| **Direction of Communication** | | one way |
| | | two way |
| **Audience** | | representatives |
| | | selected public |
| | | general public |
| **Independence from public power supply** | | not independent |
| | | independent |
| **Speed/Durability/ Maintainance/Level of Technology/Knowledge to Operate/Price** | | low |
| | | medium |
| | | high |
| **24/7** | | available 24/7 |
| **Trigger** | | direct trigger |
| | | remote trigger |

| | | |
|---|---|---|
| **Purpose** | | for alarming purpose only |
| | | can carry additional information |
| **Communication type** | | audio |
| | | visual |
| **Range** | | line of sight |
| **Reception** | | inside |
| | | outside |
| **Mobility** | | mobile |
| | | not mobile |
| **Multi Purpose** | | yes |
| | | no |

## Appendix II

Table of Early Warning Technologies in Padang*

| Technology | Direction of Communication | Audience | Availability | Availability during power loss | Speed | Overload save | 24/7 | Comment |
|---|---|---|---|---|---|---|---|---|
| **FAX** | | | | | | | x* | very slow, reliable on power |
| **Flares** | | | | | | | x | Service offered by TNI but no SOP's yet |
| **FM RDS** | | | | | | | x | testing in Padang |
| **HP** | | | | | | | x | Experience shows that voice communication via hp in emergency situations is unreliable and not an option. No plans for hp voice notification in Padang. |
| **Radio (Local)** | | | | | | | x** | Needs 24/7 attendance and power back up. Only useful if people are tuned into radio. No SOP's yet. |
| **RANET** | | | | | | | x | RANET needs a power back up to be 100 % reliable. Currently only available at PUSDALOPS and SATLAK. |
| **Sirens** | | | | | | | x | One BMG siren is already installed in Padang. It is triggered through BMG Jakarta. So far no SOP's for use and intended reaction of community are developed. A government team is currently surveying locations for additional sirens. PT. Telkom agrees to install sirens on its towers. 7 new sirens will be installed by the end of 2007. |
| **SMS** | | | | | | | x | RANET at PUSDALOPS is equipped with modem server with SMS sending capability. System has not been tested. Price is an issue: Telkomsel is willing to provide 2000 SM/month for free. Mobile phone networks tend to break down in emergency situation because of overload. Infrastructure is very vulnerable to earthquakes. Telkomsel guarantees power and delivery within Padang city. They have UPS. |
| **Speakers (Mobile)** | | | | | | | x*** | Mobile speakers are fixed to fire and police cars. PUSDALOPS receives reliable 24/7 early warning info through BMG (RANET) and can notify police via VHF radio. No SOP's yet. |
| **Speakers (mosque)** | | | | | | | x*** | A letter from the government is needed to utilize mosque speakers, power back up for mosque is essential, communication with mosque unclear, use of FM RDS is an option, no SOPs, Rabab system is an option |
| **Telephone** | | | | | | | x | very limited calling capacity if time is scarce, might be affected by breakdown of communication systems after earthquake |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **TV (local)** | → | | ✓ | | ●● | ✓ | x** | Very vulnerable to power outages, INDOSIAR got UPS and needs about 1 minute to start |
| **TV (RI)** | → | | ✓ | | ●● | ✓ | x** | Warning bulletins from BMG are broadcasted via national TV. Can not be utilized for local messaging. Very vulnerable to power outages. |
| **VHF Radio** | ↔ | | ✓ | ↗ | ●●● | ✓ | x | PUSDALOPS members are obliged to operate VHF radio sets. VHF is one of the most reliable emergency communication devices for short distance communication. |

*according to GITEWS Workshop, Padang 10.09.07

## Legend Appendix II

**Direction of Communication:**

↔ two way

→ one way

**Audience:**

Representatives

Selected Public

General Public

**Availability:**

✓ ready to use

available but not ready

coming up

**Availability during power loss:**

↗ unaffected

limited

not available

**Overload save:**

✗ unsafe

✓ safe

**Speed:**

● low

●● medium

●●● high

**24/7:**

*= no alert signal

**= not always in use

***= depends on arrangement

## Abbreviations

| | |
|---|---|
| BAKORNAS | National Natural Disaster Management Coordinating Board |
| BMG | Badan Meteorologi dan Geofisika<br>National Federal Geological and Meteorological Survey |
| DEPDAGRI | Department of Home Affaires |
| DEPKOMINFO | Department of Communication and Information Technologies |
| GITEWS | German Indonesian Tsunami Early Warning System |
| GTZ IS | German Technical Cooperation – International Services |
| IDR | Indonesian Rupia |
| RRI | Radio Republik Indonesia |
| RSC | Regional Seismic Centers |
| SAR | Search and Rescue |
| SMS | Short Message Service |
| SOP | Standard Operational Procedure |
| TNI | Tentara National Indonesia<br>Indonesian Armed Forces |
| UPS | Uninterruptible Power Supply |
| VKC | Village Knowledge Centers |
| WIB | Waktu Indonesia Barat<br>Western Indonesia Standard Time |

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