Epidemiologi
BENCANA ALAM DI INDONESIA

Training of Facilitators
HOSPITAL DISASTER PLAN

PMPK UGM_Depkes_WHO
Surabaya, 9 Mei 2010

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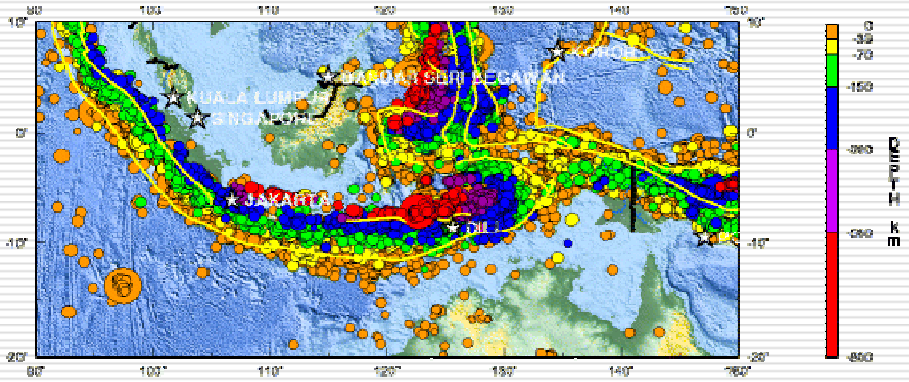
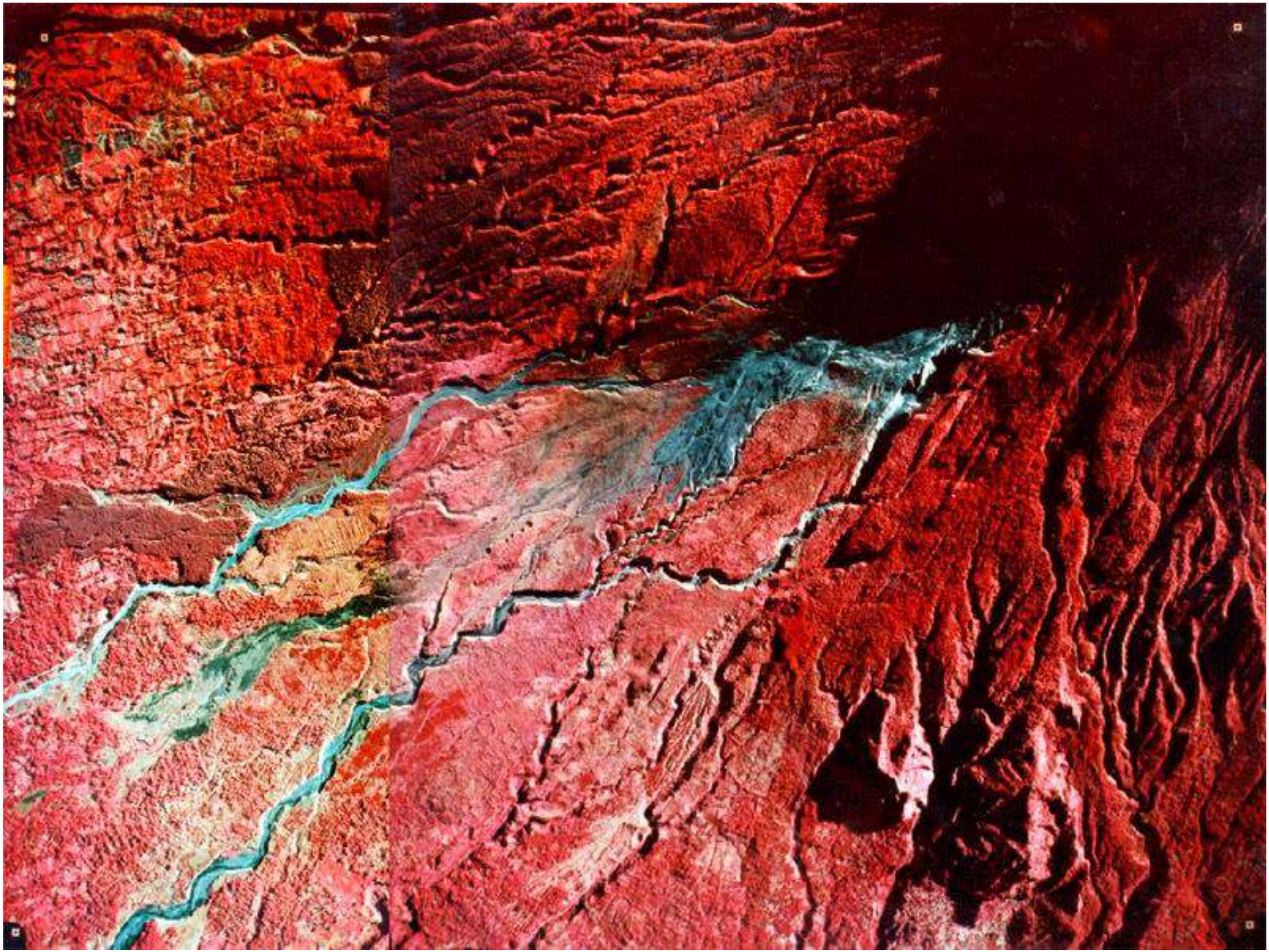


