Guidebook

Dissemination of Tsunami Early Warning at the Local Level in Indonesia

gtz | IS International Services

GITEWS

The GTZ IS (German Technical Cooperation – International Services) project "Capacity Building in Local Communities" is part of the German-Indonesian Cooperation for a Tsunami Early Warning System (GITEWS). Jointly with its partners at national level and in the GITEWS Pilot Areas of Bali, Java and Padang, the pilot project accompanied the implementation of the Indonesian Tsunami Early Warning System (InaTEWS) from 2006 to 2010 and developed various tools that help coastal communities to link effectively to the warning system and prepare for tsunamis. The TSUNAMIKit presents the project's products. It can be accessed at: www.gitews.org/tsunami-kit. Links in this document refer the reader to specific content of the kit.

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2010

German-Indonesian Cooperation for a
Tsunami Early Warning System (GITEWS)
Capacity Building in Local Communities

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Preface

The term the "last mile" is often associated with the dissemination of tsunami early warning to the communities living in the risk areas. It is usually perceived as a purely technical problem due to the fact that a huge area must be covered in a short time and often under adverse conditions following strong earthquakes. Indeed, the question of viable early warning dissemination technologies for the "last mile" still remains a major challenge. Nevertheless, it must be addressed in close relation to the development of adequate warning dissemination procedures and the strengthening of the necessary capacities of the individuals, communities and institutions involved.

A good and complete understanding of the overall set up of InaTEWS, the time line, the warning scheme and how warnings are being distributed is needed by all actors who are involved in the development of the local warning dissemination mechanism. Providing warnings to the ones at risk in a fast and reliable way must be the bottom line for all such efforts.

There is no universal blueprint. There are many ways that can be used to disseminate early warning - from traditional techniques that are still utilised by the rural communities, such as the *kentongan* (wooden slit drum), to modern electronic gadgets, such as mobile phone texting (SMS) and Internet. Tailor-made solutions are required, taking into account the specific needs of the community and the communication networks and technologies that are already in place and can be further developed. No dissemination technology is fail proof; therefore it is vital to establish more than only one communication line for warning purposes. When deciding to set up extra technology for warning dissemination, always make sure that it can be used for other purposes as well and will be utilised on a regular basis. This does not only reduce costs, but also increases the likelihood that the technology will be properly maintained and will work when it is really needed.

This reader is dedicated to all who are involved in designing or implementing local tsunami warning mechanisms. It provides an introduction into methods and technologies for the dissemination of tsunami early warning at the local level. Except for a short overview about warning dissemination methods in general, this document focuses on the specific challenges, requirements and options for early warning dissemination technologies that are related to near-field tsunamis and the Indonesian context. A short description about the warning dissemination process and technologies applied by the National Tsunami Warning Center (NTWC) helps to set the stage for the main issue of the document: an overview about technologies, which can be applied to disseminate tsunami early warning on the "last mile" and some related background information to help evaluate whether a certain technology is appropriate and fits the specific situation in your community.

Introduction into Warning Disemination Methods

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

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 organisational preconditions for successful and efficient early warning.

There are many factors and questions that must be considered before setting up a warning dissemination system. Key factors and questions are:

- who needs to be informed
- how many people should be covered by the system
- where are recipients located
- what are they doing at what time of the day/night
- what kind of season do the people have (e.g. fishing, harvesting, tourist season)
- what specific needs do recipients have
- how fast the warning message must reach the target
- what technologies are already available
- do people have access to TV and radio
- what happens in the case of an electric power failure
- how to maintain and upgrade new technologies

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, as is their optimal utilisation. Coverage, as well as message design, is of the essence. The outcome should meet the following criteria:

Table 1: Important Characteristics of Warning Dissemination Systems

Criteria	Characteristics
Reliability	- Redundancy - Security - Availability in the absence of power - Always operational and ready to warn - Fast transmission with assured delivery and confirmation - Easy to operate in normal, as well as stressful, situations - SOP's for operation are in place and understood by relevant stakeholders
Coverage	- Reaches all people within a risk area - Easy to expand in case a larger warning area needs to be covered - Accessible to people with special needs (specific language requirements, disabled)
Message features	*Security & Reliability* - Enables only authorised persons to insert a message - Hoax proof *Content* - Message content follows official rules and is explicit - Message terminology is clearly understood by recipients - Provides means for obtaining additional information - Messages are geographically specific - Warnings must be specific about the nature of the threat and its impact *Structure* - Message structure is standardised and officially communicated - Recipients should be familiar with message structures and varieties (e.g. Advisories, Warnings, All Clear messages)
Other points to consider	- Supports multiple distribution technologies (e.g., sirens, radio, TV, phones, Internet-based social networks, FM-RDS, etc.) - Supports strategies for evacuation, response and recovery plans - Applies to multiple types of hazards - Does not put message provider or recipients at risk - Cost effective - Easy to maintain - Optimal utilisation of pre-existing infrastructure - Clear and concise SOP's for the creation and dissemination of early warning messages are available

Source and modified from: British Columbia Tsunami Warning Methods – a Toolkit for Community Planning

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

Warning messages can be distributed to the public in general or to specific locations (such as beaches and certain parts of town) or specific target groups (e.g., all hospitals, markets, hotels, public schools, mosques).

Some dissemination technologies have capabilities to confirm that a message has been received; others offer means for two-way communication. 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

Alerts and Messages

Public warning announcements should consist of two essential components: alerts and messages with instructions.

Alerts
demand attention and alarm people

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

	Objectives & Characteristics	Possible Means of Dissemination
Alert	- interrupts people from whatever they are doing - demands attention - can be received at any time of day or night - can signal people to tune into local television or radio stations for further information / guidance - is simple, e.g., wailing siren tone - cannot carry complicated content - can be delivered audibly, visually, physically (e.g., through vibrating devices)	- siren - horn - bell - *kentongan* - loudspeaker
Message	***provides information about:*** - what happens - when - severity of hazard - likeliness of occurrence of hazard - need for action - can be delivered audibly or visually	- TV - Local Radio Stations - Loudspeakers - Fax - SMS - IBSN - Blackberry Messenger - WRS - RANET - FM-ROS

Source and modified from: British Columbia Tsunami Warning Methods – a Toolkit for Community Planning

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

Outdoor and Indoor Warning Methods

Different audiences can be addressed through indoor and outdoor warning messages. The majority of reliable outdoor warning methods are 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 has its specific limitations and strengths that need to be taken into consideration.

Outdoor Warning Systems

The most commonly used general mass outdoor notification device is the siren. It can reach large segments of the population. Although they are formidable alerting devices, sirens are usually not geared to deliver messages. For their successful use it is crucial that the warning sound is clearly audible to the recipients and the listener is already informed about the message/meaning of the tone. Another common outdoor warning device is a fixed or mobile loudspeaker. In the case that loudspeakers transmit siren sounds, alerts and messages can be put on the air by the same device.

Indoor Warning Systems

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

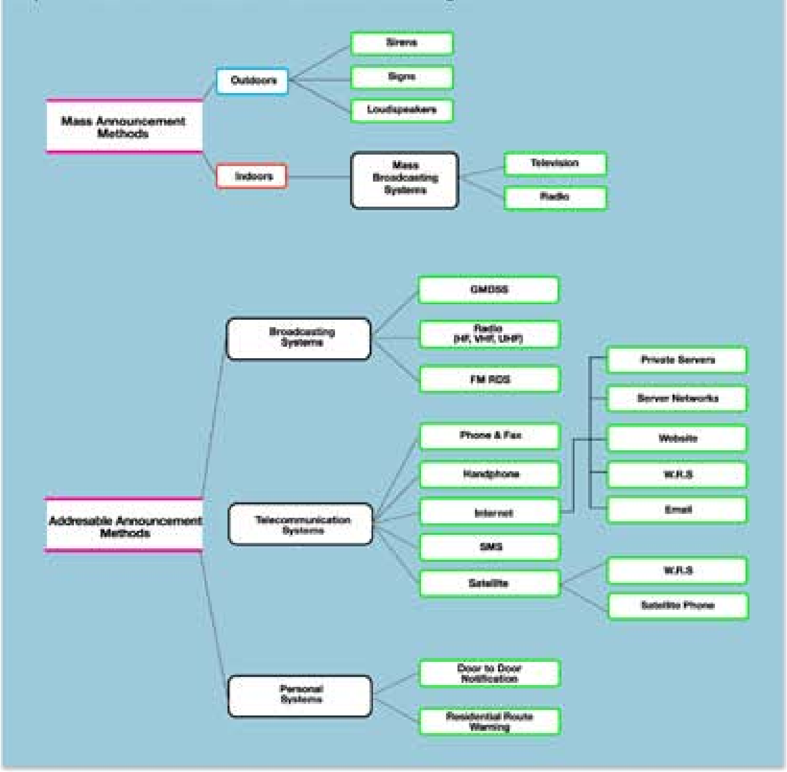
- capable of penetrating inside spaces
- widespread enough to ensure that they can reach any space where people are residing
- sufficiently disruptive to capture undivided attention
- capable of disseminating messages at any time of day or night
- preferably independent from external electrical power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

Most indoor warning devices, 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. In the event of a warning, depending upon the kind of activity people are engaged in, it may be necessary to use different methods that cater to different senses (e.g., 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, while others support two-way, or interactive, messaging (e.g., telephones or HF-radio). These features become important when an action, such as a confirmation of the reception of the warning message by 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 (mass) dissemination methods have less specific targets and are mainly represented by the mass media, while specific (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 reaches the target groups, a mixture between general and specific warning methods should be considered. 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 graph gives an overview of mass and addressable notification methods:

Graphic 1: Mass and Addressable Announcement 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 reaction. Looking at general warning dissemination methods, sirens will alert people more quickly than radio, television or, for example, internet websites. When it comes to specific dissemination methods, WRS, FM RDS, RANET and two-way-radio group calls will reach target groups more quickly than e-mails, fixed or mobile address systems, fax, or door-to-door notification.


