



UNIVERSITAS GADJAH MADA

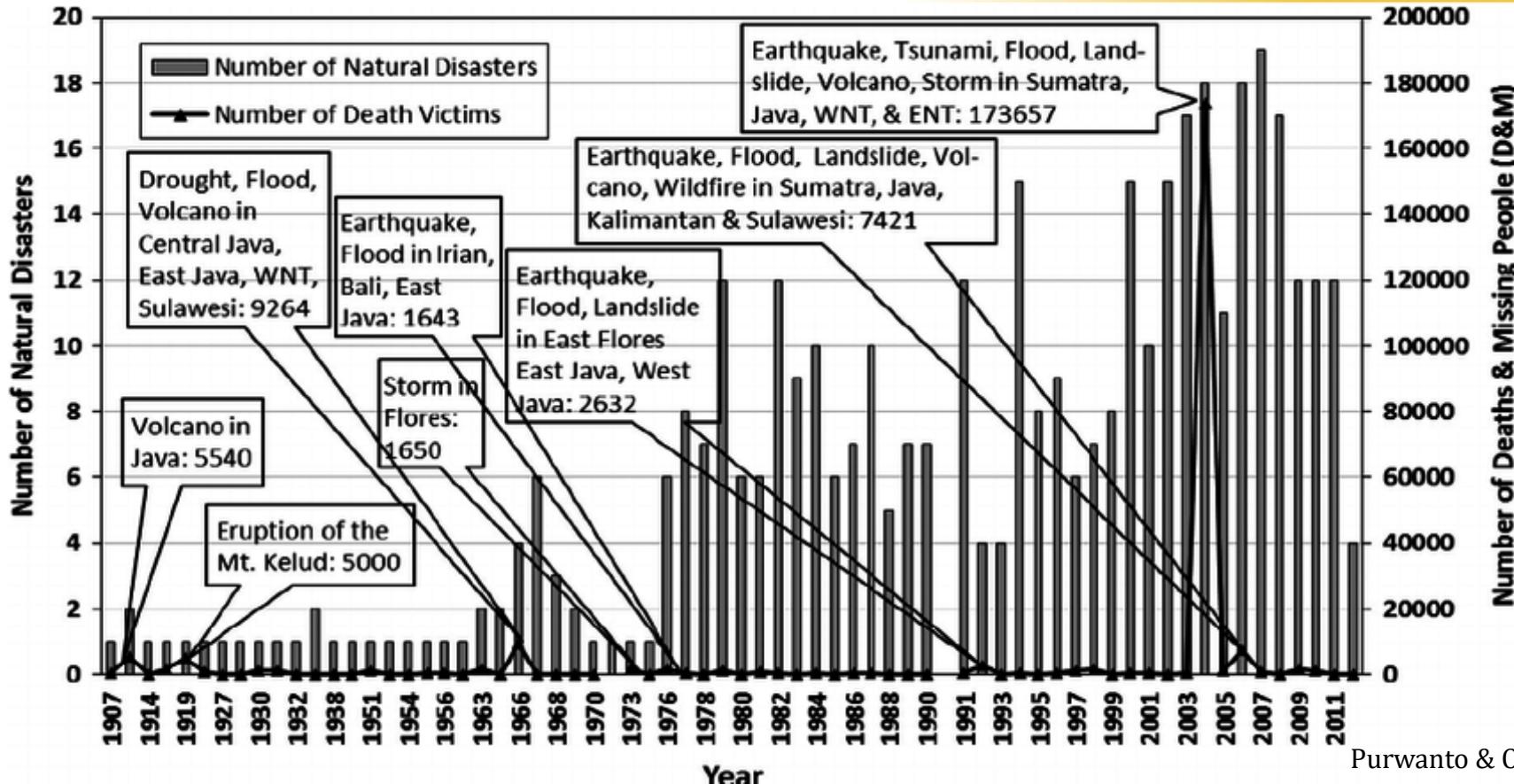


# Early Warning System for Earthquake and Volcano in Indonesia

*(a hazard mitigation effort for the Nation)*

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FieldCamp Workshop 2019  
Yogyakarta, Indonesia April 6, 2019



Purwanto & Oyama, 2013



# Key Words

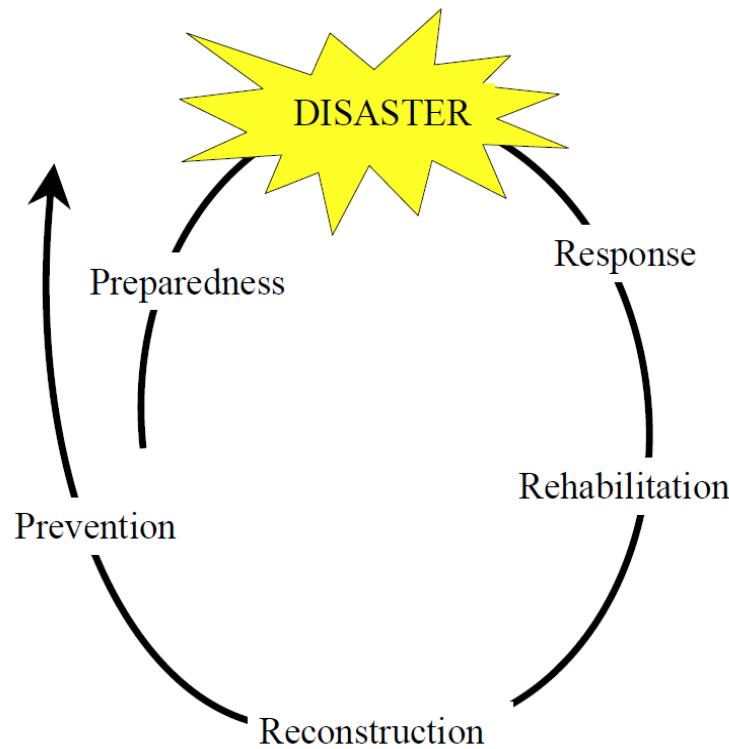
- DISASTER : is an occurrence disrupting the normal conditions of existence and causing a level of suffering that exceeds the capacity of adjustment of the affected community

**It is the people who matter most,  
and without the people we have no disaster**

WHO/EHA Training Package, 2002



# The disaster-development continuum



WHO/EHA Training Package, 2002



# Disasters are not aberrant phenomena.

- They are reflections of the ways societies structure themselves and allocate their resources.

TABLE 2.3

## Disaster-related casualties and costs, median annual values by HDI group, 1971–1990 and 1991–2010

Country group	Deaths (per million people)		Affected population (per million people)		Cost (percent of GNI)	
	1971–1990	1991–2010	1971–1990	1991–2010	1971–1990	1991–2010
<i>HDI group</i>						
Very high	0.9	0.5	196	145	1.0	0.7
High	2.1	1.1	1,437	1,157	1.3	0.7
Medium	2.7	2.1	11,700	7,813	3.3	2.1
Low	6.9	1.9	12,385	4,102	7.6	2.8
World	2.1	1.3	3,232	1,822	1.7	1.0

Note: Values are for median impacts of climatological, hydrological and meteorological natural disasters.

Source: HDRO calculations based on Centre for Research on the Epidemiology of Disasters Emergency Events Database: International Disaster Database.



# Key words

- **EMERGENCY**

a state in which normal procedures are suspended and extra-ordinary measures are taken in order to avert a disaster

- **HAZARD**

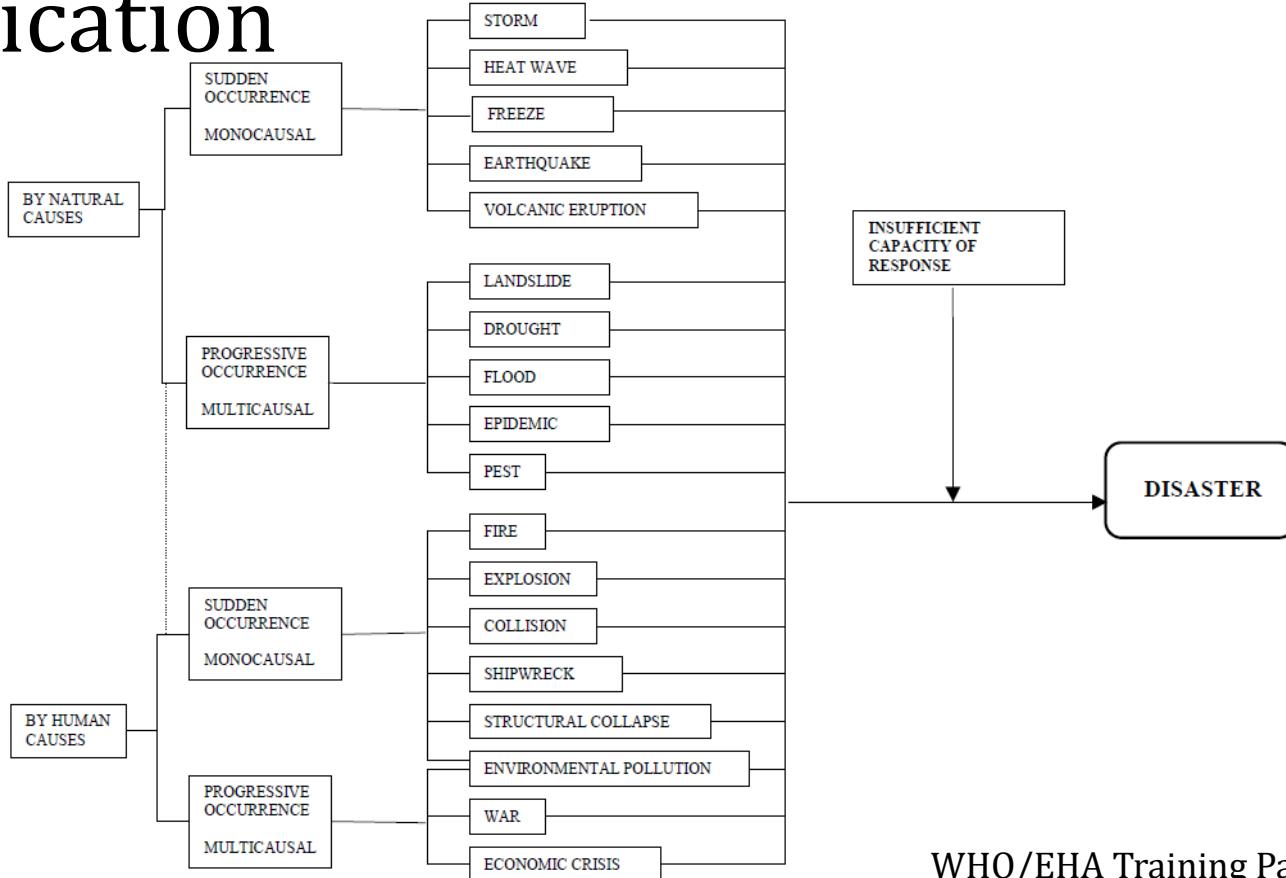
A natural or human-made event that threatens to adversely affects human life, property or activity to the extent of causing a disaster.