Seismicity of Indonesia, 1990 - 2000

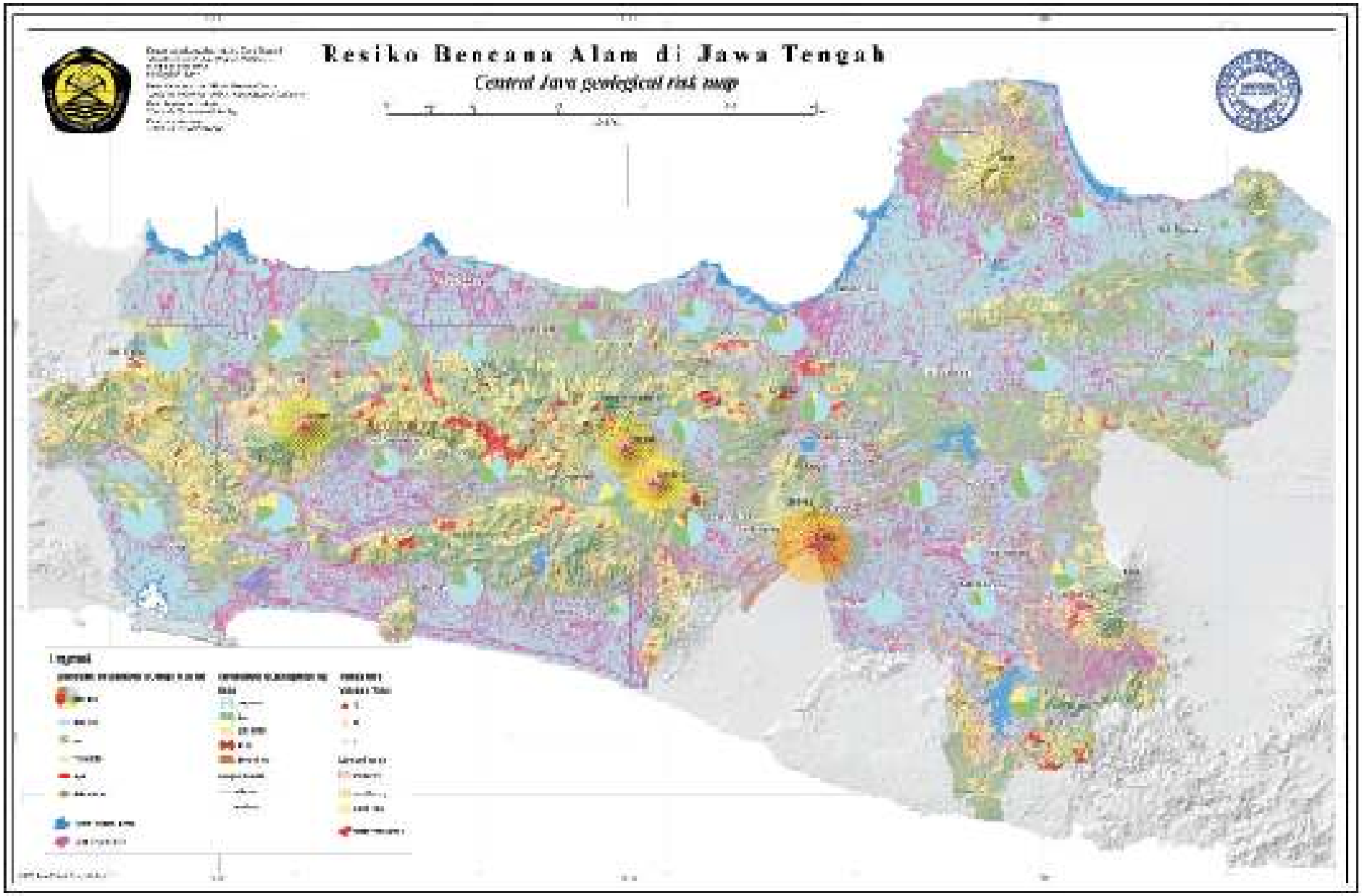


Classification of Hazards

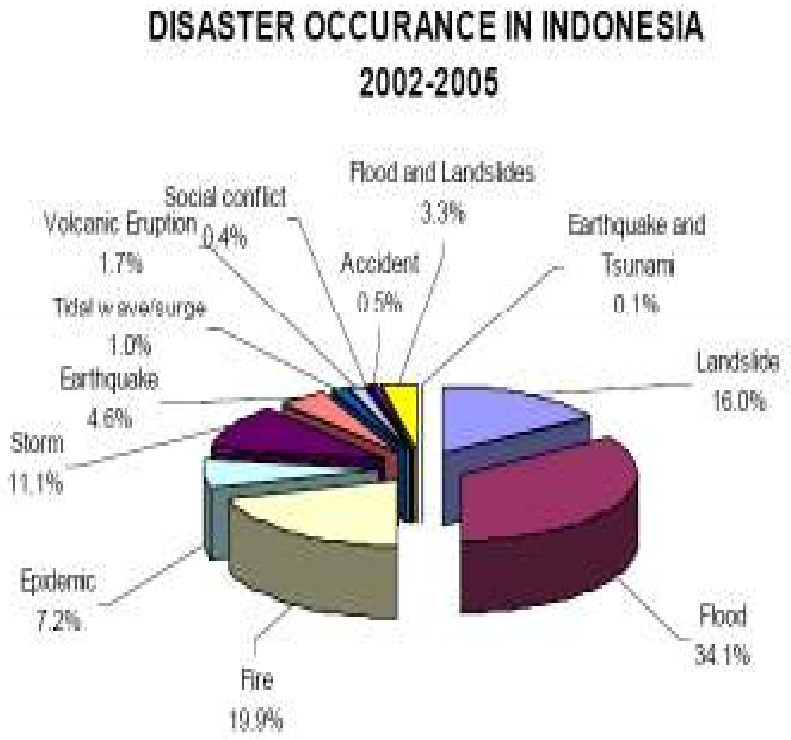
- Natural
- Biological
- Technological
- Societal