BMG

The National Tsunami Warning Centre at BMKG sends out earthquake information or a first tsunami warning and advice to TV and radio stations and to local authorities five minutes after an earthquake occurs.

Understanding the Warning Dissemination Process and Distribution by BMKG

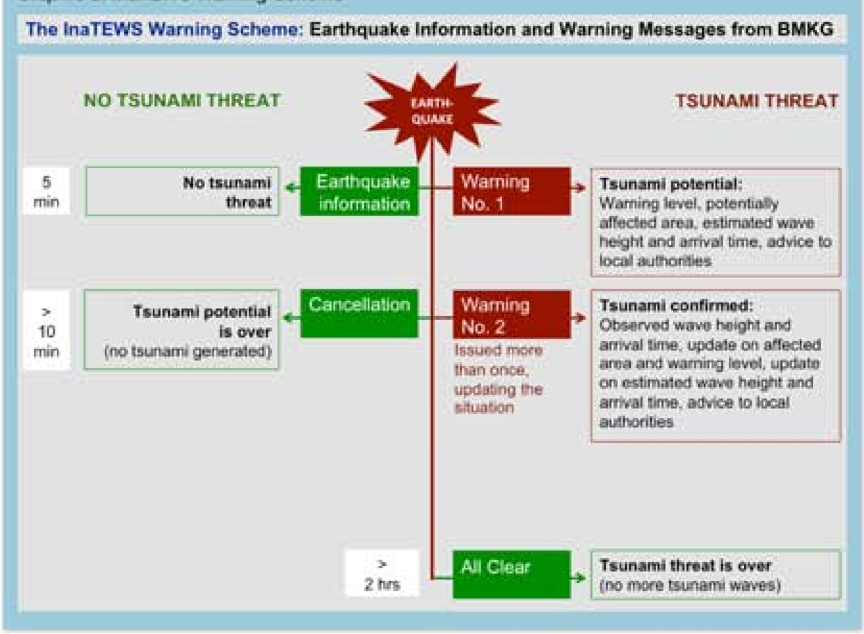
Badan Meteorologi Klimatologi dan Geofisika - National Agency of Meteorology, Climatology, and Geophysics (BMKG) operates the National Tsunami Warning Center (NTWC) in Indonesia and is the only appointed official institution responsible to generate tsunami warnings. Besides issuing tsunami warnings, BMKG also provides information on meteorological, climatological and geophysical issues (weather, climate, earthquake, air quality).

Using multiple communication channels (so-called "6 in 1"), BMKG produces and sends tsunami warnings from its Warning Center in Jakarta to "Interface Institutions" (the media, local governments, BNPB, police, army, emergency operation centers, and other national institutions, etc.). BMKG warning messages are also accessible by the general public via the public media, BMKG website, or social networks (Facebook, Twitter).

The BMKG Tsunami Early Warning Scheme

BMKG provides earthquake information and tsunami warning messages according to the following scheme:

Graphic 2: InaTEWS Warning Scheme



All earthquake information and warnings are distributed by six different channels at the BMKG Warning Center. Earthquake information or warning messages will be distributed only when the earthquake has a magnitude of more than 5 SR. Earthquake information for smaller events is displayed on the BMKG website.

Warning Message Formats

Information and warning messages are provided in three different formats: Short Text (SMS), Long Text (fax, e-mail, and GTS), and long media format (web and WRS)

Short Text Format

Short text format in the form of an SMS allows only a limited number of characters (160 characters):

> TEST! Major Tsunami Warning in LAMPUNG, Tsunami Warning in JABAR, Advisory in BALI, Eq Mag:7.5RS, 02-Sep-09 07:55:01 UTC, Loc:8.26S/107.22E, Dep:51km::BMKG

> TEST! Warning Tsunami: Awas di LAMPUNG, Siaga di JABAR, Waspada di BALI, Gempa Mag:7.5SR, 02-Sep-09 14:55:01 WIB, Lok:8.26LS/107.22BT, Kdlmn:51km::BMKG

Long Text Format

Long text format messages contain more detailed information and are disseminated by e-mail , fax and GTS:

Graphic 3: Long Format Text Message

The header indicates the **information source**: BMKG as the warning provider of InaTEWS.

The second component gives the **earthquake parameters**.

The **evaluation** section assesses the tsunami threat and provides information on **affected areas**. The respective **warning level**, the **estimated wave height** and the **estimated arrival time** of the tsunami.

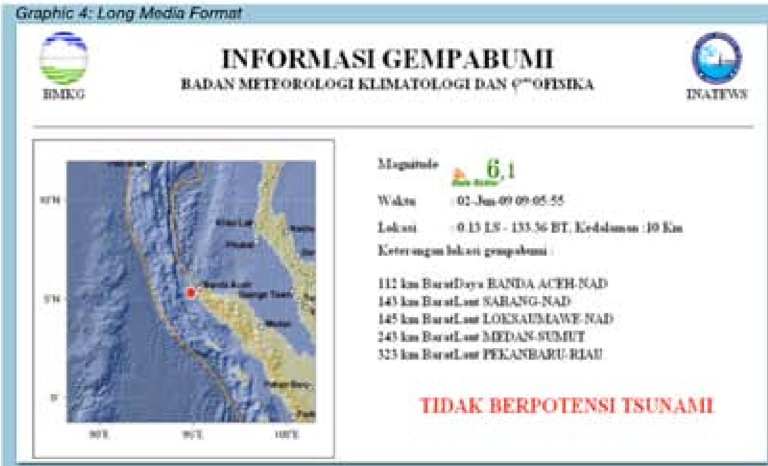
The **advice** section gives recommendations to local governments on how to react to the tsunami threat.

```
:::::::BMKG::::::::::!!TEST!!::::::::::BMKG::::::::::!!TEST!!::::::::::BMKG::::

        Indonesian Tsunami Early Warning System (InaTEWS)
    Address: Jl. Angkasa I no.2 Kemayoran, Jakarta, Indonesia, 10720
    Tel.: (+62-21) 4246321/6546316, Fax: (+62-21) 6546316/4246703
           P.O. Box 3540 Jkt, Website: http://www.bmg.go.id
--------------------------------------------------------------------------
               Issued date: 02-Sep-2009, 08:10:23 UTC
             (Message No. 3 related to this earthquake)

Bulletin No. 2

AN EARTHQUAKE HAS OCCURRED WITH THESE PRELIMINARY PARAMETERS:

Magnitude   : 7.5 RS
Date        : 02-Sep-2009
Origin Time: 07:55:01 UTC
Latitude    : 8.26 S
Longitude   : 107.22 E
Depth       : 51 Km

Location    : Java, Indonesia
Remarks     : 120 km SOUTHWEST of Banjar
              138 km SOUTHWEST of Tarogong
              145 km SOUTHWEST of Sorreang

Evaluation:

THERE IS THE POSSIBILITY OF A TSUNAMI IN THE FOLLOWING AREAS:
--------------------------------------------------------------------------
Province  Warning Segment                    Warning Level  ETA (UTC) EWH
--------------------------------------------------------------------------
LAMPUNG   Kota-Bandar-Lampung Pantai-Panja.  MAJOR WARNING  12:19:53   2.8m
BENGKULU  Bengkulu-Utara S                   MAJOR WARNING  12:15:54  13.5m
BENGKULU  Bengkulu-Utara U                   MAJOR WARNING  12:34:52   4.0m
BENGKULU  Kaur                               ADVISORY       12:10:28   0.4m
LAMPUNG   Kota-Bandar-Lampung                MAJOR WARNING  12:10:28   4.4m

--------------------------------------------------------------------------

ACTUAL ARRIVAL TIMES AND WAVE HEIGHTS MAY DIFFER AND THE INITIAL WAVE
MAY NOT BE THE LARGEST.

Advice:

Province/District/City governments that are at "Major Warning" level are
expected to pay attention to this warning and immediately guide their
communities for full evacuation.

Province/District/City governments that are at "Warning" level are expected
to pay attention to this warning and immediately guide their communities
for evacuation.

Province/District/City governments that are at "Advisory" level are
expected to pay attention to this warning and immediately guide their
communities to move away from the beach and river banks.

:::::::BMKG::::::::::!!TEST!!::::::::::BMKG::::::::::!!TEST!!::::::::::BMKG::::
```