- **VULNERABILITY**

the predisposition (tendency) to suffer damage due to external events

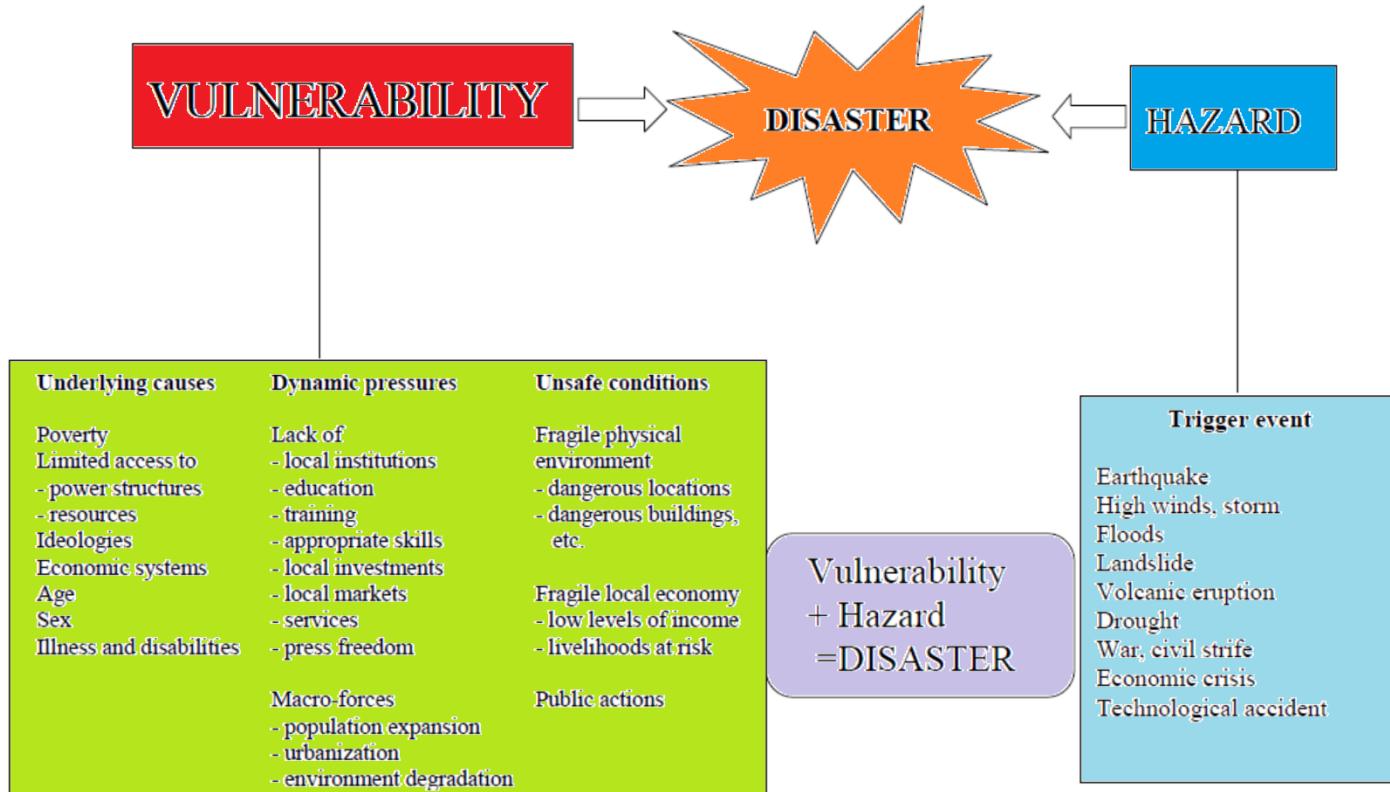


# Classification



WHO/EHA Training Package, 2002

# When hazard and vulnerability meets



WHO/EHA Training Package, 2002



# Key words

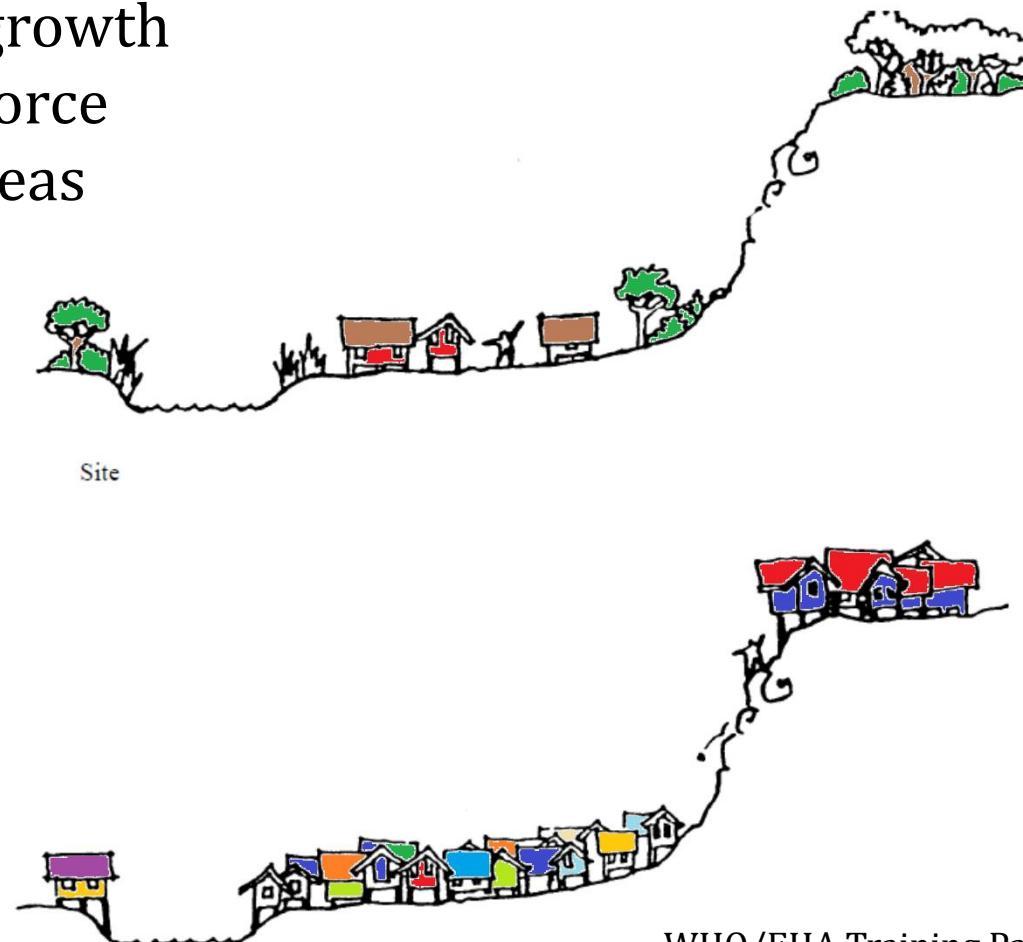
- **SUSCEPTIBILITY**

exposure to danger

- **RESILIENCE**

adaptability, capacity to recover

# Poverty, population growth and urbanization force living in unsafe areas



WHO/EHA Training Package, 2002



# Aims of disaster management

- Reduce (avoid, if possible) the potential losses from hazards
- Assure prompt and appropriate assistance to victims when necessary
- Achieve rapid and durable recovery
- **CAPACITY** = ability, ableness to do
- **Capacity for emergency management is made of:**  
**(1) INFORMATION (2) AUTHORITY (3) INSTITUTIONS (4) PARTNERSHIPS (5) PLANS, RESOURCES AND PROCEDURES TO ACTIVATE THEM**

WHO/EHA Training Package, 2002

# MITIGATION:



- Permanent reduction of the risk of disaster
- “Primary Mitigation”
  - reducing the PRESENCE of the Hazard
  - reducing VULNERABILITY
- “Secondary” Mitigation:
  - reducing the EFFECTS of the Hazard (Preparedness)

WHO/EHA Training Package, 2002

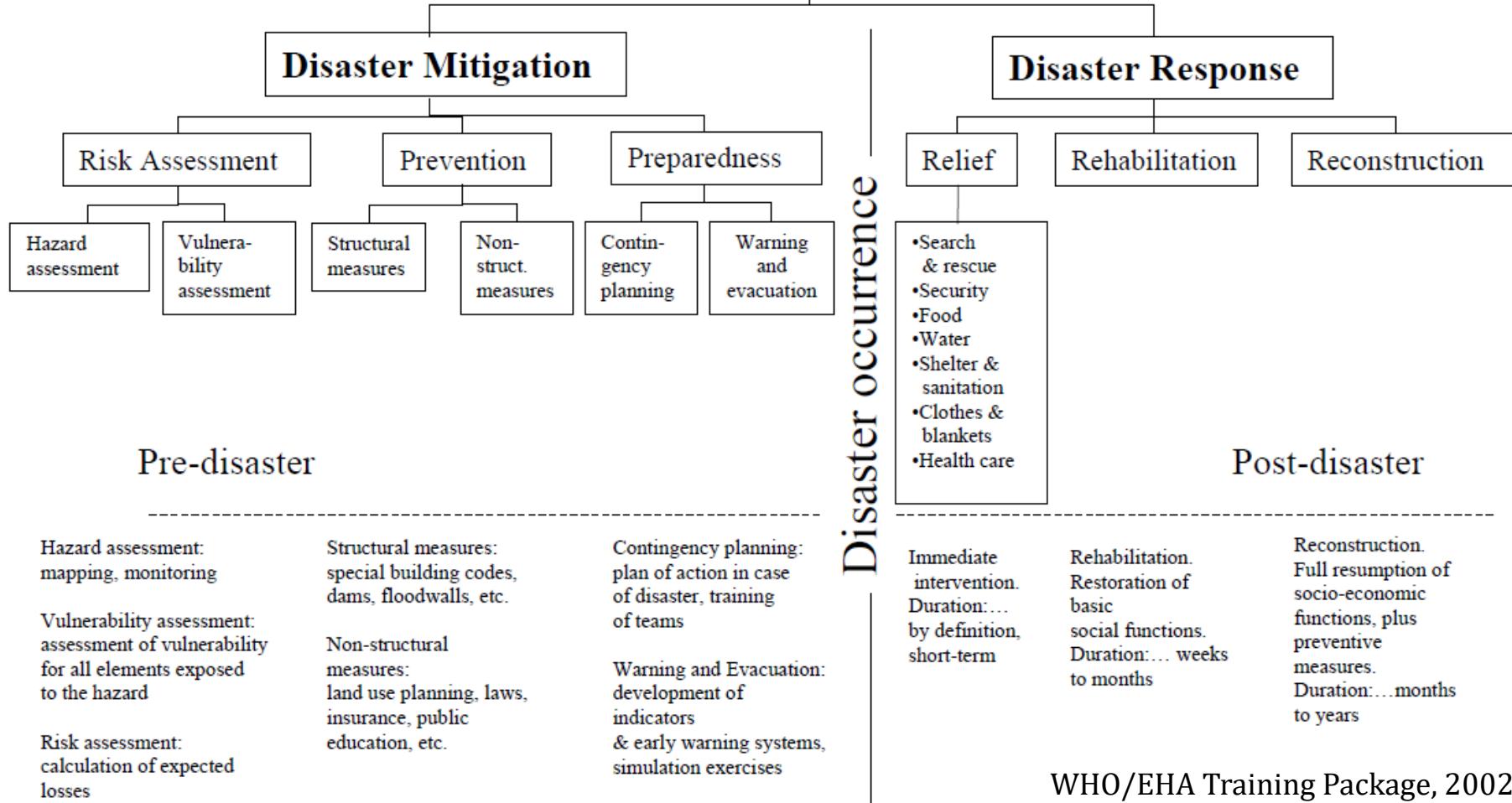


# Elements of Disaster Management

- **Disaster preparedness planning**
  - \* vulnerability and risk assessment
- **Disaster response**
  - \* disaster assessment
- **Rehabilitation & reconstruction**
- **Disaster mitigation**