Klasifikasi Hazards

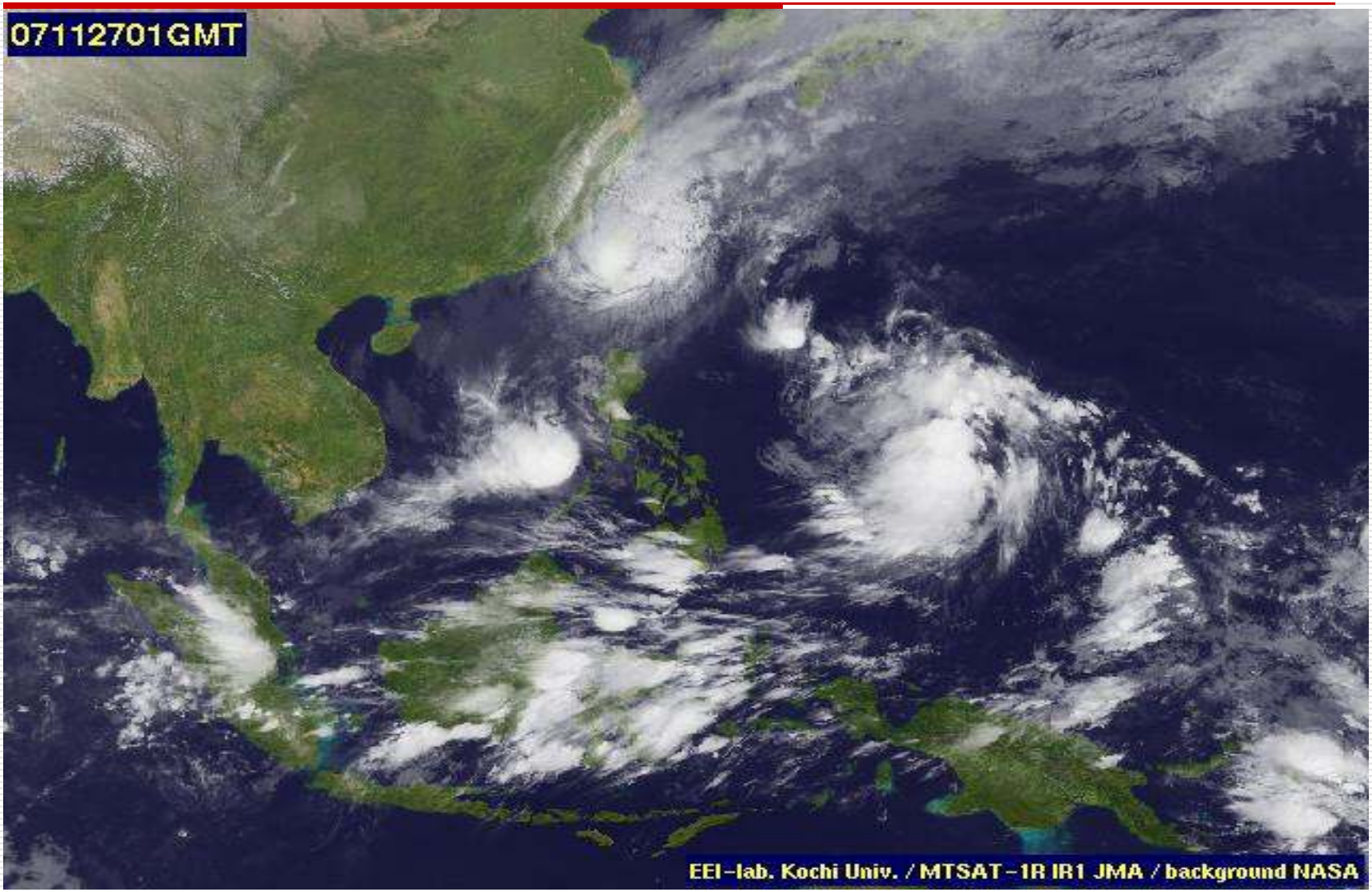
➢ **Atmospheric** *Single element* Excess rainfall Freezing rain (glaze) Hail Heavy snowfalls High wind speeds Extreme temperatures	**Atmospheric** *Combined elements/events* Hurricanes 'Glaze' storms Thunderstorms Blizzards Tornadoes Heat/cold stress
2. Hydrologic Floods – river and coastal Wave action Drought Rapid glacier advance	**3. Geologic** Mass-movement Landslides Mudslides Avalanches Earthquake Volcanic eruption Rapid sediment movement
4. Biologic Epidemic in humans Epidemic in plants Epidemic in animals Locusts	**5. Technologic** Transport accidents Industrial explosions and fires Accidental release of toxic chemicals Nuclear accidents Collapse of public buildings