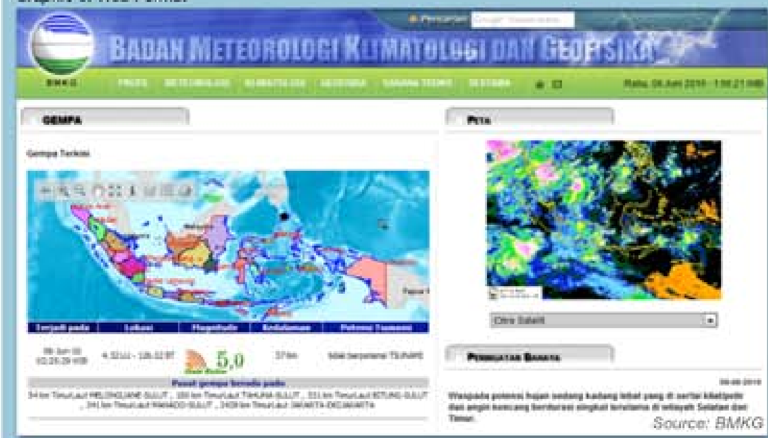
Long Media Format

Long media format is used for screen display purposes. It has a graphical user interface, which allows the user to interact with the program. The web format is used for the BMKG website and WRS (including television):

Graphic 4: Long Media Format



Graphic 5: Web Format

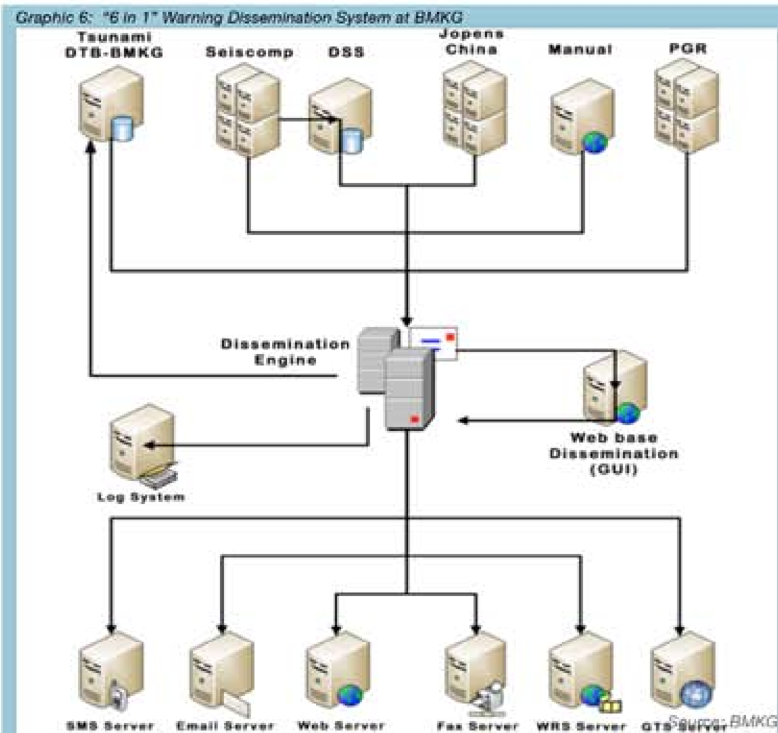


Source: BMKG

BMKG Warning Distribution Channels

Currently, BMKG uses six channels (SMS, e-mail, Internet, fax, WRS, GTS) to disseminate warnings. For each channel, a server is installed at the NTWC:

Graphic 6: "6 in 1" Warning Dissemination System at BMKG



Source: BMKG

SMS

Short text format messages are transmitted via SMS. Generally, it is a quick and reliable way to disseminate information as users receive it directly on their hand phones. Nevertheless, SMS delivery may suffer considerable delays during emergency situations due to network overload or break down. The SMS gateways are located at BMKG and at the SMS provider. BMKG disseminates information on earthquakes, weather, climate, and air quality via SMS. Tsunami warnings are provided as a special service to inform people who are involved in disaster management and decision-making at national and local levels (governors, *bupati*, *walikota*, police, army, warning centers, experts, and others) reagrding all occurring earthquakes (magnitude more than 5 SR) and tsunami threats.

The BMKG SMS service works as a auto-sending/ push service: earthquake information and tsunami warnings are sent to users who have registered their mobile numbers in the BMKG database. Currently, more than 1,700 numbers are registered. Important note: not everyone may register their phone number with the BMKG and further subscription is limited.

In the past BMKG also offered an auto-response service where users could request information by sending a predefined keyword to BMKG using 2303 access code. This service is suspended and there are currently no plans to reactivate it again.

SMS at a glance

Usually fast - but considerable delays during network overload. Network infrastructure is vulnerable to earthquakes

Pre-registration of phone number is necessary. Number of subscription is limited

Personally recived and targeted to specific groups - but geographically targeted delivery is difficult

Easy to multiply (using copy paste and sms forwarding)

Provides short, relevant and easy to understand information in a written form

Limited number of characters for message text

E-mail

The e-mail server works in the same way like the SMS server, but uses a different media. In the event of stronger earthquakes (> 5 SR) and tsunami threats, the BMKG warning dissemination system will produce a warning message using the long text format and send it to the registered e-mail addresses. Target groups are the people who are involved in disaster management and decision-makers at national and local levels (governors, *bupati*, *walikota*, police, army, warning centers, experts, and others). Local governments and emergency operation center can subscribe the BMKG e-mail service.

Email at a glance

Unlimited number of recipients,can easily be forwarded

Easy to ungerstand as in a written form, can be printed

Dependent on Internet access and power supply, wich is might be interrupted during emergencies

Own e-mail account and pre-registration is required

Usually people do not have constant access to e-mails

Fax

Long text format messages for earthquakes and tsunami threats are also distributed via facsimile. The target group is much smaller than SMS and e-mail, and comprises people who are involved in disaster management and decision-making at national and local levels.

Fax at a glance

Slow and dependent on land-line communication network, wich might be down after an earthquake.

Fax receiver requiers power back-up, needs to be in stand-by mode and supplied with papper

Pre-registration of phone number is necessary. Limited capacities at BMKG fax server

Targeted to specific groups

Provides easy to understand information in a written form

Unlimited number of characters for message text

Web a glance

Open access and unlimited number of recipients

Interactive media prividing written and visual information (text messages, maps). Provides detaled information and updates on alert status

Dependent on Internet access and power supply, wich might he interrupted during emergencies

Usually people don't have contant access to the Internet

Web

BMKG provides a website using a web server where the public may have access to information on earthquake events and tsunami threats (**www.bmkg.go.id**). Besides that, people may also have access to other information and disaster warnings, such as weather forecasting, waves, floods, etc.

Graphic 7: BMKG Website Screenshot

Source: BMKG

Warning Receiver System - WRS

The WRS server is used to distribute earthquake information and warning messages to registered WRS clients (the media, local governments, BNPB, police, army, emergency operation centers, and other national institutions, private companies, etc.). All local PUSDALOPS are expected to have WRS installed in their warning center. WRS actually is software specially designed by BMKG for tsunami early warning. A client must have a personal computer with a continuous Internet line or a satellite connection system to the BMKG WRS server. More detailed information about WRS will be presented in Chapter 4.

Global Telecommunication System - GTS

This is not a public server. The main function of the GTS server is to send information to and communicate with other members of the World Meteorological Organisation (WMO). BMKG is a member of WMO.

Warning Receiver System (WRS)

Connection via Internet

Access to Internet is easy to acquire and subscription fees are moderate. Can be used for multiple purposes

Easy to set-up and maintain. Technical problems can be handled by local technicians

Internet access and power supply might be interrupted during emergencies

Usually connection speed is not stable and can be very slow in certain circumstances

Vulnerable to computer virus attacks

WRS stands for Warning Receiver System and is one of the dissemination tools used by InaTEWS. It is a web-based information system that enables the exchange of information between a server and clients. The WRS computer software was developed by BMKG and sends earthquake and tsunami warning information from the server at BMKG to the WRS clients in the interface institutions (police, military, television stations, radio station, and others). It is designed to serve as the principal channel between the NTWC at BMKG and local interface institutions (BPBD / PUSDALOPS). Once new information comes in at the client computer, a loud audio signal is released to catch the users' attention. In some interface institutions WRS clients are equipped with a mechanism to forward the incoming information directly via SMS and fax to other recipients.

Getting started for WRS

The client must have a computer that is connected to a reliable 24/7 Internet provider and the respective software. The internet connection can be via normal leased line, wireless or by satellite. The hardware specifications are not different from the ones for any normal computer workstation. For the leased line or wireless Internet connection, an IP public address is needed. Contact your internet service provider for your IP public address number.

Connection via DVB

Connection is one-way and only downstream

Special knowledge for set-up, and regular checks and mantenance are required

Local specific technical problems

The position of the antenna is very critical as it may be displaced during an earthquake, leading to connection failure

BMKG also uses the DVB (Digital Video Broadcasting) system to distribute the WRS data in half-duplex mode (one-way direction) via satellite. A small parabolic disc antenna receiver will catch the signal and it will be decoded by the computer. Please remember that the antenna should be placed outside of the building, facing the satellite and there should not be any obstacles between the antenna and the satellite. The position of the antenna must be solid and tightened. Connection with the satellite may be lost by only a small movement of the antenna's position.

The next step is the installation of the WRS software into the computer system. The installation of hardware and software should be supervised or guided by a WRS expert from BMKG. The WRS hardware and software can be acquired from the BMKG head office or can be procured by the client. For registration and further details, please contact: Pusat Gempa dan Tsunami - BMKG office at Jl. Angkasa No.2, Kemayoran, Jakarta Pusat 10720. Telp. : (021) 6546316 – Fax. (021) 6546316.