WHO/EHA Training Package, 2002

# Disaster Management





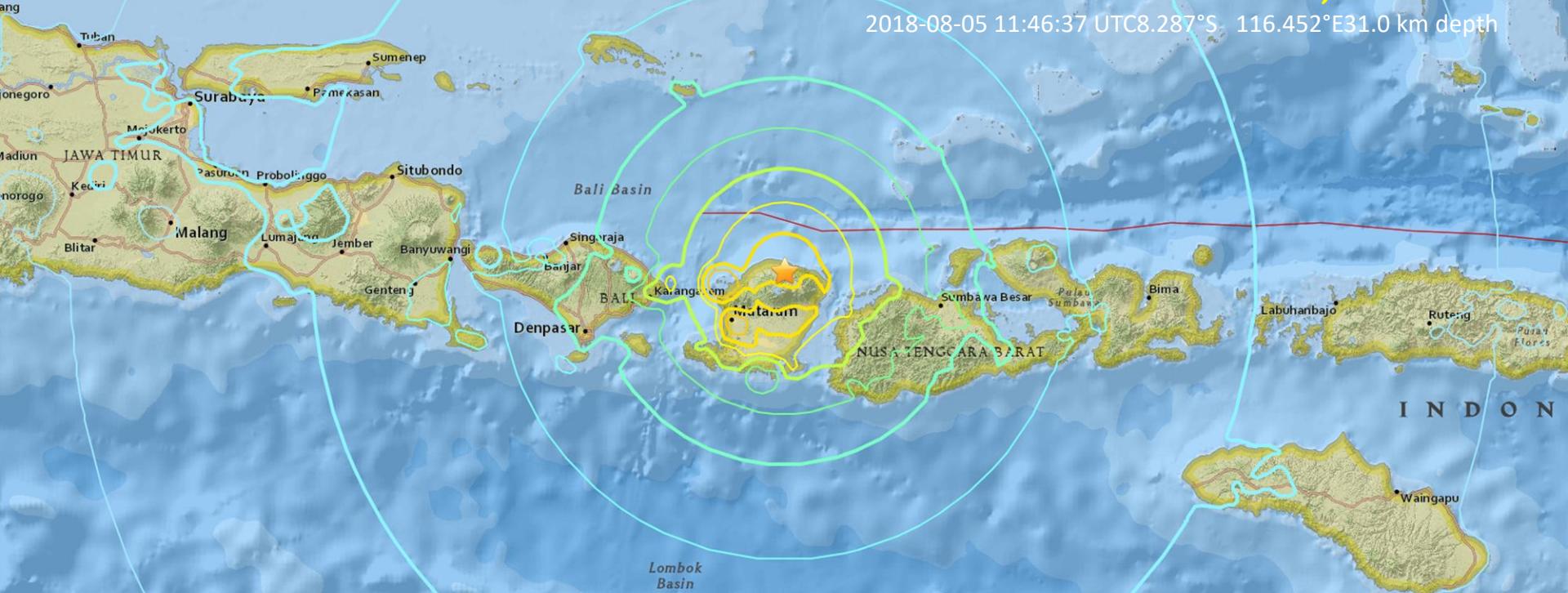
# Examples in Indonesia



# Lombok Earthquake

M 6.9 - 3km SSE of Loloan, Indonesia

2018-08-05 11:46:37 UTC 8.287°S 116.452°E 31.0 km depth





# Lombok Earthquake

## SMS-Alert System For magnitude > 5.0

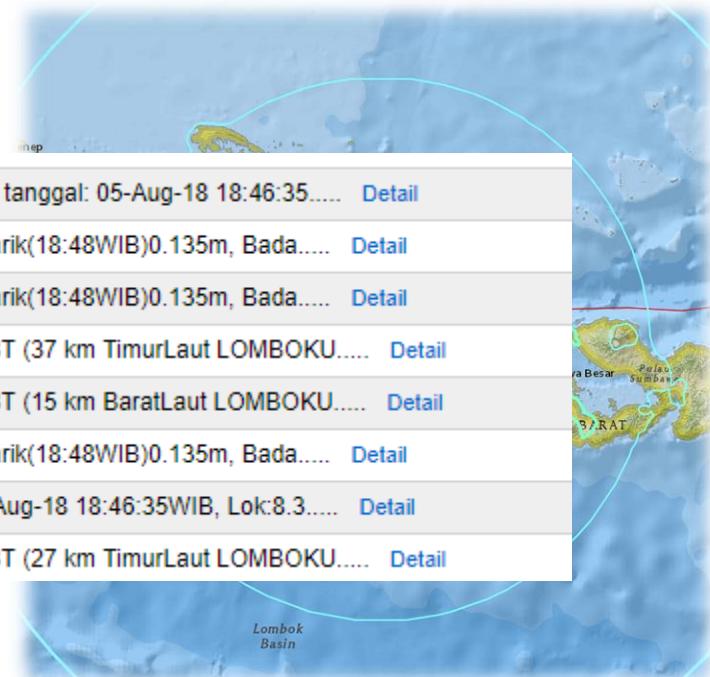
15 Diseminasikan informasi gempabumi melalui SMS

6	20180805202501	Peringatan dini TSUNAMI
7	20180805201648	Pemutakhiran,Tsunami
8	20180805201141	Pemutakhiran,Tsunami
9	20180805201057	Info Gempa Mag:5.0, 0
10	20180805195304	Info Gempa Mag:5.6, 0
11	20180805192125	Pemutakhiran,Tsunami
12	20180805185715	Pemutakhiran,Peringata
13	20180805184931	Info Gempa Mag:6.8, 05-Aug-18 18:46:35 WIB, Lok:8.25 LS,116.49 BT (27 km TimurLaut LOMBOKU.....
14	20180805175331	Info Gempa Mag:5.2, 05-Aug-18 17:50:21 WIB, Lok:9.51 LS,121.24 BT (89 km Tenggara NGADA-NT.....
15	20180805165429	Info Gempa Mag:5.1, 05-Aug-18 16:51:27 WIB, Lok:2.33 LS,99.46 BT (36 km BaratDaya KEP-MENT.....



**M 6.9 - 3km SSE of Loloan, Indonesia**

2018-08-05 11:46:37 UTC 8.287°S 116.452°E 31.0 km depth





# Key elements

1. Disaster risk knowledge based on the collection of data and assessments
2. Detection, monitoring, analysis and forecasting of the hazards and consequences
3. Dissemination and communication, by an official source, of authoritative, timely, accurate and actionable warnings and associated information on likelihood and impact
4. Preparedness at all levels to respond to the warnings received.



# Multi Hazard EWS

- **Multi-hazard early warning systems** address several hazards of similar or different type in contexts where hazardous events may occur alone, simultaneously, cascadingly or cumulatively over time, and taking into account the potential interrelated effects.
- A multi-hazard early warning system with the ability to warn of one or more hazards increases the efficiency and consistency of warnings through coordinated and compatible mechanisms and capacities, involving multiple disciplines for updated and accurate hazards identification and monitoring for multiple hazards.



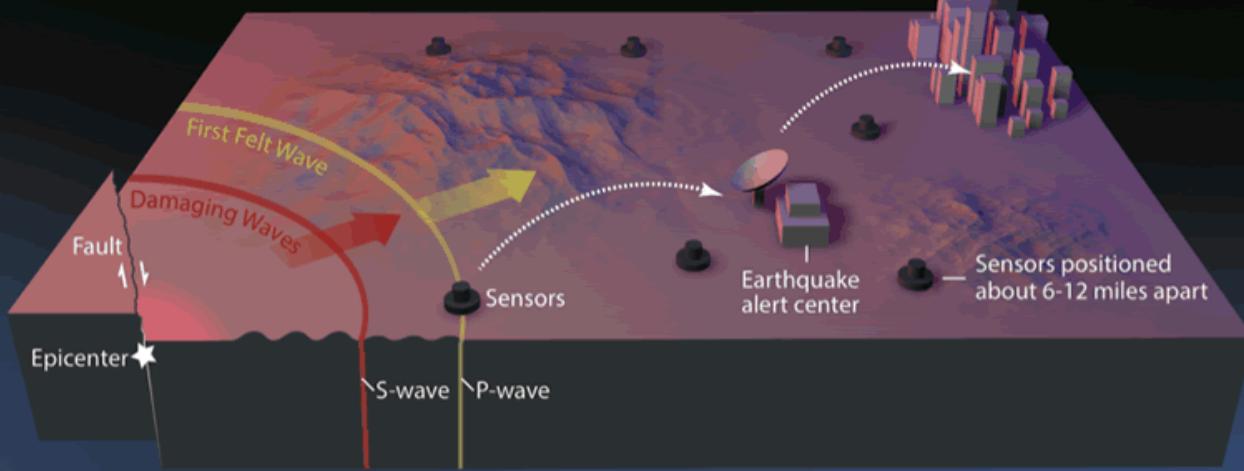
# Earthquake Early Warning

- Earthquake early warning (EEW) systems use earthquake science and the technology of monitoring systems to alert devices and people when shaking waves generated by an earthquake are expected to arrive at their location. The seconds to minutes of advance warning can allow people and systems to take actions to protect life and property from destructive shaking.



# Earthquake Early Warning Basics

- 1 In an earthquake, a rupturing fault sends out different types of waves. The fast-moving P-wave is first to arrive, but damage is caused by the slower S-waves and later-arriving surface waves.
- 2 Sensors detect the P-wave and immediately transmit data to an earthquake alert center where the location and size of the quake are determined and updated as more data become available.
- 3 A message from the alert center is immediately transmitted to your computer or mobile phone, which calculates the expected intensity and arrival time of shaking at your location.



Source : USGS



# Earthquake EWS

Even a few seconds of warning can enable protective actions such as:

1. **Public:** Citizens, including schoolchildren, drop, cover, and hold on; turn off stoves, safely stop vehicles.
2. **Businesses:** Personnel move to safe locations, automated systems ensure elevators doors open, production lines are shut down, sensitive equipment is placed in a safe mode.
3. **Medical services:** Surgeons, dentists, and others stop delicate procedures.
4. **Emergency responders:** Open firehouse doors, personnel prepare and prioritize response decisions.
5. **Power infrastructure:** Protect power stations and grid facilities from strong shaking.



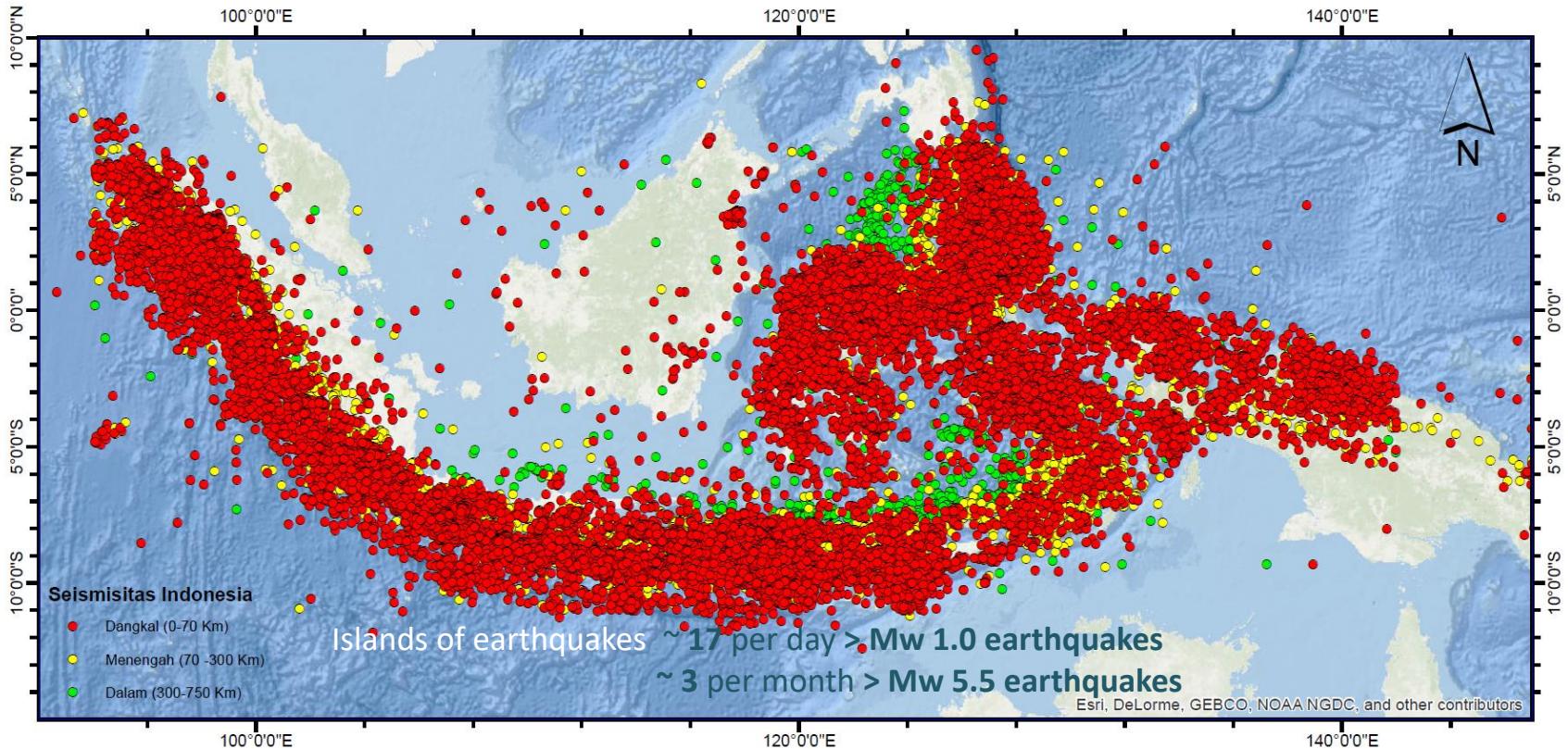
# Early Warning System in Indonesia

- The starting point of Indonesian EWS was in 2004, after the M9.1 Sumatera Andaman Earthquake and Tsunami
- Affecting **Asia and Africa** including : Indonesia, Malaysia, Thailand, Myanmar, Bangladesh, Srilangka, India, Maladewa, Somalia dan Kenya.