Resiko Bencana Alam di Jawa Tengah
Central Java geological risk map

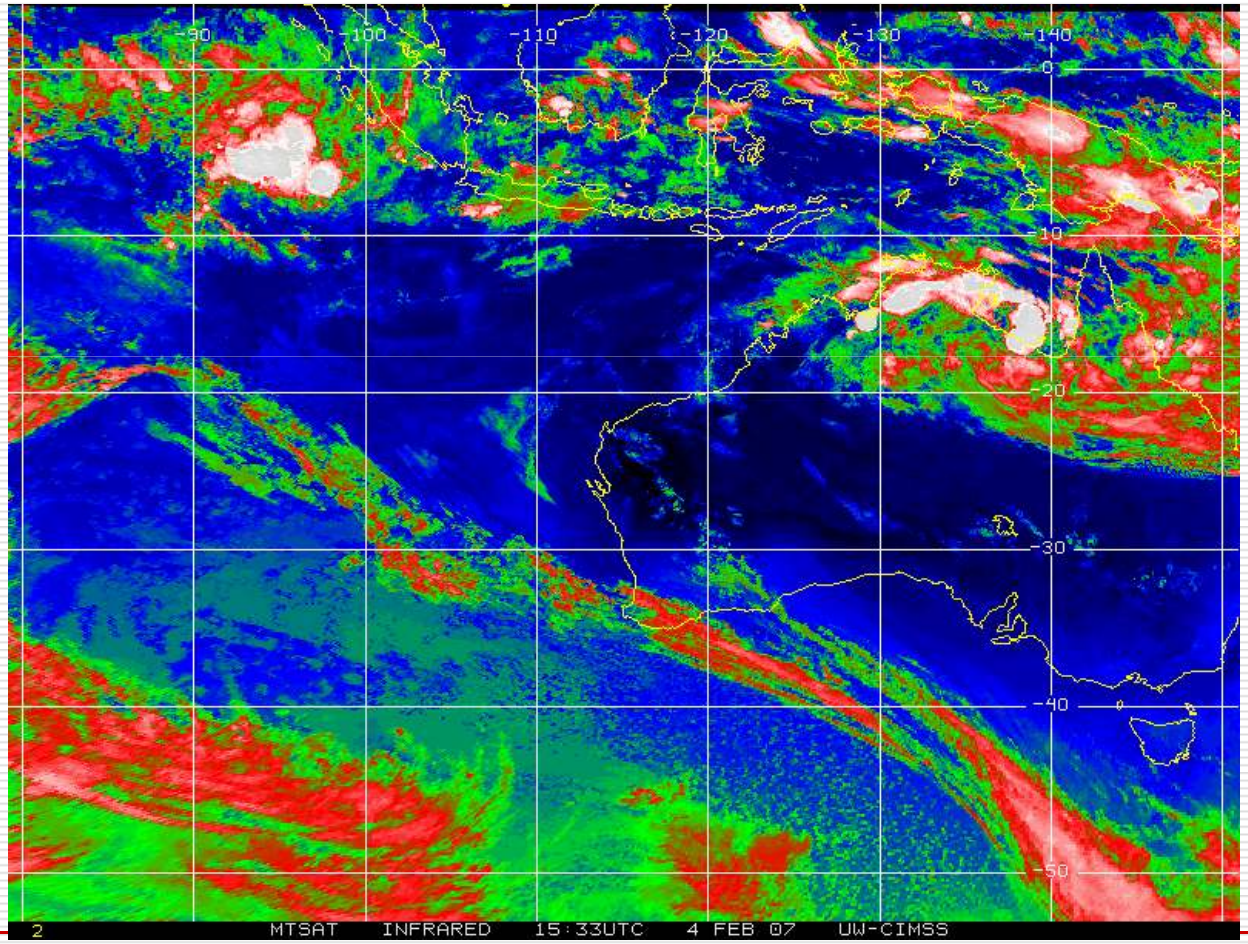
Potensi “hazards” di Indonesia



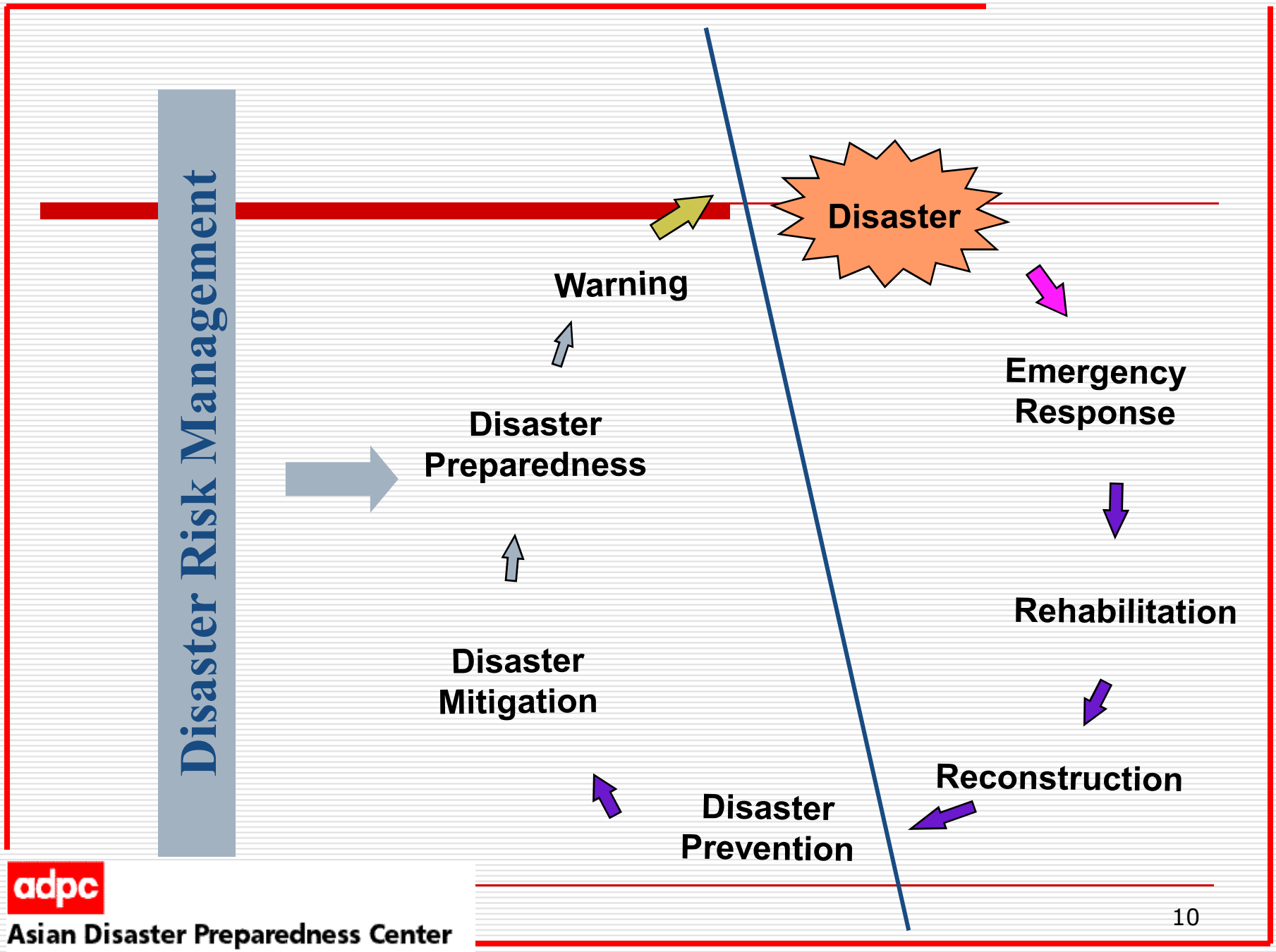
Dampak badai di Asia



Dampak badai di Australia



Convensional DM cycle



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Hazard

is an event or occurrence that has the potential for causing injuries to life and damaging property and the environment.