The WRS Application

WRS client is a web-based application. A web browser (e.g., Internet Explorer, Mozilla, Opera, Google Chrome, etc.) must be pre-installed in the computer.

Table 3: WRS Software Specification

Program Language	ASP, HTML, and JAVAscript
Web Server	IIS Web server
Operation System	Windows XP pro
Application Features	- Capabilities to display a map with the location of earthquake - Capability produce different sounds for earthquake information or tsunami warning - Data history of last 20 events - Web based designed - Other BMKG information (Weather, Climate, etc) also available

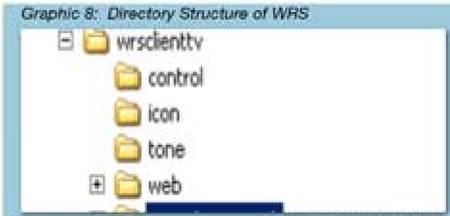
Source: Karyono (BMKG)

How to Operate the WRS Application

It is important to understand how the WRS application works. If you plan to acquire or install a WRS unit, you must understand and follow the procedures as described below:

The WRS application is designed to operate automatically when the computer is switched ON. WRS Computer at clients (interface institutions, local warning centers) MUST be switched ON 24/7 and in stand-by mode. No screen saver mode should be activated. The WRS application is stored in the directory c:\wrsclient\ with the structure as described in the graphics below:

Graphic 8: Directory Structure of WRS



Source: Karyono (BMKG)

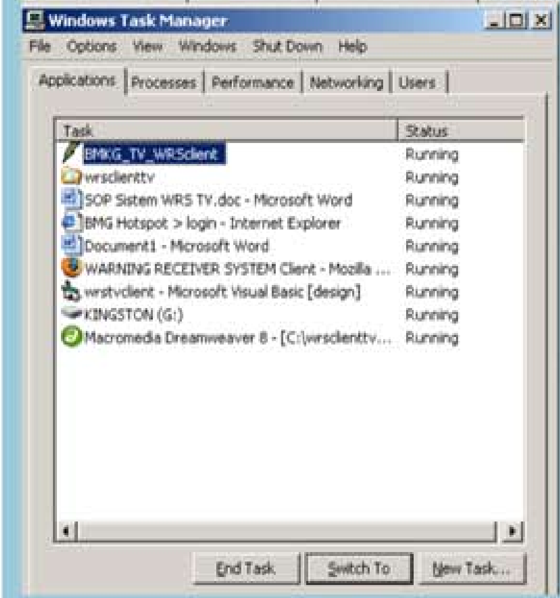
The directory of *wrsclient* contains the application to control any new information derived from the BMKG WRS server. The name of this application is *bmkgwrsclient.exe.* The web sub-directories inside *wrsclient* contain information pages received from BMKG.

The web directory is split into two main directories: *inatews* and *infobmg*. The directory of *inatews* contains earthquake and tsunami warnings. The directory of *infobmg* contains general information about BMKG.

The application *bmkgwrsclient.exe* inside the directory of *wrsclient* is responsible for managing the automatic start when the computer is to startup/boot or logon. Theoretically, the application may run well continuously. However, as a precaution, this application should re-start once every hour by a scheduler.

The restart program application is located inside the directory control. It is also advised to execute a physical computer restart manually once every two weeks.

Graphic 9: Window task manager for wrs client



Source: Karyono (BMKG)

To check whether the program is still running, press the combination of ctrl+alt+del buttons and a "Task Manager" window (see graphic 9) will appear. Check if the program *bbmkg_tv_wrsclient* is working or not.

If you do not find *bmkgwrswrsclient*, re-run the program manually by double clicking *bmkgtvclient.exe* inside the directory of *wrsclienttv*.

How to Check the Incoming Messages

The WRS application produces a specific sound for earthquake information and tsunami warnings. The computer will automatically display (pop-up) a map with the latest information on the earthquake event. It will show a blinking red dot on the map and information on whether it has tsunami potential or not (Graphics 10 and 11).

Graphic 10 and 11: Earthquake Information with (no) Potential Tsunami

Source: (BMKG)

Graphics 10 and 11 show the present screen design. Once the new Decision Support System (DSS) is activated, the format of warning messages will be changed and display information on estimated wave heights, affected areas and estimated arrival times in accordance with the new warning levels (Graphic 12):

Local authorities in tsunami-prone areas are in charge of informing their communities about an imminent threat and providing clear guidance on how to react

Graphic 12: Earthquake Information with Potential Tsunami (Future Warning Scheme)

Source: (BMKG)

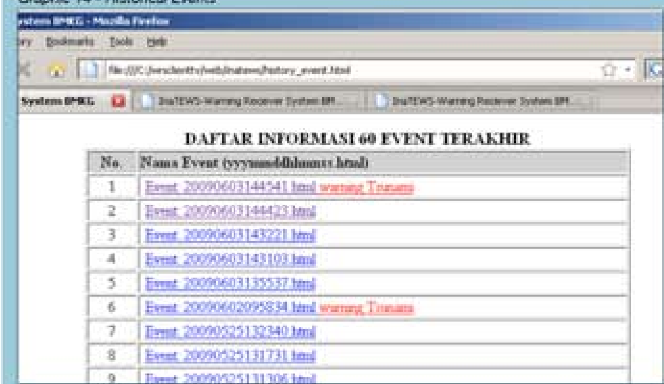
Warning Receiver System on other Computers within a Network

The WRS application is a web-based design and it can be accessed or run on other computers within a network where the WRS Client is installed. Open a web browser (e.g., Internet Explorer or Mozilla Firefox) and type the address of the WRS Client. The main menu of the WRS application will appear (graphic 13):

Graphic 13: Main Menu of Web-based WRS Client

Source: (BMKG)

Graphic 14 - Historical Events



Source: (BMKG)

Technologies for Warning Dissemination at Local Level

Local authorities in tsunami-prone areas are in charge of informing their communities about an imminent threat and providing clear guidance on how to react. Near-field tsunamis, however, give only little time for warning and evacuation, so local dissemination must be quick and reliable. Tailor-made solutions are required. Therefore, it is critical to have local needs properly evaluated.

As tsunamis in Indonesia are typically triggered by strong earthquakes, the dissemination system must withstand the effects related to earthquakes, such as power failures, breakdown of ordinary communication networks and general chaos. As a rule, all dissemination technologies depending on electricity need a back-up power source. Experiences show that radio communications (VHF / FM) have proven to be the most reliable system. Cellular phone networks often collapse and therefore do not qualify as a single solution for local information dissemination. Using multiple methods of delivering the message is important to deal with failure of any one channel. Public dissemination is key. Those with access to non-public channels can forward warnings to others.

Using pre-established and well-proven communication technologies is better than setting up new ones only for tsunami early warning. If you decide to set up a new dissemination system or technology, always check whether they can serve other purposes as well.

When planning to implement new technologies, make sure that they are in line with local resources and budget to cover not only the procurement cost, but also long-term maintenance. Certain dissemination technologies (e.g., sirens) may require supporting systems, such as power back-up and trigger mechanisms. Operational and training costs must also be taken into account. However, high expenses for purchasing and implementing a new system could be offset by higher maintenance costs of existing systems. The overall cost can be reduced if several communities decide to acquire the same equipment or even share warning dissemination services and systems.

Finally, remember that the success of local dissemination systems does not only depend on technical solutions. Operators, decision-makers and the general public must be informed about how they can receive information long before anything happens.

This chapter provides an introduction to dissemination technologies that can be used at the local level in the Indonesian context. The technologies are presented according to their classification as mass notification and addressable notification systems.

Outdoor Mass Notification Systems

Sirens

Sirens are amongst the most popular and widely used outdoor alerting devices. They can reach large portions of the population, including those in more remote areas. Sirens are an option, especially when alerting people with limited access to other warning devices, such as 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, such as radios or TV, to seek further instructions. They can also be used to call for evacuation.

To be effective, the population must be continually educated about the purpose of the sirens and the intended reactions. Without proper training, sirens can cause confusion and panic amongst the local population.

Proper understanding of siren sounds can also help to reduce negative impact in case of a false alarm due to technical problems. On Monday, June 4, 2007 a tsunami early warning siren in Aceh sounded for one 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 and did not know how to recognise a "normal" tsunami warning and the "all clear" signal. As a consequence, angry residents destroyed the siren infrastructure. This incident serves as an example that education of the local community is just as important as the technical set-up of the dissemination system.

Sparks Panic in Aceh

Tsunami alarm sparks panic in Aceh

Aceh tsunami alarm shut down by locals

Source: Jakarta Post, Monday, June 4, 2007: Tsunami Alarm

False Alarm?

The example from Aceh on Monday, June 4, 2007, clearly can be classified as a false alarm. However, there are also cases when an alarm is intentionally triggered - because all indicators suggest a tsunami has been generated, but - for whatever reason, it doesn't happen. There can be several reasons for this. Most tsunami alarms are based on predictions that are derived from information collected immediately after a possible tsunami-triggering event, which is usually a strong earthquake. Due to the fact that arrival times in Indonesia generally are very short, the official goal is to issue a tsunami warning five minutes after an earthquake occurs. Nevertheless, within such a short time it is only possible to evaluate whether the earthquake had the potential to trigger a tsunami. The analysis whether a tsunami has actually been generated usually needs more time. As a consequence, you will occasionally witness that a tsunami warning has been issued, but that no tsunami occurred.