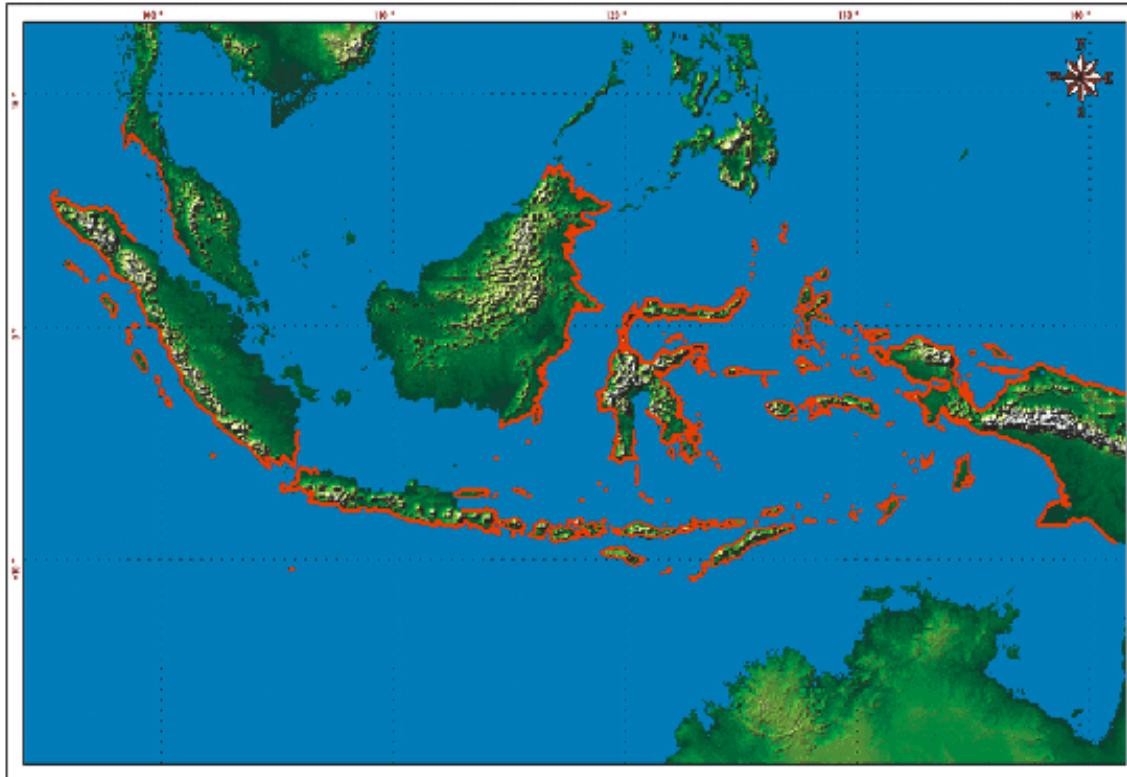


# Earthquakes in Indonesia



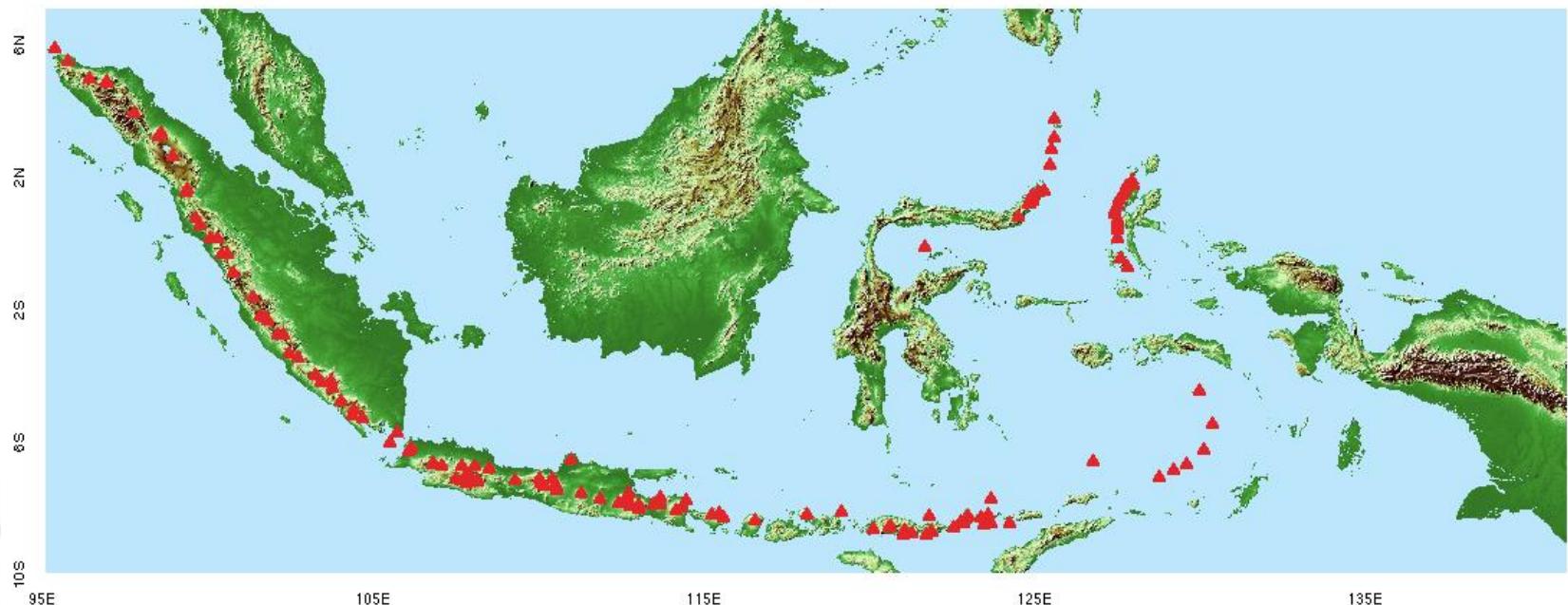


# Tsunami Hazard





# Volcano Hazard



Islands of volcanoes ~ **140 active volcanoes**



# EWS Concept

## 1. Operating component

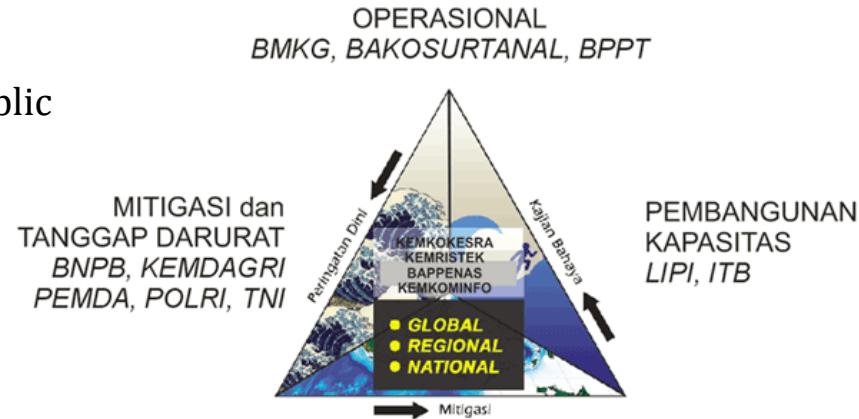
Monitoring activity, processing, analysing, preparation and dissemination of tsunami warning

## 2. Mitigation component

Emergency response, through (1) education and public awareness and alertness (2) shelter preparation (3) evacuation route (4) hazard map (5) logistic (6) training etc.

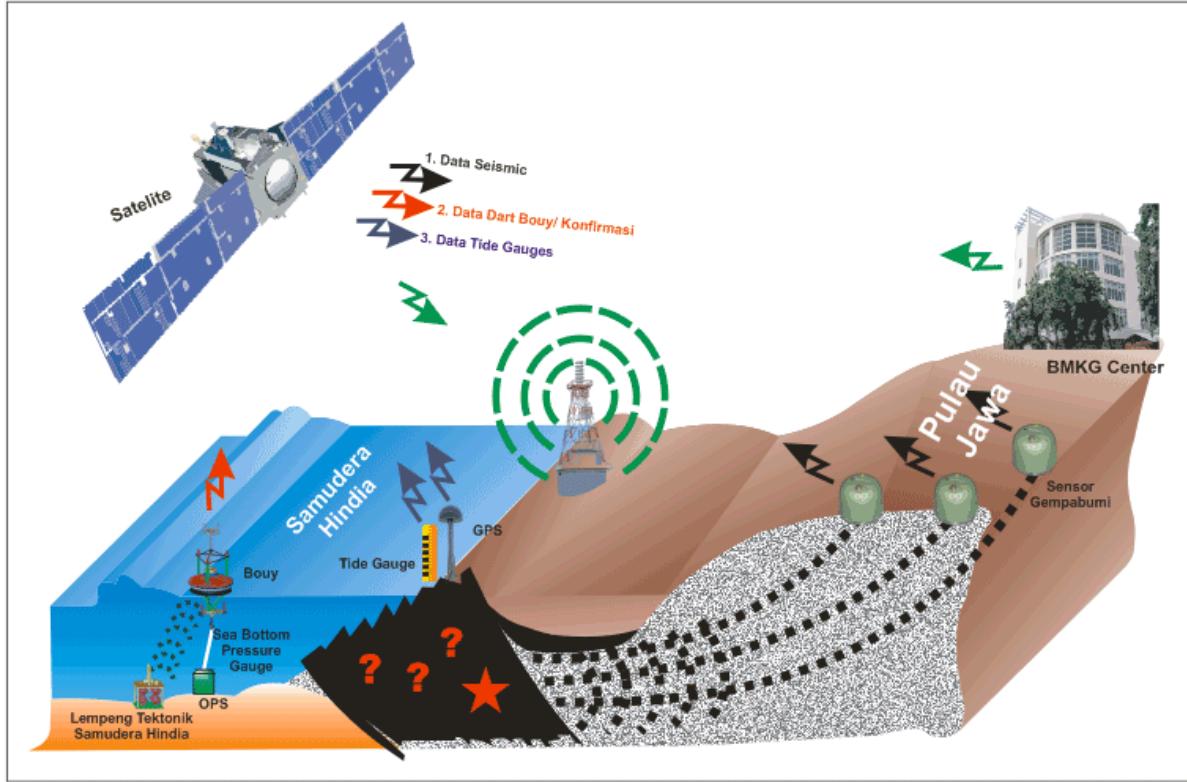
## 3. Capacity building

Research and development of the above two components for human resource development





# The InaTEWS Design





## OPERATIONAL

### Observation

1. SEISMIC MONITORING (BMG)
  - SEISMOGRAPH  
Proposed : 160
  - ACCELEROGRAPH  
Proposed : 500

2. SEA MONITORING
  - Tide Gauge (Bakosurtanal)
  - Buoys (BPPT)

3. CRUSTAL DEFORMATION
  - GPS (Bakosurtanal)
  - EO (LAPAN)

### Processing (BMG)

1. REAL TIME AUTOMATIC PROCESSING
  - Earthquake Location, Time and Magnitude

2. INTERACTIVE PROCESSING
  - Tsunami Generated
  - Issue Tsunami Warning
  - Cancel the Warning, all clear notification

3. DATABASE
  - Historical Tsunami
  - Pre Calculated Tsunami

### Alert Dissemination

E.Q Information

TSUNAMI WARNING !