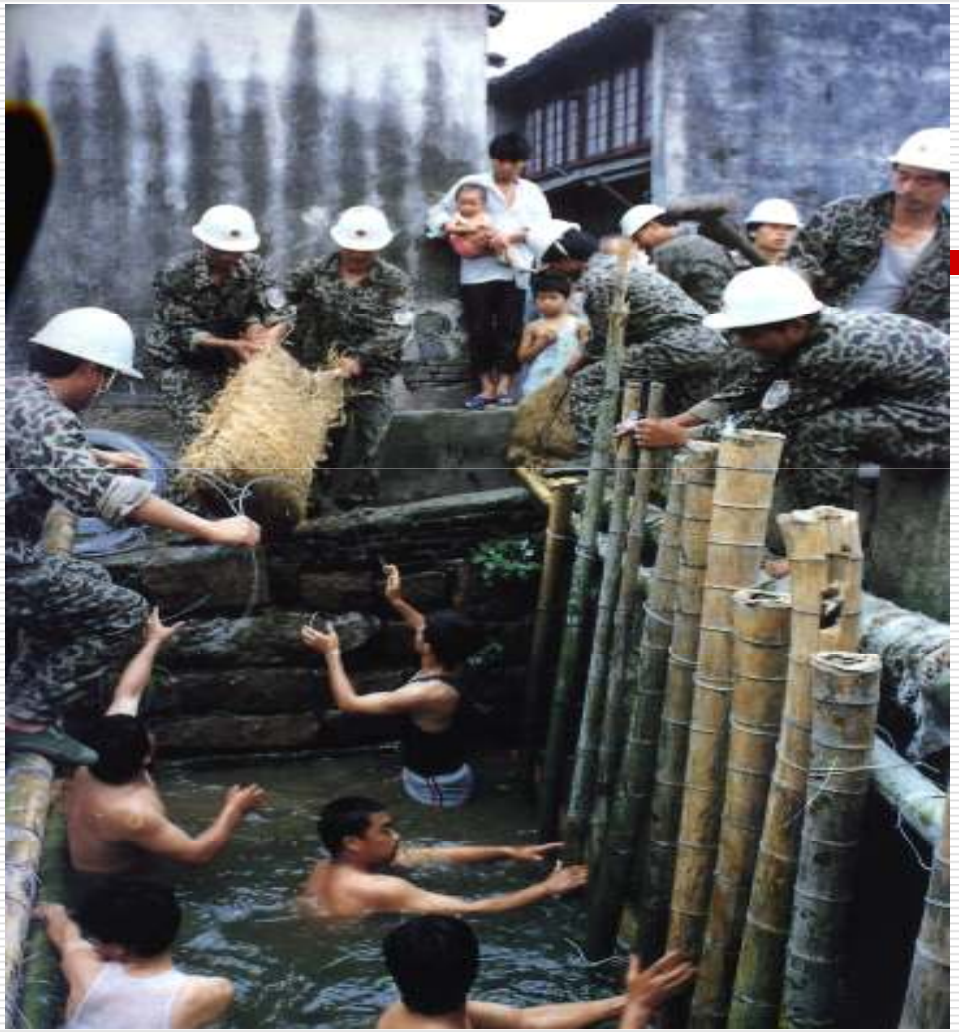
Disaster

A serious disruption of the functioning of a community causing widespread human, material or environmental losses which exceed the ability of the affected community to cope using its own resources

Vulnerability

Vulnerability is a condition or sets of conditions that reduces people's ability to prepare for, withstand or respond to a hazard

Capacity



Capacities are those positive condition or abilities which increase a community's ability to deal with hazards.

Risk

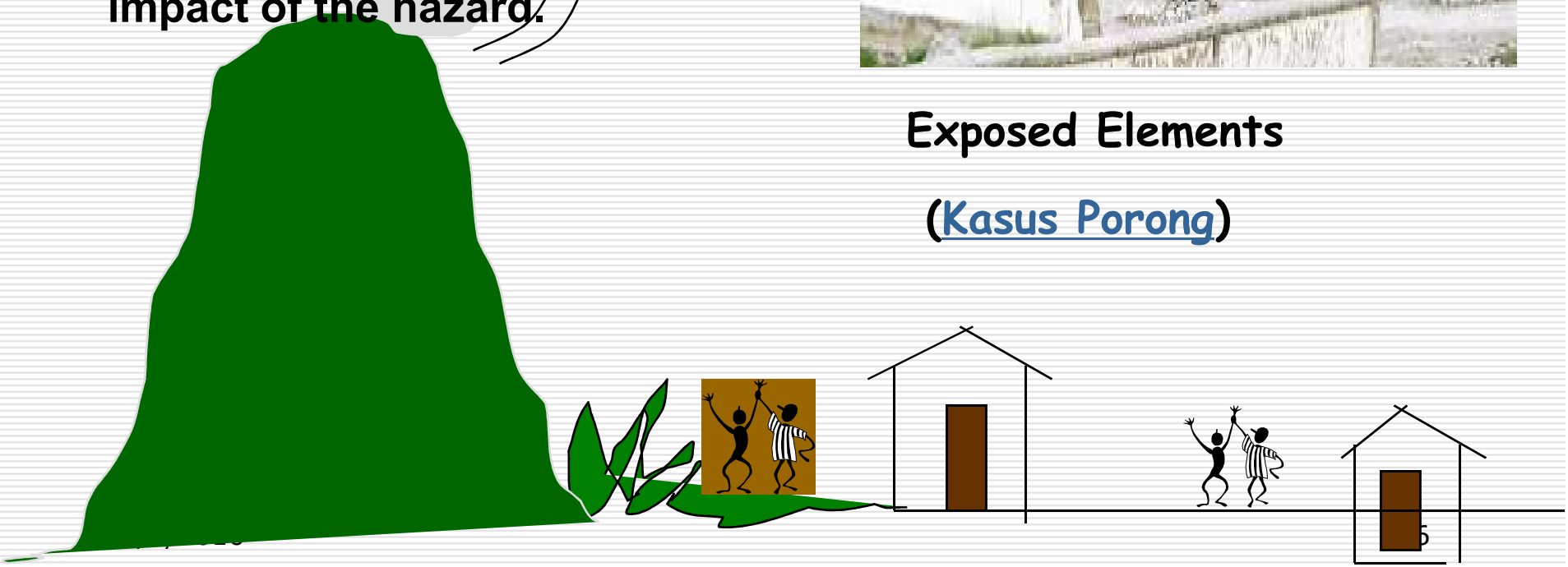
The probability that a community's structure or geographic area is to be damaged or disrupted by the impact of a particular hazard, on account of their nature, construction, and proximity to a hazardous area

Elements at Risk

Persons, buildings, crops or other such like societal components exposed to known hazard, which are likely to be adversely affected by the impact of the hazard.

Exposed Elements

(Kasus Porong)



Session 2.3.
HAZARDS, VULNERABILITY, AND RISK IN THE COASTAL AREA

How these terms are interconnected to each other?