Formerly, many people judged such a situation as a "false alarm". But is it really a "false alarm" when all available indicators at that time indicate a tsunami might happen and a warning is issued? Was it really "false" to trigger the alarm? Or, weren't we just lucky that nothing happened?

Important factors to consider when setting-up a siren system:

Siren Types

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

Electromechanical Sirens

Electromechanical sirens consist basically of a rotating disk with holes in it (rotor) and a casing that 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 produce sound. These sirens can consume large amounts of energy and are very heavy. Electromechanical sirens are also called pneumatic sirens. Electromechanical sirens cannot 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. This means that they can carry voice messages. This feature is valuable when instructions must be conveyed to a population. These instructions can be relayed 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 provide reliability in emergency situations. On the other hand, electronic sirens require more maintenance than electromechani cal 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 directly or by remote-control. 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.

Electromechanical Sirens

Electronic Sirens

Coverage

Some sirens are designed to radiate sound in a 360-degree circle (omni- directional). Others emit the sound in just one direction. Sirens can be mounted at a fixed location or be mobile. An elevated mounting point can increase the siren's effectiveness. Rotating sirens have a greater reach than static sirens, however the sound of a rotating siren seems to oscillate for a stationary listener.

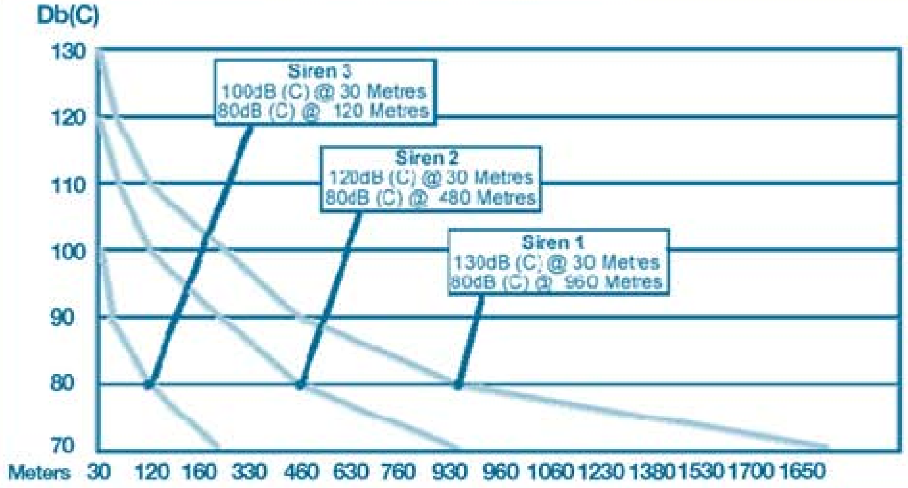
The loudness of a siren is measured in decibels (db). A siren of 120 db will be perceived as being louder from a distance of 30 meters than a siren with an output of 100 db. When calculating the reach of a siren, one subtracts 10 db for every doubling of distance, starting at 30 m away from the source of the 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:

- terrain (e.g., hills, outcrops, etc.)
- vegetation (e.g., tall trees, dense foliage)
- surrounding building structures (e.g., the typical db loss in residential areas may be 10 db, in areas with high buildings, such as business districts it may be 12 db)
- wind patterns (e.g., if the prevailing wind is from the west, it may prove useful to install the siren towards the western edge of the area to be covered)
- air humidity and temperature (e.g., sounds travel upwards in hot weather)
- sound frequency (e.g., 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. Note that approximately 80 db are needed to wake people up in insulated houses. As a rule of thumb, the effectiveness of a siren ends where the sound level drops below 80 db.

The following graphic 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 15: Sound Projection for Three Sirens with Different Output Power



Source: British Columbia Tsunami Warning Methods – A Toolkit for Community Planning

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 broadcast over the same loudspeaker that sounds the warning tones. Broadcasting is a valuable feature for instructing the local population, as well as groups such as travellers who might not be familiar with the local situation. The broadcasted message must be clear and concise.

Power Source

Sirens run only with a power source. Should a local tsunami-triggering earthquake destroy the public power grid, a back-up source 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 prices have recently been considerably reduced.

Another advantage of battery-powered sirens is that they are almost immune to power irregularities, which are common in Indonesia and could damage the control system. Batteries are also a good protection against surges caused by lightening. However, batteries need constant testing to maintain 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 sub-optimal power outputs and a reduced life span. Experience shows that for 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 planned and executed by experts.

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 pass over areas closer to the siren. Because of these variables, it is desirable to test the sound coverage of the siren at several heights and locations whenever possible.

Some places, such as cliffs or buildings, might prove especially hazardous during earthquakes. Sirens in tsunami-prone areas 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 saltwater spray and wind-blown sand.

Testing and Maintenance

Sirens should be tested on a regular basis even though it might cause some disturbance. Test runs can be used as a reminder to the community to be 'tsunami ready'. All siren manufacturers recommend biannual maintenance and testing at least once every month.

Cost: Sirens are costly and require a budget for set-up, maintenance and supporting infrastructure, such as batteries or solar panels. Siren costs may vary, depending on type, level of complexities, number of sirens on site, etc. The estimated cost of the system in Padang operated by PUSDALOPS is USD 30,000 for the master unit and USD 16,000 for each of the 9 sirens on site.

Advantages of Sirens	Disadvantages of Sirens
- Wide area outdoor coverage, especially in areas with no other means of alerting - Can awake/alert indoor residents near sirens and thus supplement indoor alerting systems - Siren units may already be in common use in the community for volunteer fire departments or other purposes - Public address versions can broadcast in different languages and can have a large number of pre-recorded messages - Low current draw required to operate from integral batteries and can be charged by solar panels or other alternative systems (e.g., wind generators) as protection from utility power disruptions - Radio-controlled and, therefore, can be independent of landline utilities - Full-time conditioning/monitoring reducing the need for live testing required solely for maintenance purposes - Great flexibility in placement of battery-powered and radio-controlled units - Can be centrally-controlled and remotely accessed - System is available 24/7	- Devices cannot always be heard in buildings and vehicles, or in areas that have high background noise levels - Inaudible in certain areas with strong winds - For non-public address versions, the public must be educated to turn to an additional source to obtain more information. Additional notification must be provided by other means - Public may have to be able to distinguish several different signals for different hazards or intended use - Siren soundings must be coordinated with other alerting methods - Large numbers of sirens may be needed to cover populated areas and must be loud enough to be heard indoors by most people - Must have a reliable power source - Poorly protected units can be damaged by waves, wind, sand, and salt spray

Our Experience: How Warnings Reach People? Dissemination Technology Development in the Pilot Area of Java

Mobile Sirens

Mobile sirens can be quickly moved to different locations. They can be mounted on a fire engine or police car, or set on a trailer or even a bicycle. They are especially useful if more time is available before a disaster strikes. Combined with a voice broadcasting function, they can supply supporting information to the public and be utilised to broadcast the 'all clear' signal. Mobile sirens can be transported to areas where they are most needed, such as evacuation routes or places with dense populations. Mobile sirens / speakers can also be equipped with an array of pre-recorded messages. However, sirens mounted on vehicles might get stuck in traffic or get bogged down on bad or damaged roads, and it may take quite a while to move them to the desired location. Mobile sirens can be battery-powered, just as their stationary counterparts.

Advantages of Sirens	Disadvantages of Sirens
- Useful in situations with longer warning time - Can be moved to where information is needed most - Independent from power grid when solar or battery-powered - Maintenance – can be done centrally or remotely.	- Difficult to use in situations with short warning times - Takes time to move to the required location and access may be difficult if roads are damaged - May be vandalised if left in public spaces

Signs

Signs can be set up at important strategic locations, such as beaches, busy roads and intersections. They can display warnings that a tsunami is imminent and give instructions for immediate action. People can be signalled when the tsunami warning sign is active by a strobe light and/or a siren. In Japan such warning signs are used 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 has been issued. Different flags can be assigned to different simple messages. Flags will only work if the public is educated about their meanings. Like sirens without a broadcasting function, flags can convey only very limited information,. Flags make sense only where they can be seen and in the daylight, so their range is limited. They can be used on popular beaches.

Kites

Kites are very uncommon communication tools. They are effective only 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 for 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' use as a warning tool, otherwise they will not be recognised as credible sources of information. If anything, kites are only complementary warning tools.

Kentongan and *Kulkul*

The *kentongan* and the *kulkul* are simple traditional communication tools. Basically, they are wooden or metal slit drums. When struck, they alert the public. Formerly, particular meanings where assigned to different rhythmic patterns. However, currently people need to be educated about the drums' purpose and the meanings of the signals. Since the *kulkul* and the *kentongan* can be beaten by virtually anyone, it will be vital to prevent misuse in order to insure the devices' credibility.

Kulkul is a Traditional Indonesian Communication Tool

Electronic Signs

Electronic Signs can be Utilised 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 utilised 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. Electronic signs can also be linked to FM-RDS technology. Electronic signs can be solar and/or battery-powered and can be managed from a central location.