- BMG**
- Situation Center
  - Control System for dissemination

Mitigation,  
awareness,  
Preparedness  
Emergency  
Response

BNPB

Situation Center  
Control system for  
dissemination

- Communication
- Public Works
- Social Affairs
- Health
- Interior Affair
- Local Gov
- Red Cross
- Media

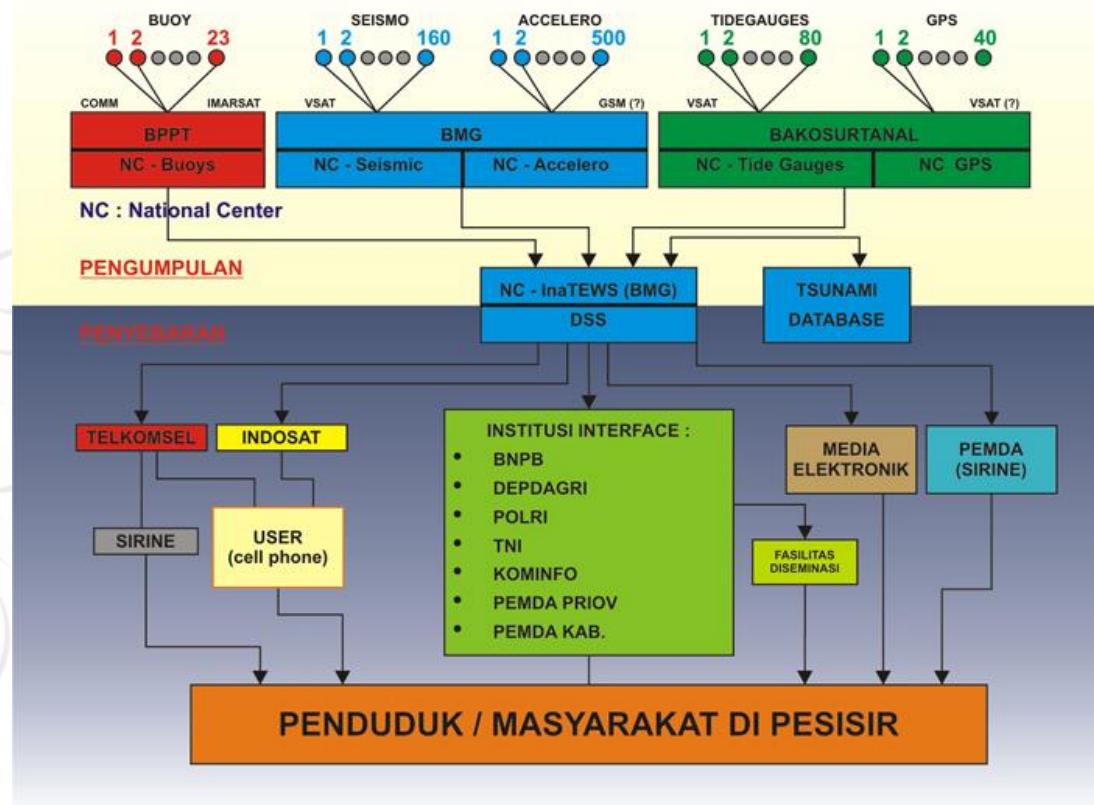
### Capacity Building

#### Research and Development

Modelling, R&D, Modules for  
Public Awareness and  
Preparedness (RISTEK,  
Universities Research Institutes)

#### HRD

Formal Education, Training,  
Public Education, Simulation  
(RISTEK, Min. Education,  
BNPB, LIPI, Loc Gov)



# Seismic Stations

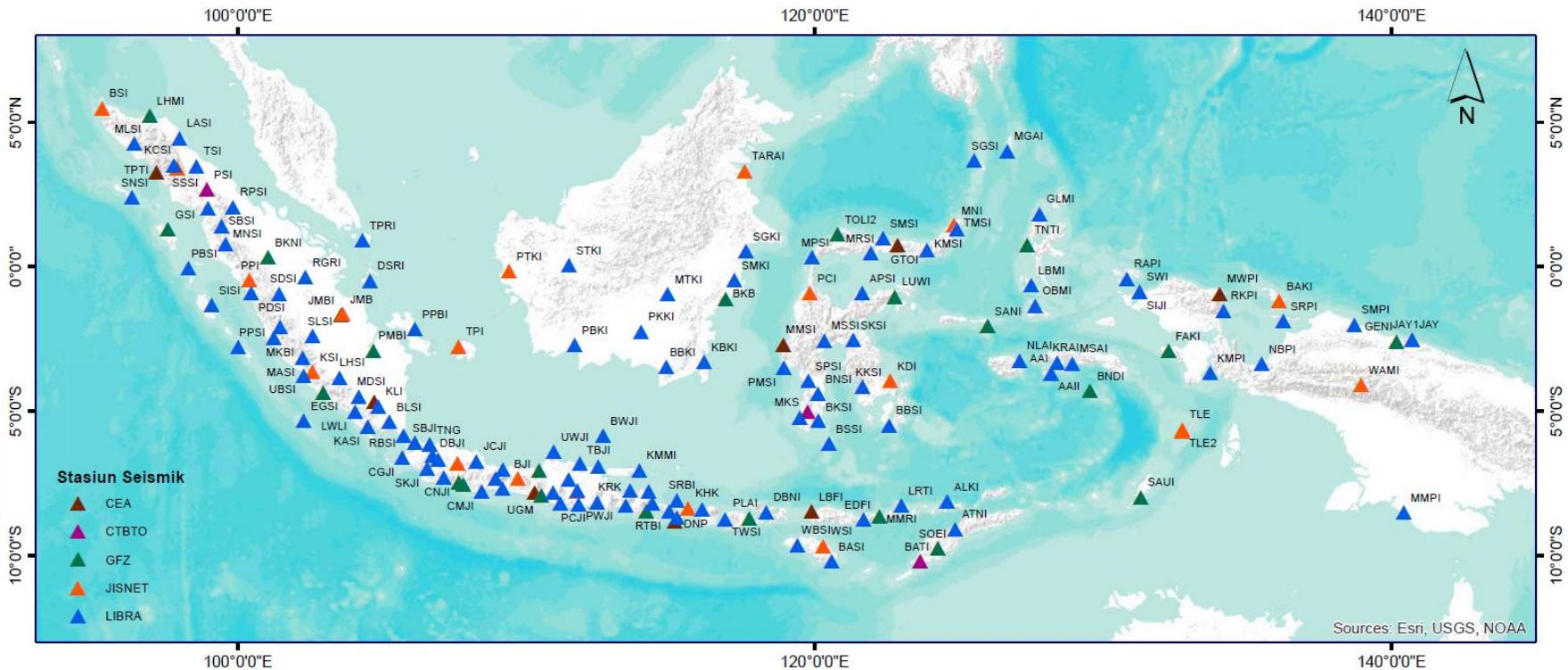


Gambar 15. Stasiun Seismik

- Consists of 160 broadband seismometer, 500 accelerometer dividing into 10 Regional Center.
- Interstation distance ~ 100 km, maksimum first 3 minutes the hypocenter (focus) of Earthquake can be determined.