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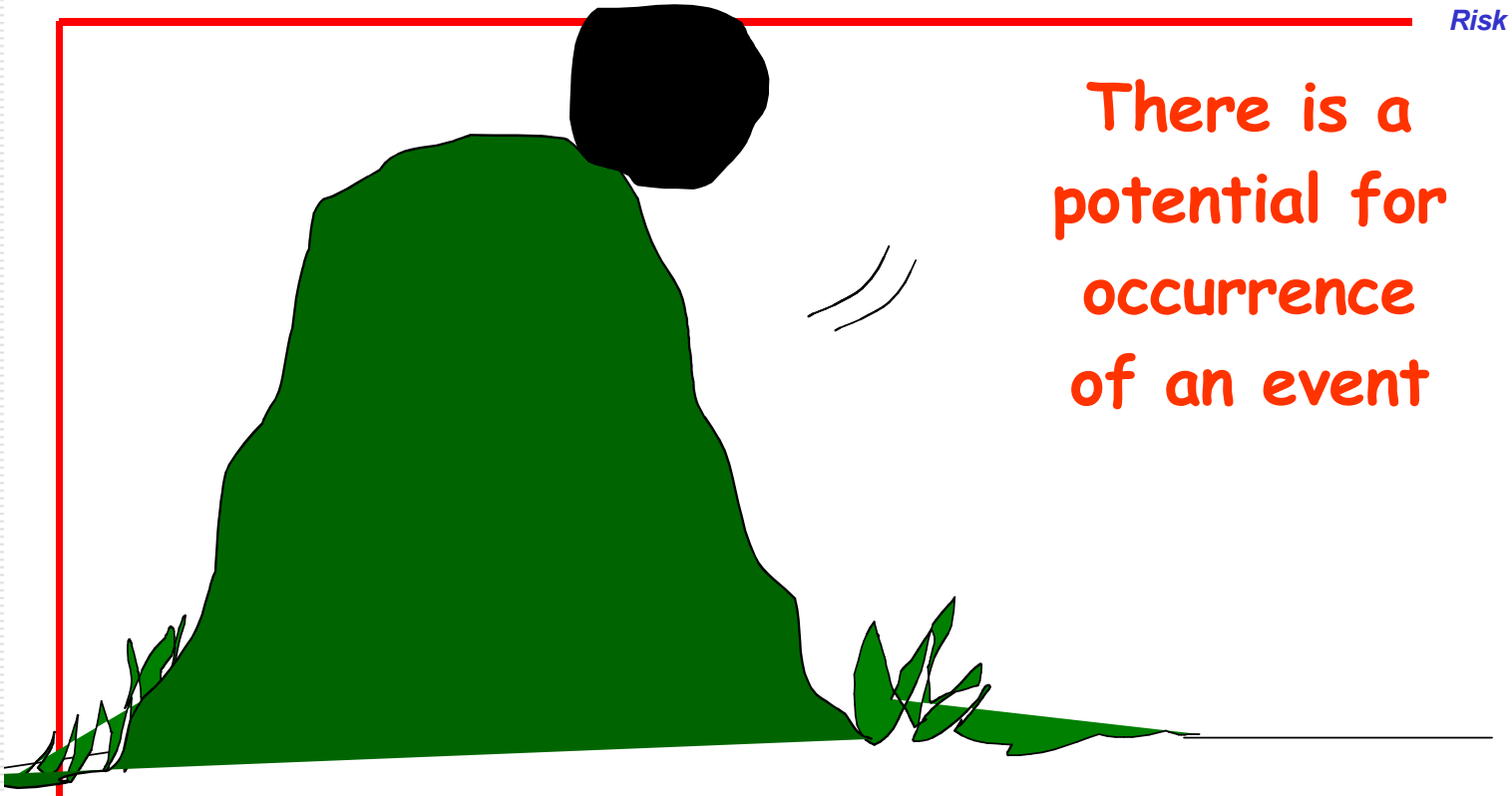


There is a potential for occurrence of an event

HAZARD is any substance, phenomenon or situation, which has the potential to cause disruption or damage to people,their property, their services and their environment

Secondary hazards

These are hazards that follow as a result of other hazard events. Hazards secondary to an earthquake may be listed as follows to illustrate the concept. Primary hazard is the earthquake. Secondary hazards are

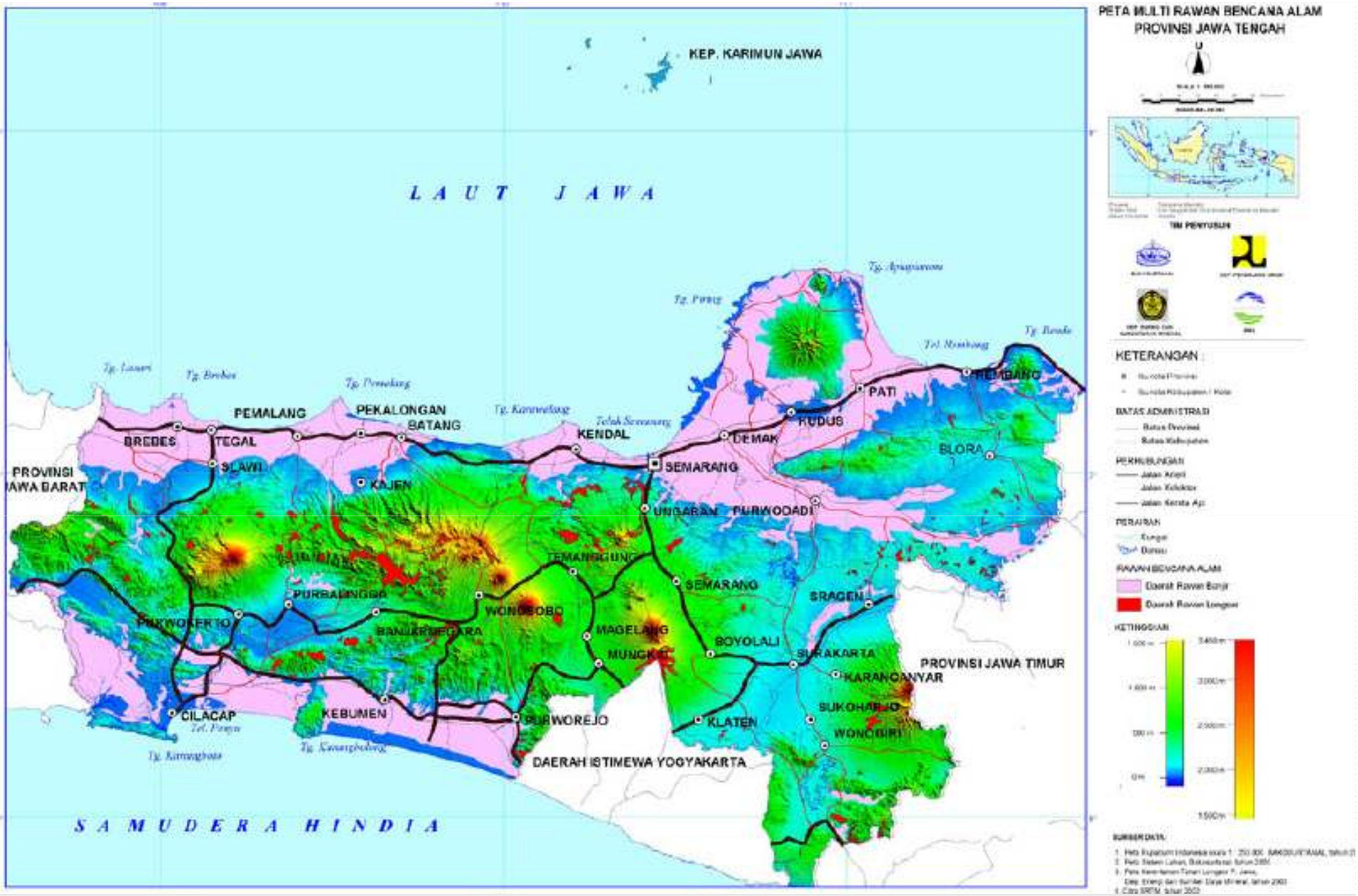
- **Building collapse**
- **Dam failure**
- **Fire**
- **Hazardous material spill**
- **Interruption of power/ water supply/ communication/ transportation/ waste disposal**
- **Landslide**
- **Soil liquefaction**
- **Tsunami (tidal wave)**
- **Water pollution**

Multiple hazards

When more than one hazard event impacts the same area, there arises a multiple hazard situation. These different hazard events may occur at the same time or may be spaced out in time.