Signal Flares

Flares can be very useful as warning signals, especially at night and if there is no electricity. Flares can be the best option for a quick sign.

A **flare** is a type of pyrotechnic that produces a brilliant light or intense heat without an explosion. Flares are used for signalling illumination, or defensive countermeasures in civilian and military applications. Flares may be ground pyrotechnics, projectile pyrotechnics, or parachute-suspended to provide maximum illumination time over a large area. Projectile pyrotechnics may be dropped from aircraft, fired from rockets or artillery, deployed by flare guns, or handheld percussive tubes.

Flares produce their light through the combustion of a pyrotechnic composition and may be coloured by the inclusion of pyrotechnic colourants. A parachute flare may be the best option for a tsunami-warning signal because it stays bright up in the sky for a longer period (approximately 10 minutes). A **flare gun** is a gun that fires flares that are typically used as distress signals, as well as other signals. It is a very bright colour that is shot high in the air so that people can see it from afar and take necessary actions according to the meaning of each colour shot.

Cost: A twin-pack night-and-day distress flare may cost around 100 USD; a single parachute rocket flare costs approximately 70 – 90 USD. Hand flares are less expensive, costing around 20-40 USD for each one.

Indoor Mass Notification Systems

Radio and Television

Radio and television are among the most common mass media used for the distribution of general information to a wide area, however, 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 watch television.

To utilise radio and TV as a means of early warning, standard operational procedures must be developed to assure that information gets broadcasted when it is required and everybody understands the message. Standardised and pre-scripted messages should be stored and SOPs for the notification process of radio and TV stations must be in place. In an emergency, it may be difficult to contact 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 RegulationNo.20/P/M.Kominfo/8/2006). 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' signal is given. Presently, the main national TV stations are directly connected to the BMKG Warning Center and they broadcast earthquake information as running text.

Advantages of TV	Challange of TV
- Instant information if turned on - Can provide detailed and up-to-date information, including graphics and maps - Reaches people indoors - Widely available - Respected source of information	- Limited access for many people during daytime (work, school, etc.) - Not available outside - Will reach people not effected by tsunami and may cause confusion - Weak signal reception in outlying areas - Not available during power outages

Local radio stations are a good option for the dissemination of more detailed and location-specific messages. Local calls for evacuation 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 stations need to be notified through the official local warning center. For communication between the radio stations and local officials, means of communication that are independent from breakdowns and power failures, such as satellite phones or VHF radios must be utilised.

INFO: Media and the Warning Chain - The role of media in disaster preparedness

In Padang, a system was developed that allows local decision-makers to directly broadcast emergency information and guidance via a handheld VHF transmitter as the announcements are retransmitted in the normal frequency of FM radio broadcasts. The system in Padang – called RABAB – also allows activation and transmission of information via loudspeakers in mosques or other public areas.

The FM radio station itself must feature a power back-up to insure uninterrupted broadcasting. It is necessary to have emergency staff on-site 24/7. Prior to an emergency, the public must be informed about the role of radio broadcasts in the case of emergencies, and the radio frequency to tune to. Sirens could alert the public to switch on their receivers and tune into the right frequency. Experiences show that the local FM radio plays a very important role for dissemination of tsunami early warning at the local level.

Advantages of Local Radio	Challange regarding use of Local Radio
- FM radio receivers are universally available and affordable - Can provide locally relevant and up-to-date information and guidance - Is often an accepted and trusted source of information - Reaches people indoors and outdoors, in moving vehicles and on boats - Battery-powered radio receivers (i.e., in vehicles) are immune to power outages and widely available	- Must be tuned in to the right frequency to receive warnings and guidance - May reach people not affected by the tsunami and may cause confusion - Radio station needs to be ready to broadcast on a 24/7 basis with robust power back-up system and link to source of information (PUSDALOPS, decision-makers) - Outlying areas might not be able to receive FM radio signals at all

Broadcasting Systems

2-Way Radio Communication

Radios have a proven track record in emergency communications. Immediately after a disaster, 2-way radio communication is often the only remaining means of communication because 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 inter-operable with other communication systems, such as e-mail, VoIP, etc. Radio communication can be used for voice and data messaging, dispatch and surveillance, as well as notification. There are three major radio communication systems: HF, VHF and UHF.

Radio communication users must register themselves and their equipment with either one of Indonesia's legal radio organisations – Radio Antar Penduduk Indonesia (RAPI) or Organisasi Radio Amatir Indonesia (ORARI) – to obtain a call sign. A RAPI call sign begins with the letters JZ (Juliet Zulu). A call sign issued by ORARI begins with the letter Y (Yankee). The registration fee is about 350.000 IDR for a 5-year period. RAPI is the more popular Indonesian radio organisation. Unlike ORARI, radio users can register without taking an exam. Both RAPI and ORARI use a certain number of dedicated frequencies in HF, VHF and UHF. Both organisations are involved in disaster-related communications and have developed their own SOPs. RAPI, for example, communicates periodically with organisations related to disaster management, such as BPBD, BMKG, Fire Brigade, etc. RAPI also offers trainings, seminars and workshops. It operates a 24/7 stand-by in 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 levels. Each province, region and city has its own disaster channel.


HF-VHF-UHF Radio Set

RAPI

ORARI

The official operational frequencies of BNPB (National Agency for Disaster Management) are:

- 11.4735 MHz (High Frequency)
- 171.300 MHz (Very High Frequency)

Frequency allocations for citizen-band radio in Indonesia are regulated in the government regulation, "Peraturan Menkominfo No. 34/2009 tentang Penyelenggaraan Komunikasi Radio Antar Penduduk". The regulation arranges frequency allocations for citizen-band radio in Indonesia as follows:

HF (High Frequency)

26.965 - 27.405 MHz divided into 40 channels

27.065 MHz (channel 9) is used for emergency information only

VHF (Very High Frequency)

142.000 - 143.600 MHz divided into 60 channels

142.250 MHz (channel 9) is used for emergency information

Frequency allocations for amateur radio in Indonesia are regulated in the government regulation, "Peraturan Menkominfo No. 33/2009 tentang Penyelenggaraan Amatir Radio". ORARI has a wider range of frequency allocations.

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 is reflected by the ionosphere. However, there are a number of factors, such as sunspot cycles, polar aurora, humidity, seasons, etc., that can limit its range. The set-up of an HF system requires expertise, but once it is set, it is robust and can be operated even from a car battery (for six hours if fully charged). HF radio can be integrated with computer networking technologies to create text messages and e-mails. Since bandwidth of HF radio is limited, digital applications are best kept to e-mail texts. The system is not powerful enough for a regular exchange of larger amounts of data, such as graphics or documents.

Cost: A standard HF node costs about 2,000 USD. The development of a national or regional HF e-mail system will require the establishment of a central server system that comes at an additional cost. Licensing fees for the commercial operation of HF radio must be taken into consideration. A major advantage of HF is that it will prove to be cost-effective in the long-run since individual calls are free-of-charge.

VHF: Very High Frequency Radio


VHF Radio Receivers are Inexpensive - Some are even Waterproof

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

An approximate calculation of the line-of-sight horizon distance in kilometres is $\sqrt{12.7 \times A_m}$ where A_m is the height of the antenna in meters. So, if a VHF antenna is 3 metres high, its horizon/range will be a bit over 6 km. However, the 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 must be placed in an elevated location, such as on a mountaintop or on a high tower. If ideally positioned, 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 do not run without power, so they require an energy back-up source.

VHF radio operates over an open-master channel. Everyone 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. Cities like Padang, or districts such as Bantul, 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. It costs 3,000 to 5,000 USD to add a repeater channel to an already existing network. Repeater stations require power to operate, so reliable back-up power in the 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 60 USD. Talking time is free-of-charge.

UHF: Ultra High Frequency Radio

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

Our Experiences: Communication Network of SARs -Linking SAR Communities along the South Coast of Java

FM-RDS

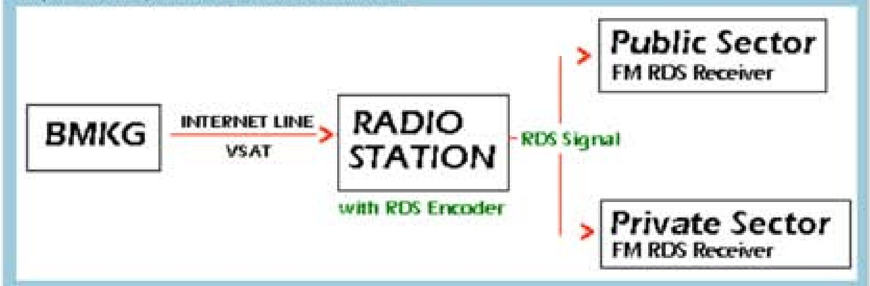
FM-RDS Reciever

FM broadcasting has proven to be useful for warning dissemination in adverse circumstances if certain precaution measures, such as power back-up systems, are in place. Combined with the Radio Data System (RDS) technology, specific warning messages can be disseminated directly by emergency management authorities as they override regular programming to broadcast them.