# Seismic Station



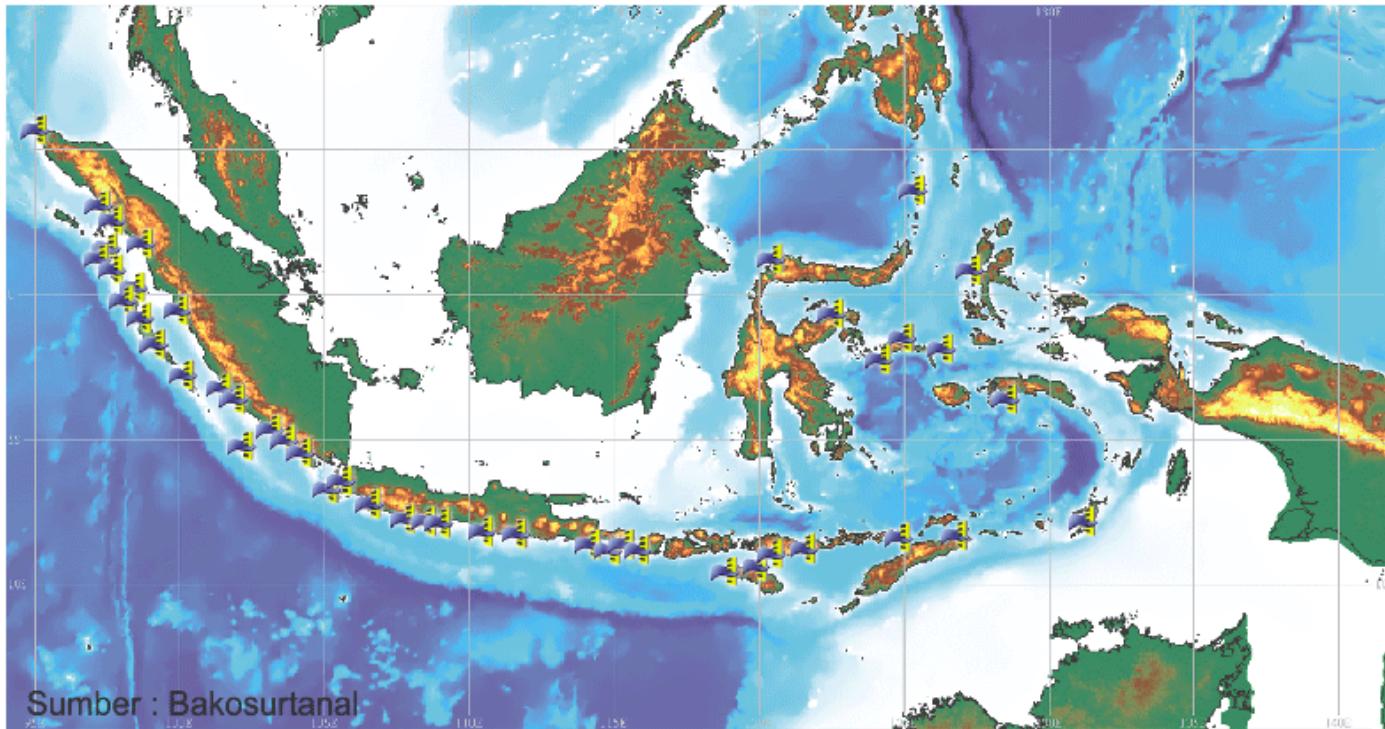


# GPS Station





# Tide station



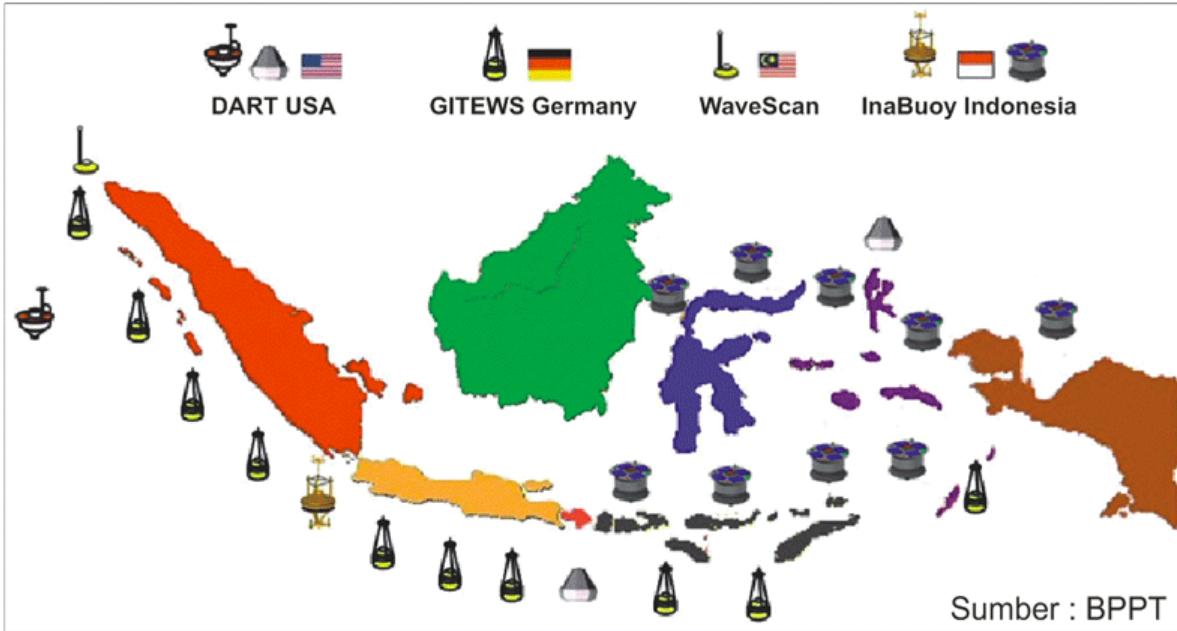
Sumber : Bakosurtanal

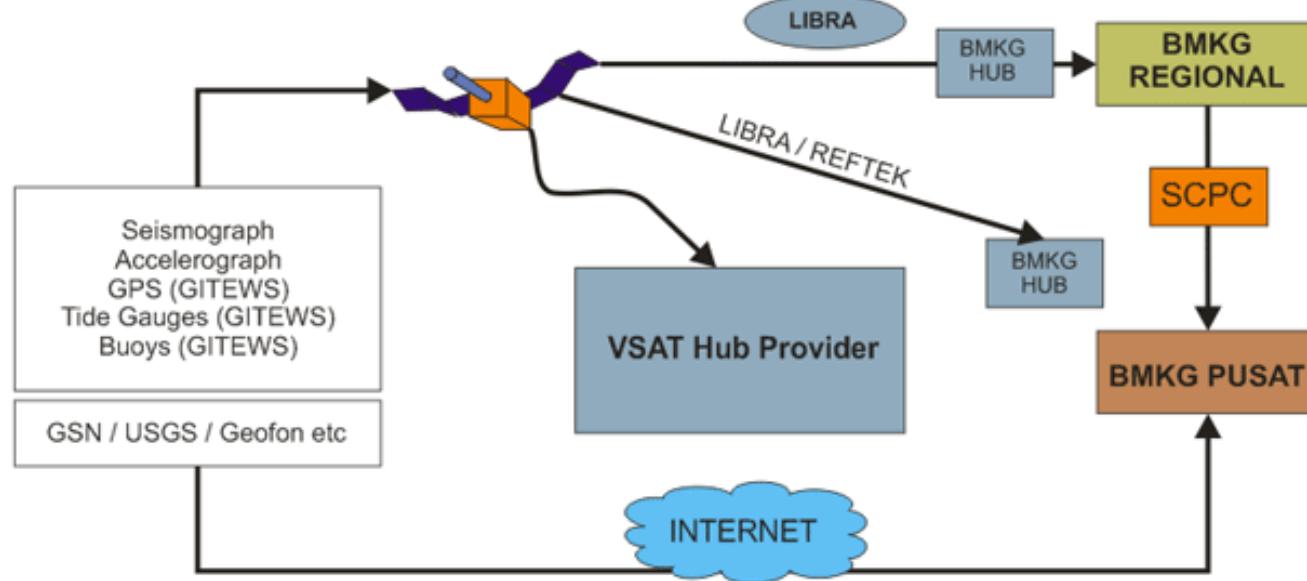
# Buoy instrument

- At the end of 2005, BPPT and Geomar Germany through the GITEWS project have installed 2 buoys in the waters of the West Indian Ocean..



# Buoy







# Decision Support System

- The Decision Support System (DSS) is a system for the duty officers in preparing for the Tsunami Warning.
- DSS provides earthquake info, observation signal (seismic, buoys, tide gauges, GPS and simulation) as decision makers and product warning.
- The decision itself is in the hands of manager on duty (Head of BMKG Tsunami Earthquake and Tsunami Early Warning), after considering information from observation and simulation.
- DSS Logic Description
- Currently the decision of the earthquake that caused the tsunami is only obtained from the magnitude and location and depth of the earthquake.
- The decision itself sometimes requires the support and detailed info of various information, tsunami simulations and related data in the DSS system.
- DSS has the essence of receiving the information system, the data and information received into consideration and at the same time will continue the results to the dissemination network.
- An overview of all the good data and maps information gives the operator the help to select what information for a particular area.



# GUI interface

The figure displays four panels of a software interface, each with a green numbered circle indicating its function:

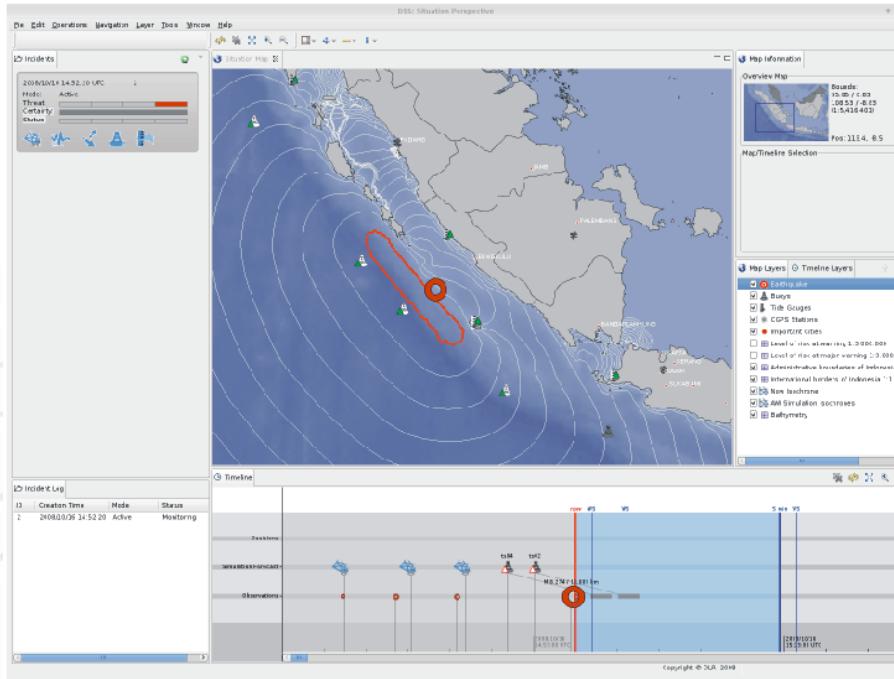
- Situasi** (Panel 1): Shows a map of Indonesia with red and green dots representing seismic activity and a timeline below.
- Observasi** (Panel 2): Displays monitoring data from various sensors in a tabular format.
- Keputusan** (Panel 3): Shows a map with a yellow line and a table of decision parameters.
- Produk** (Panel 4): Displays a summary of the decision-making process and its output.

**1. Situasi** : Tiga menit pertama setelah gempabumi

**2. Observasi** : Observasi langsung dari semua monitoring sistem

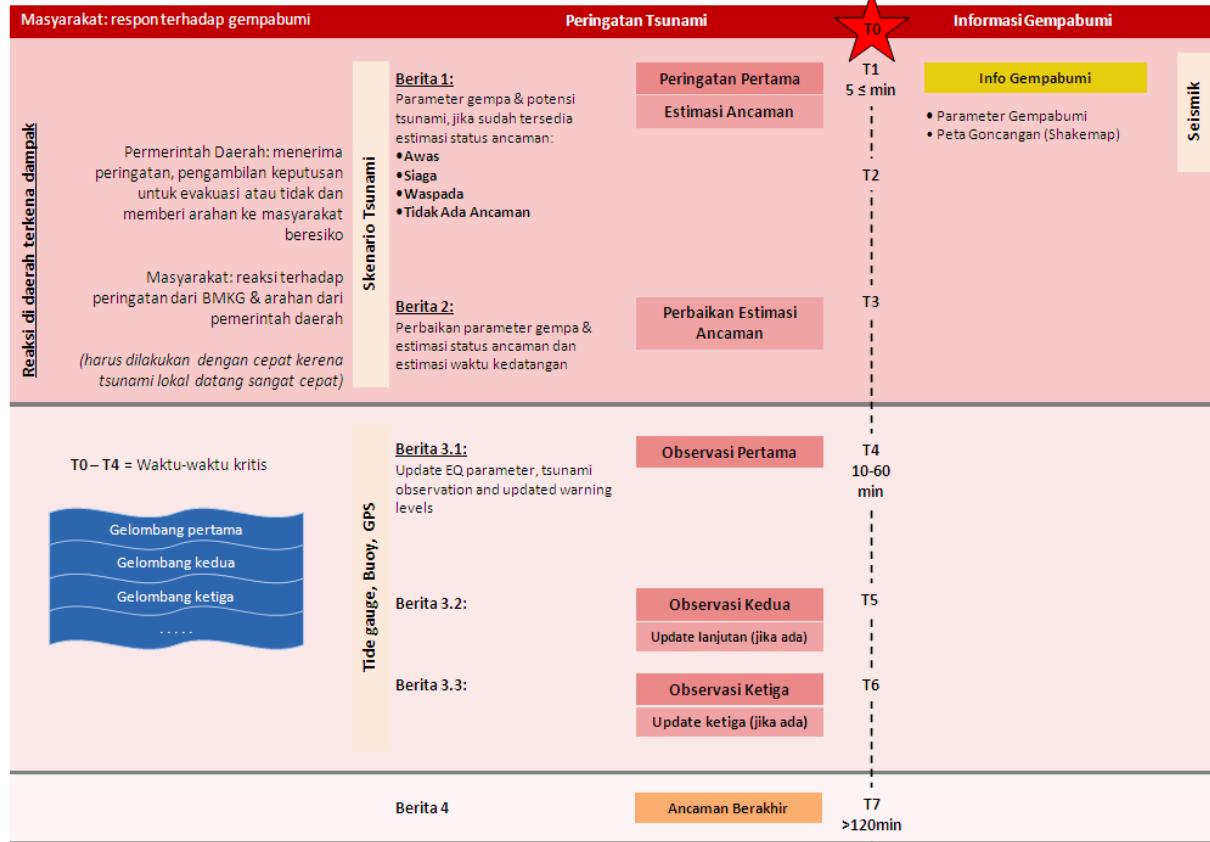
**3. Keputusan** : Usulan jenis peringatan dari sistem

**4. Produk** : Informasi yang dikirimkan ke suatu daerah



## Situation Perspective

- Within 3 minutes of the earthquake, DSS earthquake location map accompanied with a tsunami simulation.