The Return Period

Majority of hazards have return periods on a human time-scale. Examples are five-year flood, fifty-year flood and a hundred year flood. This reflects a statistical measure of how often a hazard event of a given magnitude and intensity will occur. The frequency is measured in terms of a hazard's recurrence interval.


PETA MULTI RAWAN BENCANA ALAM
PROVINSI JAWA TENGAH
KEP. KARIMUN JAWA
L A U T J A W A
S A M U D E R A H I N D I A
PROVINSI JAWA BARAT
PROVINSI JAWA TIMUR
DAERAH ISTIMEWA YOGYAKARTA
BREBES
TEGAL
SLAWI
PEMALANG
PEKALONGAN
BATANG
KENDAL
SEMARANG
DEMAK
KUDUS
PATI
REMBANG
BLORA
KAJEN
UNGARAN
PURWODADI
TEMANGGUNG
PURBALINGGA
WONOSOBO
BANJARNEGARA
PURWOKERTO
MAGELANG
MUNGKID
SEMARANG
SRAGEN
BOYOLALI
SURAKARTA
KARANGANYAR
SUKOHARJO
WONOGIRI
KLATEN
CILACAP
KEBUMEN
PURWOREJO
KETERANGAN
BATAS ADMINISTRASI
PERHUBUNGAN
PERAIRAN
RAWAN BENCANA ALAM
KETINGGIAN

Hazards on the rise?

Climate Change

Sea level rise

Global worming

- Urbanization
- Population growth
- Land degradation
- poverty

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Hazard assessment
INTRODUCTION

- ***A hazard is a potentially damaging event and the measure of hazard is it's probability of occurrence at a certain level of severity within a specified period of time in a given area*.**

- Hazard identification implies to **"what might happen and where?"**
- Hazard assessment implies to **"How and when?"**

HAZARD ASSESSMENT

"The process of studying the nature of natural /man made hazards determining its essential features (degree of severity ,duration,extent of the impact area) and their relationship"..

Hazards
ASSESSMENT APPROACHES

Quantitative Approach

- Use mathematical functions with numerical values
- Each variable will describe the relationship among parameters that characterize the phenomena

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Hazards
ASSESSMENT APPROACHES

Qualitative Approach

- Use qualitative descriptions (such as low, medium or high) instead of numerical values

Hazards
ASSESSMENT METHODS

Deterministic Approach.

- Determined through associated physical characteristics and analysis of consequences.

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Hazards
ASSESSMENT METHODS

Probabilistic Approach

- Estimates the probability of each hazard affecting an area or region, and likelihood of occurrence and can be determined through research studies, simulation studies, etc (eg. Flood/erosion simulation studies, slope stability calculations, landslide hazard zonation).

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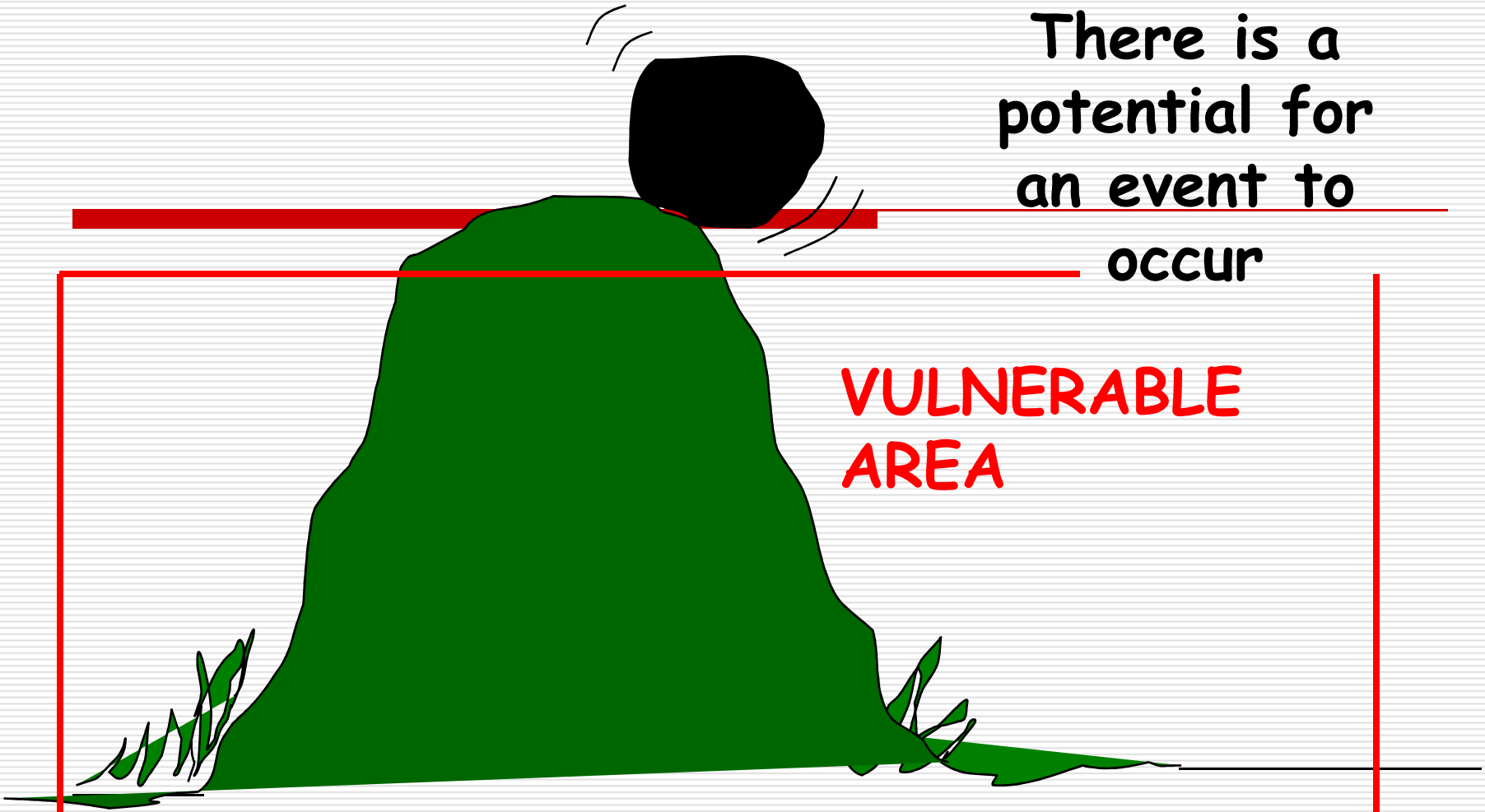
HAZARD ASSESSMENT TECHNIQUES AND TOOLS