An FM RDS system set includes an RDS encoder connected to an FM radio station transmitter, an RDS decoder as controller and FM RDS receiver to receive the RDS signal. FM RDS receivers usually are clock/radio receivers that are activated on a 24/7 basis. They spring to life when they receive a special RDS signal even if they are switched off or are in standby mode. No matter which radio station the receiver is tuned to, it will automatically be directed to the frequency that delivers the warning messages. The same principle is used in car radios when they receive a traffic warning and override the current programme to broadcast it. The FM RDS radio receivers are equipped with rechargeable batteries that assure operation in case of power loss.

FM RDS has been tested in the GITEWS pilot areas. In case of a (test)-warning, BMKG sent digital data to local radio stations equipped with RDS encoders. An alert signal was broadcasted and interrupted the normal programming. FM RDS radio receivers then produced loud audio tones, and large flashing displays provided the warning alert. The receivers displayed real-time text information. In addition to the dissemination of warnings through BMKG, FM-RDS could also be utilised by local governments and emergency response bodies to broadcast evacuation orders and instructions. However, this would still require a major coordination effort. In addition to the dissemination of warnings through BMKG, FM-RDS could also be utilised by local governments and emergency response bodies to broadcast evacuation orders and instructions. However, this would still require a major coordination effort.

Graphic 16: Set up of FM RDS in GITEWS Pilot Areas



The strength of the system definitely lies in the direct and quick link from the National Tsunami Warning Center (NTWC) at BMKG to the community at risk and its "wake up" function, as well as the possibility for a regional or national alert with the transmission of a single signal.

Our Experience: FM – Radio Data System - Introduction and Testing of FM-RDS for TEW

The feedback from the target groups in all three Pilot Areas to the FM-RDS tests indicated a real demand for, and positive acceptance of, warning devices with the features of the FM-RDS system (individual receivers, wake-up function, price).

Interestingly, the testing also revealed that the biggest challenges for a successful application of the FM-RDS technology were not technical, but were related to organisational aspects, such as the overall management of the system, mandates and procedures.

Advantages of FM-RDS	Disadvantages of FM-RDS
- Does not have to be tuned in to receive warning. It is activated automatically as long as the FM RDS receiver within the coverage of the RDS signal - Earthquake Information and Tsunami Warning displayed as running text combined with alarm buzz and live announcement from radio announcer for additional information and guidance - Reaches people indoors and outdoors, in moving vehicles and on boats - Battery-powered receivers are immune to power outages	- Local radio station needs to be ready to broadcast on a 24/7 basis and is resistant to power outages - Messages can only be received by special FM RDS radio devices - Messages can only be received within the coverage area of RDS signal - FM RDS radio receivers are not yet widely available in the Indonesian market - The price for a FM RDS radio receiver is higher than a normal FM radio device

GMDSS (Global Distress and Safety System)

GMDSS is an integrated communications system implemented by the International Maritime Organization (IMO) to ensure 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. Since 1 February 1999, all SOLAS vessels (passenger and cargo ships of 300 gross tonnage and upwards) must comply with the GMDSS, and be fitted with GMDSS communications equipment (international NAVTEX and-or Safety NET Inmarsat), according to the sea areas in which the ship operates.

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 authorised the direct dissemination of tsunami warnings by tsunami warning centers through the Safety NET communication system. Safety NET 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 organisations, the IOC, and a number of countries are working to establish protocols and content standards for tsunami warning bulletins to vessels, as well as to identify what kind of 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 is essential (source: UNESCO Tsunami Teacher – 3.3.6 Tsunami Mitigation: Alerting Vessels at Sea – SOLAS Vessels).

Sunda Kelapa Harbor - Jakarta

GMDSS could be installed in harbour master offices throughout Indonesia. Since harbours are usually also equipped with VHF and HF radios, they can play a role in informing ships and boats about possible tsunami threats. BMKG could be linked to IMO and Safety NET to broadcast specific warning messages relating to Indonesia.

Telecommunication Systems

Telephone Notification Systems

Telephone notification systems are designed to ring a certain list of predefined numbers and play pre-recorded messages. Multiple numbers can be dialled simultaneously, depending on how many ports are available on the server. If the target phones are not answered, the system will redial until the time-out limit is reached. The system can be triggered through any pre-defined emergency operation center. Telephone notification systems are not considered useful for local 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 that increase their flexibility. 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 notifications.

Telephone notification systems are usually offered by service companies. These companies should be experienced and offer a 24/7 service. The maintenance of the outbound calling database should be easy and secure. Before the set-up of a telephone notification system, the local telephone network's engineers should be consulted to make sure it can handle the required calling rate. The possibility of placing priority calls must 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). Thus, the delivery of a 30-second message would take about 50 seconds to be completed. It is crucial that the telephone server is equipped with sufficient outgoing lines to be effective. Assuming that the completion of one call will take 60 seconds, 10 lines and 30 minutes would be needed to make 300 calls. The number of calls successfully completed depends on whether phones are answered, the lines are in use, or there is network congestion.

Advantages of telephone notification system	Disadvantages of telephone notification system
- Available on 24/7 basis and can be used for multi-purposes - Messages can be pre-recorded - System can be supplemented with cellular and satellite phones - Predefined groups or organisations can be supplied with targeted information and called parties can be logged - Can be configured to target specific geographic locations and linked to GIS applications - Easy and quick updating / modification to address changing conditions	- Telephone notification systems are vulnerable to earthquakes due to related power failures and damage to infrastructure, e.g., cables, etc. - Effectiveness decreases rapidly as public phone networks become congested - Limited capacity to reach more people in a short time - Will not reach people outdoors unless they are carrying hand or satellite phones - People must answer the phone to receive the message - Trade-off between content and speed may become necessary to get as many messages delivered as possible

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 cell's capacity is 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 depended upon 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

Tsunami early warning via SMS is controversial!

SMS is more reliable than cellular voice transmission. BMKG notifies around 2,000 people via SMS in the case of emergency. Every computer with Internet access can theoretically initiate the sending of a SMS.

Private SMS Broadcast

Since the capacity of the BMKG SMS server is limited, there is also a possibility for Local Emergency Centers to set-up their own private SMS broadcast. The principle is to forward SMS warning messages from BMKG to the registered local clients. There are two methods that can be used:

- Web to SMS (Bulk SMS)
- Modem to SMS

Web to SMS: Most telecommunication providers in Indonesia already have this facility. A client – a local emergency operation center – upon registering with a provider will obtain access to use the WEB to SMS facility (username & password to login). The client can set up their own data bank and send out their own SMS to predefined groups. The provider will charge the same fee as for ordinary SMS use. An additional monthly subscription fee might also be charged to the client. The cost per SMS depends on the provider and varies between 49 IDR to 250 IDR per SMS. The monthly subscription fee is 25,000 IDR to 30,000 IDR.

Modem to SMS: Another option for local emergency operation centres is to have their own GSM or CDMA modem and connect it to a personal computer. There are many modem types and brands available on the market. Normally, the software to send bulk SMS is already included in the package. The cost for a modem is approximately 50 USD. The cost per SMS depends on the provider nd ranges from 49 IDR to 250 IDR per SMS.

For both methods, recipient lists can be prepared in advance. However, it might prove quite costly to maintain and operate a larger-scale SMS service. The set-up of your own SMS bank may be technically challenging. It is essential to have 24/7 power source back-up, as well as trained operating personnel. For high volume use of messages, it might be easier and safer to hire a commercial SMS provider. For a low volume user, a private SMS broadcast might prove cheaper in the long run.

Advantages of SMS	Disadvantages of SMS
- More reliable than cellular voice transmission - Can target specific groups - Usually people keep their hand phones close by and most people are familiar with SMS - High multiplication factor as many recipients can be reached in a short time. Messages can be sent via Internet and can be forwarded easily - Relatively inexpensive - Works indoors and outdoors - Cell phones are battery-powered and thus immune to power outages	- Transmitting infrastructure vulnerable to earthquakes and delivery of messages can be delayed due to congested systems - Does not reach people in areas with limited coverage - Pre-registration of phone numbers is necessary. - Geographically targeted mass delivery is difficult - SMS might not be read immediately after reception - Message content is limited to 160 characters - Method is not hoax-proof

Hoax Warning via SMS

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

"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 Wednesday, 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" (translated from Indonesian language)

Of course this SMS was a hoax. People who don't have sufficient knowledge about the nature of earthquakes and tsunamis have difficulties to classify such a message as a hoax and tend to take it for real, especially as renown institutions were mentioned as the source of information. In this case the SMS coincided with the malfunction of the siren in Aceh and caused considerable panic in the population, which was already traumatized through the 2004 tsunami.

Internet

Internet-based warning distribution channels have become very popular and familiar to many people. They are fast, reach unlimited target groups, and the warning message can be visualised attractively and combined with sounds and maps. There are unlimited channels for warning distribution using Internet connections because of its flexibility. The drawbacks of the Internet are related to its connectivity in emergency situations and dependence on electricity, as well as the fact that it is not "hoax-proof", as it is easy to manipulate information that can create a panic.

E-mail, websites, Internet-based social networks (e.g., Facebook, Yahoo Messenger, Twitter), Blackberry Messenger, the BMKG Warning Receiver System, and others, are examples of tools for Internet-based warning distribution channels. Experiences showed that many people receive information through these channels.