Following

## BMKG

@infoBMKG

Perhubungan Jateng

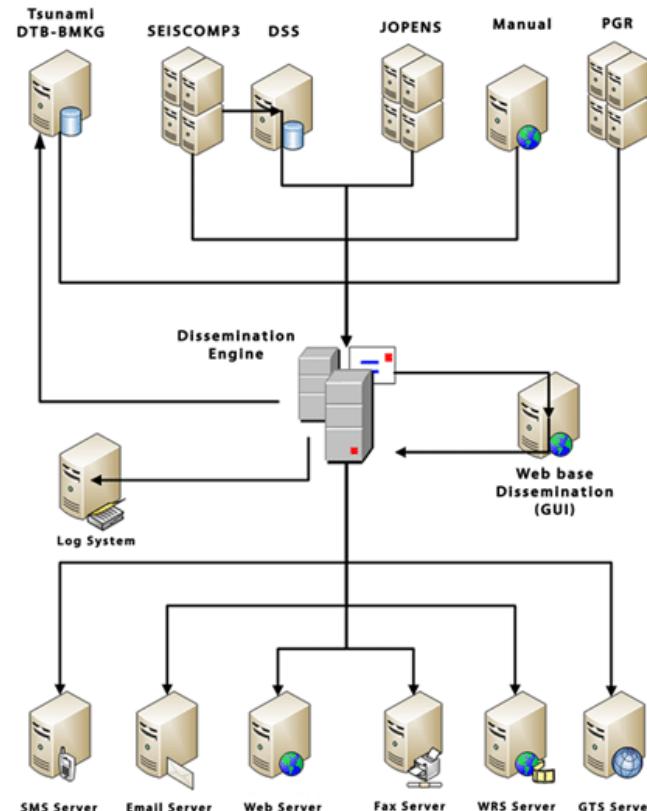
#RoadToPestaRakyat, JALIN Merapi, and  
10 others follow

The official Twitter of BMKG -  
Indonesia - Twitter resmi BMKG -  
Informasi Cuaca, Iklim, dan  
Gempabumi di Indonesia - Badan  
Meteorologi, Klimatologi, dan  
Geofisika

⌚ Indonesia ⌚ [bmkg.go.id](http://bmkg.go.id)

⌚ Born on 21 July 1947

22 Following 3,5M Followers





# Summary

- The dissemination pattern adopted here is from BMKG. Warning tsunami is sent to the interface institution through various modes ie: SMS, Email, Web, common social media. While the interface institution in question is primarily Provincial Government, Department of Home Affairs, POLICE, National Army, Television, Radio, GSM Operator, BNPB, etc ..
- So far the most optimal dissemination system is through SMS either to the individual (official) or to the institution.
- Warning via SMS is followed up with the delivery to the public through various facilities such as television, radio, serial order from officials to siren, because of the harsh sound of its location in an area that is potentially affected by the tsunami.



# Volcano EWS (by PVMBG)

MAGMA Indonesia Home VONA Press Release Tentang Magma Legenda Live Seismogram Staff Login

The screenshot shows the official website of MAGMA Indonesia. At the top left is the logo "MAGMA INDONESIA" with the text "Multiplatform Application for Geohazard Mitigation and Assessment in Indonesia". Below the logo is a circular emblem with the same text. A quote "Bridging the will of nature to society" is displayed. A sidebar on the left lists "Visitors" and a recent entry about a visit by the Minister of Energy and Mineral Resources. The main content area features a heading "MAGMA Indonesia" and a detailed description of the application. To the right, there's a "Penghargaan" section about awards received, a "Link berita selengkapnya" link, and a "System Developers" section.

**MAGMA Indonesia**

**MAGMA Indonesia (Multiplatform Application for Geohazard Mitigation and Assessment in Indonesia)** adalah aplikasi multiplatform (*web & mobile*) dalam jaringan berisikan informasi dan rekomendasi kebencanaan geologi terintegrasi (gunungapi, gempabumi, tsunami, dan gerakan tanah) yang disajikan kepada masyarakat secara kuasi-realtime dan interaktif. Sistem ini dibangun dan dikembangkan secara mandiri oleh PNS Pusat Vulkanologi dan Mitigasi Bencana Geologi (PVMBG) sejak tahun 2015 dengan menggunakan teknologi terkini berbasis *open-source*. MAGMA Indonesia meliputi aplikasi yang digunakan secara internal/pegawai (analisis data dan pelaporan) maupun eksternal/publik (informasi dan rekomendasi). Prinsip utama MAGMA Indonesia adalah mengubah data menjadi informasi dan rekomendasi yang mudah dipahami oleh masyarakat umum. MAGMA Indonesia adalah sistem yang terus belajar dan berevolusi, fitur-fitur baru akan lahir disesuaikan dengan kebutuhan jaman. Diharapkan bahwa seluruh informasi kebencanaan geologi nantinya dapat diakses oleh masyarakat dengan mudah melalui satu jendela (*single-window*). Hal ini merupakan manifestasi hadirnya negara secara aktif di tengah-tengah masyarakat dalam upaya mitigasi bencana geologi di Indonesia.

Pelayanan publik yang disajikan MAGMA Indonesia PVMBG saat ini terdiri dari:

- Gunungapi ::** (a) Informasi data pengamatan visual dan instrumental, tingkat aktivitas (status), dan rekomendasi gunungapi (Volcanic Activity Report/VAR), (b) Peta Kawasan Rawan Bencana (KRB) Gunungapi, maupun (c) Informasi abu vulkanik gunungapi untuk keselamatan penerbangan (Volcano Observatory Notice for Aviation/VONA).

DAPATKAN DI  
Google play

**Penghargaan**

Pada peringatan Hari Ulang Tahun Pertambangan dan Energi ke-71 yang diselenggarakan di Kantor Kementerian Energi dan Sumber Daya Mineral pada hari Selasa 4 Oktober 2016, MAGMA Indonesia memperoleh 2 (dua) penghargaan pada KESDM Innovation Awards (KIA), yaitu Peringkat Terbaik pada Kategori 3 dan Top 10 KIA 2016.

[Link berita selengkapnya](#)

**System Developers**

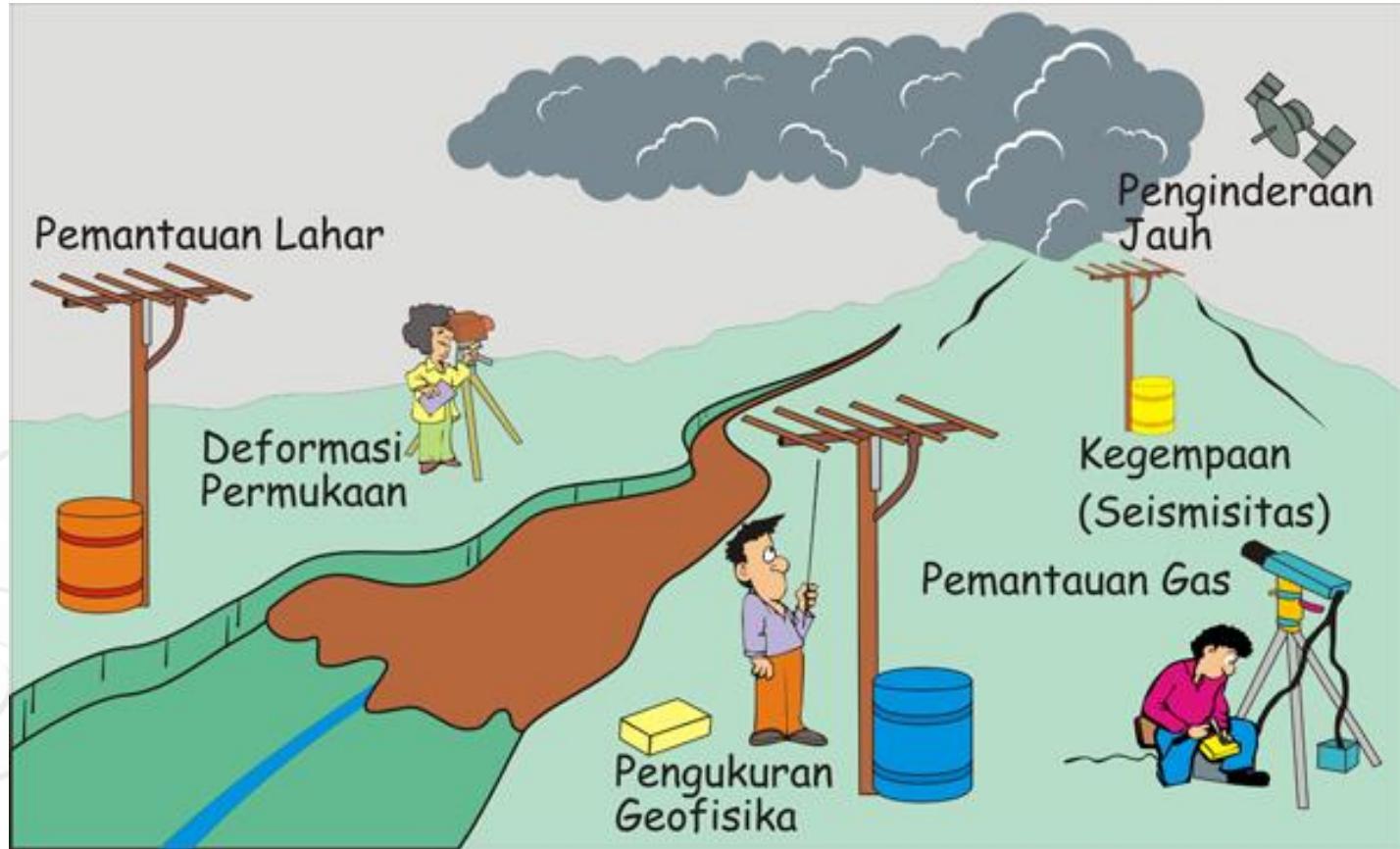
Tim developer (pengembang) MAGMA Indonesia seluruhnya

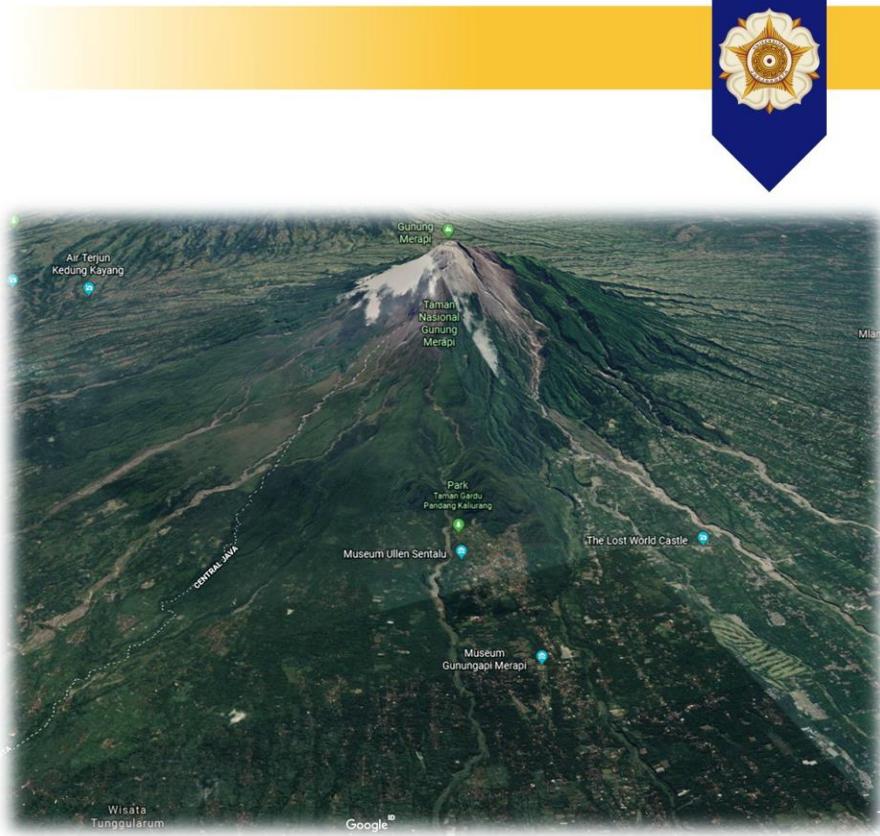
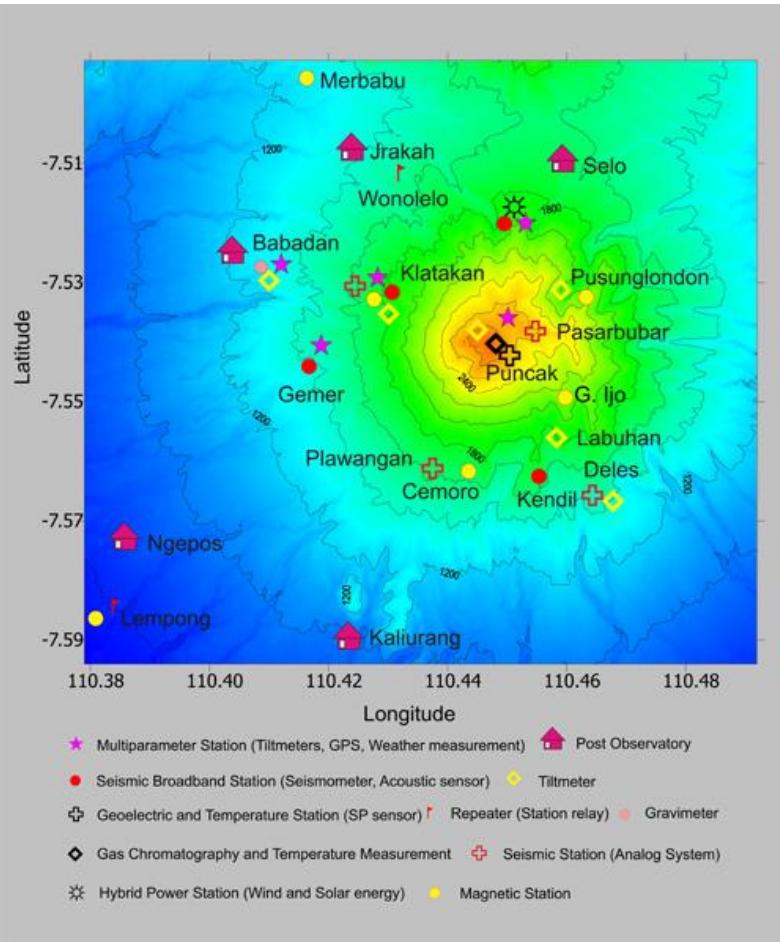