E-mail

E-mail is based on a set of protocols that allows for sending messages to a mail server, transmission across the network, and delivery to (or retrieval by) the user. Applications include the direct e-mailing of warnings to community members, as well as sending warnings to secondary warning providers. Messages can be received by personal computers or mobile e-mail devices, such as Blackberries or SMS-compatible cell-phones.

Advantages of E-mail	Disadvantages of E-mail
- Email is an easy way to disseminate information, ranging from text files to maps, sound and video files - Every computer with Internet access usually also has an e-mail program - 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 - E-mail can also be used to send messages to hand phones in SMS format - Very low cost	- E-mail it is not an alerting device, it needs the recipient to become active (open the mail and read it). Not everybody has constant access to e-mail and there is no guarantee for timely delivery of messages - Dependent on availability of Internet connection and electric power - To distribute e-mail messages a central e-mail server and specialised knowledge for set-up are required - Has low security and can be easily faked

Websites

Websites can be quickly updated and supply an almost unlimited number of users with a wide variety of information, however, they do not function as an efficient alerting or notification tool. Websites can be considered only as supplementary sources of information. Users must know the web address and open the website. Expert knowledge is required to change the content of a website. Websites are useful as long as the 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, such as fire fighters and emergency operation centers.

BMKG provides update information on the latest events of earthquakes and tsunami alerts on their website at *www.bmkg.go.id*

Private Server

A private server is a computer system that is connected 24/7 to the Warning Center via an Internet line or satellite. A private server runs a tailor-made program that interacts with the main warning dissemination server at the NTWC. The Indonesian NGO Yayasan Air Putih (White Water Foundation) developed a software program called "Info Gempa" and distributes it to the public freely. When installed on a personal computer or laptop connected to the Internet, a window will pop-up on the computer screen and will generate an alert sound when there is a warning issued by BMKG. The latest earthquake information from BMKG is also provided.

Graphic 17: Screenshot of "Info Gempa" Software of Airputih

Source: Airputih Software

Graphic 18: Screenshot of Gempaloka for Blackberry Smartphone

Source: Gemploka Software

Another example of privately developed software is called "Gempaloka". Gempaloka is designed for Blackberry Smartphone users and developed by an Indonesian Blackberry application provider named "7langit". When a warning is issued by BMKG, the Blackberry phone will vibrate or sound an alert to the user. The warning information of Gempaloka is limited, but comes with a map.

The "Info Gempa" application is distributed freely and can be downloaded at:
http://www.4shared.com/get/143308575/cfc5ad6/info_bmg.html

The application of "Gempaloka" is free for Blackberry Smartphone users and can be downloaded at:
http://appworld.blackberry.com/webstore/content/3970

Internet-Based Social Networks (IBSN)

Social networks on Internet, such as Facebook, Twitter, Yahoo Messenger Chat, Google Chat, etc., are currently very popular. IBSN can be accessed not only from personal computers and laptops, but also from cellular phones. All telecommunication providers in Indonesia have these IBSN facilities.

Government institutions do not consider the use of IBSN as an option as a formal warning dissemination channel because the networks are fragile and the warning messages can easily be modified, exaggerated or even faked. The advantages of IBSN are that they are very popular and information is spread very quickly within the network.

Personal Warning Systems

Door-to-Door

Door-to-door warning can be carried out by trained groups of people. The advantage is that very specific information can be exchanged in a personal encounter. Personal warnings can 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 may be the only working option.

However, door-to-door warning can be very time and resource-consuming. Therefore, door-to-door notification may not be a good option for tsunami early warning in Indonesia because the country is more likely to be hit by local tsunamis that do not allow much preparation time. Experience shows that it takes four to six minutes to complete the notification of one single house. Ten two-man teams (20 people) will take at least one hour to notify 100 homes. This rate can vary considerably depending of the time of day/night, week- day/weekend (people tend to be at home more on weekends than on weekdays) and population density.

Nevertheless, in some areas it might be useful to have a quick "door knocking" procedure at the neighbourhood level to call people who are still indoors for immediate evacuation. Local volunteers could be trained and introduced to the residents beforehand, or arrangements made between close neighbours. It is important to always make sure that one's own safety comes first! Alerting neighbours should be engaged in only when sufficient time is available to ensure the knockers safety.

In the case that sufficient time is available, the visits might 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. When considering door-knocking as an option, 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.

Residential Route Warning

Residential route warning can be a very efficient warning method, especially in densely populated areas, such as cities or villages, and much faster than door-to-door warning. Residential route warning uses public address systems that are mounted on vehicles. Most police and fire cars, as well as ambulances, are already equipped with these systems. Mobile public address systems are comprised of a controller, an amplifier, a microphone, and a siren/speaker.

The entire system is relatively inexpensive. Prices range from 1,000 USD to 2,000 USD per unit. The speaker is necessary for voice notification. Announcements can be pre-recorded or live. In areas where financial resources are limited or 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 may also be an option. For residential route warnings the following factors must be considered:

Range of warning: The average public announcement system has a range of about 300 m. Beyond that range the message may become incomprehensible. The announcement vehicle must travel at a slow speed and the message must be repeated at least every 300 meters.

Message type: To cover as broad an area as possible, the message should be kept simple and be as brief as possible. The message should advise people to turn to other sources, such as TV or radio, for further information. If only a very short time is available, the main message should point out evacuation routes and emergency centers.

Warning routes: Warning routes can be planned in advance, but should be flexible due to possible destruction or blockage of traffic infrastructure because of damaged buildings or traffic jams.

Advantages of residential route warning	Challange of residential route warning
- Can disseminate specific and targeted information. High credibility if carried out through emergency vehicles, e.g., fire or police cars - Usually already installed in emergency vehicles like police or fire cars and easy to in stall on different types of vehicles - Very flexible, can change routes and announcements quickly - Can reach people indoors if loud enough - Cost-effective and suitable for large areas, such as public beaches, markets or parks	- Safety first! Personnel disseminating information via residential route warning must not be endangered during the activity - Road damage and traffic jams can hinder the mobile units advancing on their routes - Limited coverage area (usually not more than a radius of about 300 m from the loudspeaker). Sound might be blocked by big buildings

Final remarks

Certainly, the warning dissemination technologies and methods illustrated in this document are not the only ones in existence or use. The methods and technologies described here are means that are available and considered to be applicable in Indonesia. Different notification systems may be used in other parts of the world that have different technical infrastructures.

Please be constantly aware that technology changes rapidly. Some of the technologies presented here may soon be outdated and it can be expected that new ones will develop in the future. What is true for technological developments also applies for the overall tsunami early warning system: it will be an ongoing and continuous development process that will never stop.

Before taking a decision on implementing new technologies, we highly recommend contacting our local partners in the GITEWS pilot areas who have developed and tested a number of interesting approaches. Several of these experiences have been documented in the "Tsunami-Kit": *www.gitews.org/tsunami-kit*.

Abbreviations

24/7	24 hours a day / seven days a week 24 jam sehari / 7 hari seminggu
BMKG	Badan Meteorologi Klimatologi dan Geofisika National Agency of Meteorology, Climatology, and Geophysics
BNPB	Badan Nasional Penanggulangan Bencana National Agency for Disaster Management
BPBD	Badan Penanggulangan Bencana Daerah Local Agency for Disaster Management
BT	Bujur Timur Longitude
CDMA	Code Division Multiple Access
CNN	Cable News Network
COMSAR	Committe on Radiocommunications and Search and Rescue
db	Decibel
DSS	Decision Support System
DVB	Digital Video Broadcasting
FM	Frequency Modulation
FM-RDS	Frequency Modulation – Radio Data System
GIS	Geo Information System
GITEWS	German Indonesian Tsunami Early Warning System
GMDSS	Global Maritime Distress and Safety System
GTS	Global Telecommunication System
GTZ	German Technical Cooperation Kerjasama Teknik Jerman
GUI	Graphical User Interface
HF	High Frequency
IBSN	Internet Based Social Networking
IDR	Indonesian Rupiah
InaTEWS	Indonesian Tsunami Early Warning System Sistim Peringatan Dini Tsunami Indonesia
IOC	Intergovernmental Oceanographic Commission
IP	Internet Protocol

kHz	Kilohertz
LAN	Local Area Network
Lok	Lokasi Location
LS	Lintang Selatan South Latitude
Menkominfo	Kementrian Komunikasi dan Informasi Ministry of Communication and Information
MSI	Maritime Safety Information
NGO	Non Governmental Organization
NTWC	National Tsunami Warning Center Pusat Peringatan Tsunami Nasional
ORARI	Organisasi Amatir Radio Indonesian Indonesian Amateur Radio Organization
PUSDALOPS	Pusat Pengendalian dan Operasi Local Emergency Operation Center
RANET	Radio Internet
RAPI	Radio Antar Penduduk Indonesia Indonesian Citizen Band Organization
RDS	Radio Data System
Ristek	Kementerian Riset dan Teknologi Ministry of Research and Technology
SAR	Search and Rescue
SMS	Short Message Service
SOLAS	Safety of Life at Sea
SOP	Standard Operating Procedure
SR	Skala Richter Richter Scale
TV	Television Televisi
UHF	Ultra High Frequency
UPS	Uninterrupted Power Supply
USD	United States Dollar
VHF	Very High Frequency
WAN	Wide Area Network
WIB	Waktu Indonesia Barat West Indonesian Time
WRS	Warning Receiver System
WMO	World Meteorological Organisation

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