# Volcano EWS (BPPTKG)



<http://merapi.bgl.esdm.go.id/pub/page.php?idf=11>



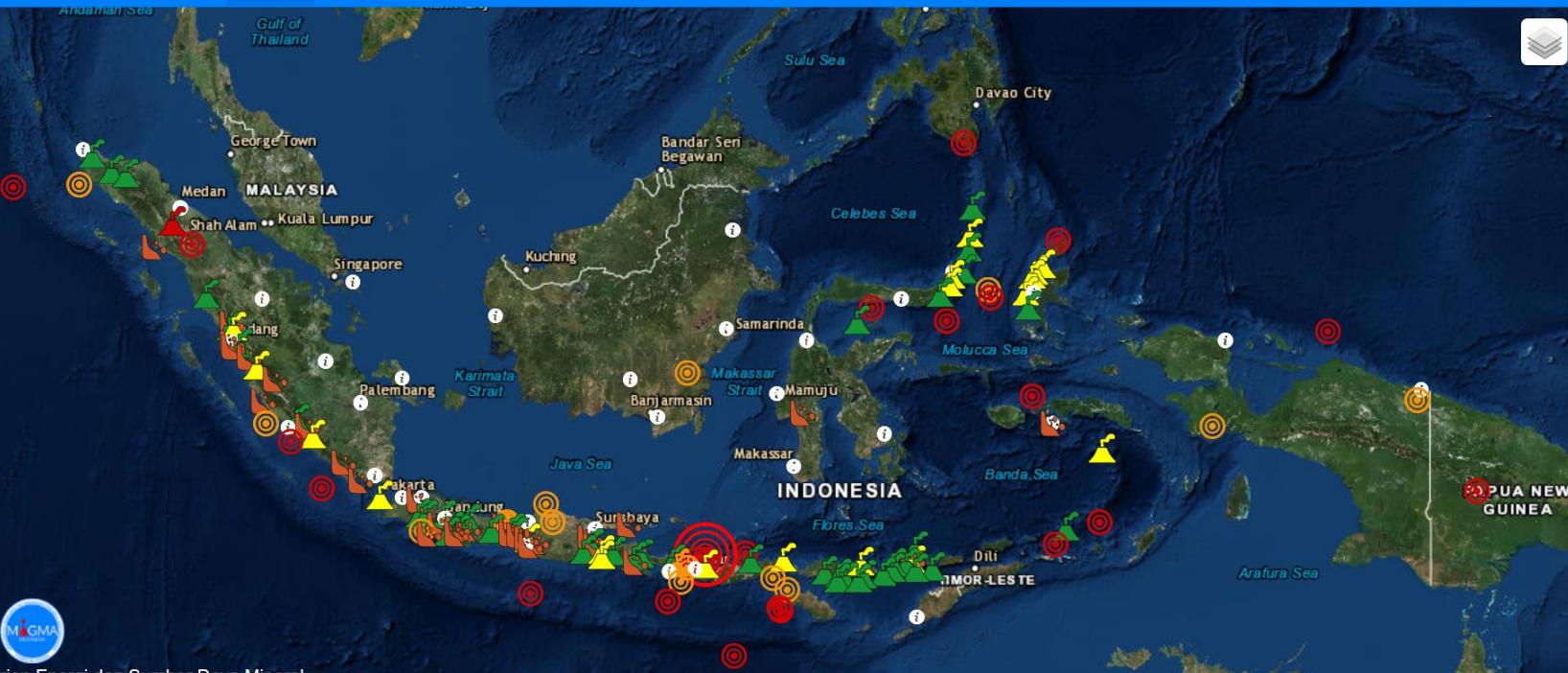




## MAGMA Indonesia

[Home](#)[VONA](#)[Press Release](#)[Tentang Magma](#)[Legenda](#)[Live Seismogram](#)[Staff Login](#)

+  
-



Kementerian Energi dan Sumber Daya Mineral



11/06/2006



13/06/2006



15/06/2006



29/11/2006

# Visual Monitoring



Kementerian Energi dan Sumber Daya Mineral

**Badan Geologi**

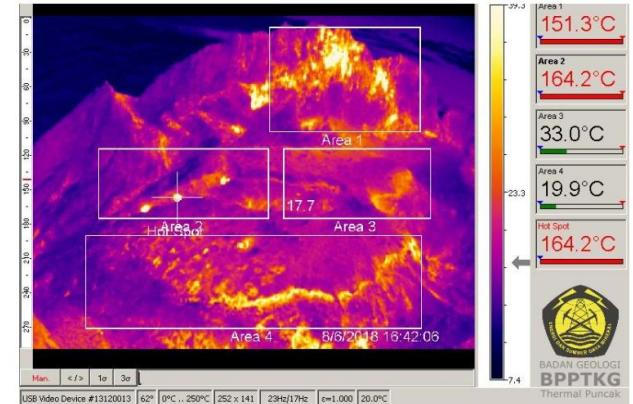
[Home](#) [BPPTKG](#) [Aktivitas Merapi](#) [Informasi Merapi](#) [Pustaka](#) [Login](#)

## Kamera CCTV Puncak BPPTKG

Merapi, CCTV Puncak



Merapi, THERMAL PUNCAK



# Public Information



MAGMA Indonesia

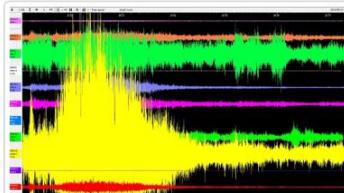
Home

Press Release



Letusan G. Merapi 24 Mei 2018 jam 10:48 WIB

Telah trjadi letusan di G. Merapi jam 10.48 WIB denga durasi 2 menit



## Letusan G. Merapi 24 Mei 2018

Terjadi letusan G. Merapi pukul 02.56 WIB, amplitudo maksimum 60 mm, tinggi kolom 6000 m arah condong ke Barat,durasi selama 4 meni...

[Detail](#)

24 Mei 2018 03:32 WIB

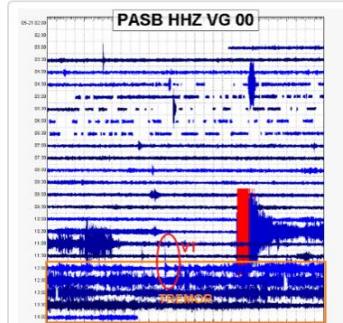


## Letusan Freatik Merapi

Terjadi letusan freatik pukul 13.49 WIB dengan amplitudo maksimum 50 mm dan durasi 2 menit. Terdengar dari Pos PGM Babadan namun ko...

[Detail](#)

23 Mei 2018 15:13 WIB



Peningkatan Status Gunung Merapi, DIY-Jateng dari Level I (Normal) menjadi Level II (Waspada)

### 1. Hasil Pengamatan

Berdasarkan pengamatan visual dari Pos Pengamatan dan CCTV cuaca...

[Detail](#)

21 Mei 2018 23:46 WIB



**BPPTKG**

@BPPTKG

JALIN Merapi, J O G J A, and 5 others follow

Akun Resmi BPPTKG - PVMBG - Badan Geologi - Kementerian Energi dan Sumber Daya Mineral

⌚ Jl. Cendana 15 Yogyakarta

🔗 [merapi.bgl.esdm.go.id](http://merapi.bgl.esdm.go.id)

290 Following 118,2K Followers

Tweets Tweets & replies Media

Pinned Tweet

BPPTKG @BP... · 21/06/18



Locally Rooted, Globally Respected

# Public Information



The screenshot shows the official Twitter account of BPPTKG (Badan Pengawas Perdagangan Luar Negeri dan Perindustrian) for Mount Merapi. The profile features a circular logo with four quadrants containing icons of a volcano, a tree, a person, and a house. The bio reads: "Akun Resmi BPPTKG - PVMBG - Badan Geologi - Kementerian Energi dan Sumber Daya Mineral". The account has 18,035 tweets, 18K tweets, 290 following, 118K followers, and 1,055 likes. A pinned tweet from June 2020 states: "Tingkat aktivitas Merapi saat ini WASPADA (Level 2) 07.39 Via PGM.Kaliurang visual #merapi tampak cuaca berawan, suhu udara 15.5 °C, kelembaban 83 %rh, pressure 918.9 hpa, angin tenang. #statuswaspada". Below the timeline is a media section showing a photograph of Mount Merapi with a watermark for "Sunaria BPPTKG 2018". On the right, there are sections for "New to Twitter?", "Sign up", and "You may also like". The footer includes the university's name and website.

Home About Search Twitter Have an account? Log in

18,035 Tweets

Tweets 18K Following 290 Followers 118K Likes 1,055

**BPPTKG**   
@BPPTKG

Akun Resmi BPPTKG - PVMBG - Badan Geologi - Kementerian Energi dan Sumber Daya Mineral

⌚ Jl. Cendana 15 Yogyakarta  
🔗 [merapi.bgl.esdm.go.id](http://merapi.bgl.esdm.go.id)  
📍 View broadcasts  
Joined April 2013

8,102 Photos and videos

Pinned Tweet

BPPTKG @BPPTKG · Jun 20 Tingkat aktivitas Merapi saat ini WASPADA (Level 2) 07.39 Via PGM.Kaliurang visual #merapi tampak cuaca berawan, suhu udara 15.5 °C, kelembaban 83 %rh, pressure 918.9 hpa, angin tenang. #statuswaspada

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IG: Merapi\_News  
@merapi\_news

JALIN Merapi  
@jalinmerapi

BPBD DIY  
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BNPB Indonesia   
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IG : inisleman  
@Inisleman

Worldwide trends

[www.ugm.ac.id](http://www.ugm.ac.id)

# Summary



- The dissemination pattern adopted here is from PVMBG and BPPTKG. Warning of a volcano activity is sent to the interface institution through various modes ie: web interface, and common social media. While the interface institution in question is primarily Provincial Government, Department of Home Affairs, POLICE, National Army, Television, Radio, GSM Operator, BNPB, etc ..
- The official social media from BPPTKG helps public to knowing the right information about the volcano activity.
- Even a 10 minutes warning signal from the BPPTKG could help the tourist/climber to sudden evacuate to the safely area.

# Tantangan Mitigasi Bencana di Indonesia



Gambar: Getty images

## Lembaga Riset + Universitas + Pemerintah

- **Data Observasi**
- **Menejemen data**
- **Resource Sharing**



- Memahami proses
- Memperkirakan kejadian
- Komunikasi ke Masyarakat



# Summary





UNIVERSITAS GADJAH MADA

# Terima Kasih