Hazard Zonation mapping

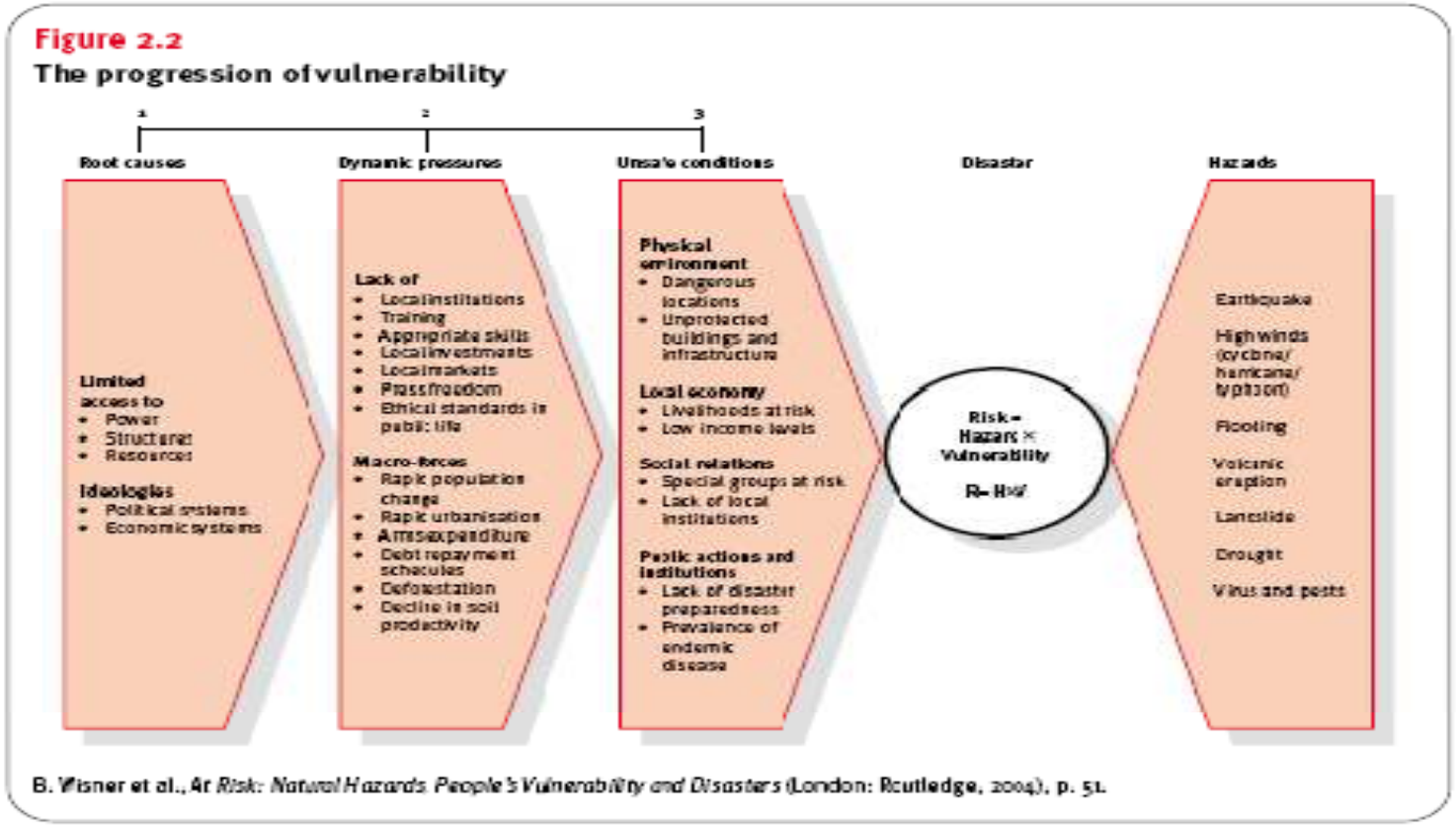
- *Hazard maps outline zones that are defined in terms of the probability of occurrence of potentially damaging phenomena within a certain span of time within a specified location or an area.(Varnes,1984)*

Vulnerability



Vulnerability is a concept which describes **factors or constraints** of an economic, social, physical or geographic nature, which **reduce the ability to prepare for and cope with the impact of hazards.**

Progression of the vulnerability



B. Wisner et al., At *Risk: Natural Hazards People's Vulnerability and Disasters* (London: Routledge, 2004), p. 51.

Definition of Capacity

- The resources, means and strengths possessed by persons, communities, societies or countries which enable them to cope with, withstand, prepare for, prevent, mitigate or quickly recover from a disaster.

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Dimensions

- **Awareness**
  - this state of being refers to a population's level of understanding of the hazards, the warning systems, preparedness measures and the ability to respond or utilize information to counter the effects of the hazards;
- **Laws and Regulations**
  - these refer to a society's existing statutes that guide the use of resources for preparation and isks brought about by hazards;

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- **Prevention and Mitigation Activities and Projects**
  - **these refer to the existing and proposed actions and activities designed to impede the occurrence of a disaster event and/or prevent such an occurrence having harmful effects on the communities and key installations;**
- **Preparedness**
  - **this refers to measures which enable governments, communities and individuals to respond rapidly and effectively to disaster situation**

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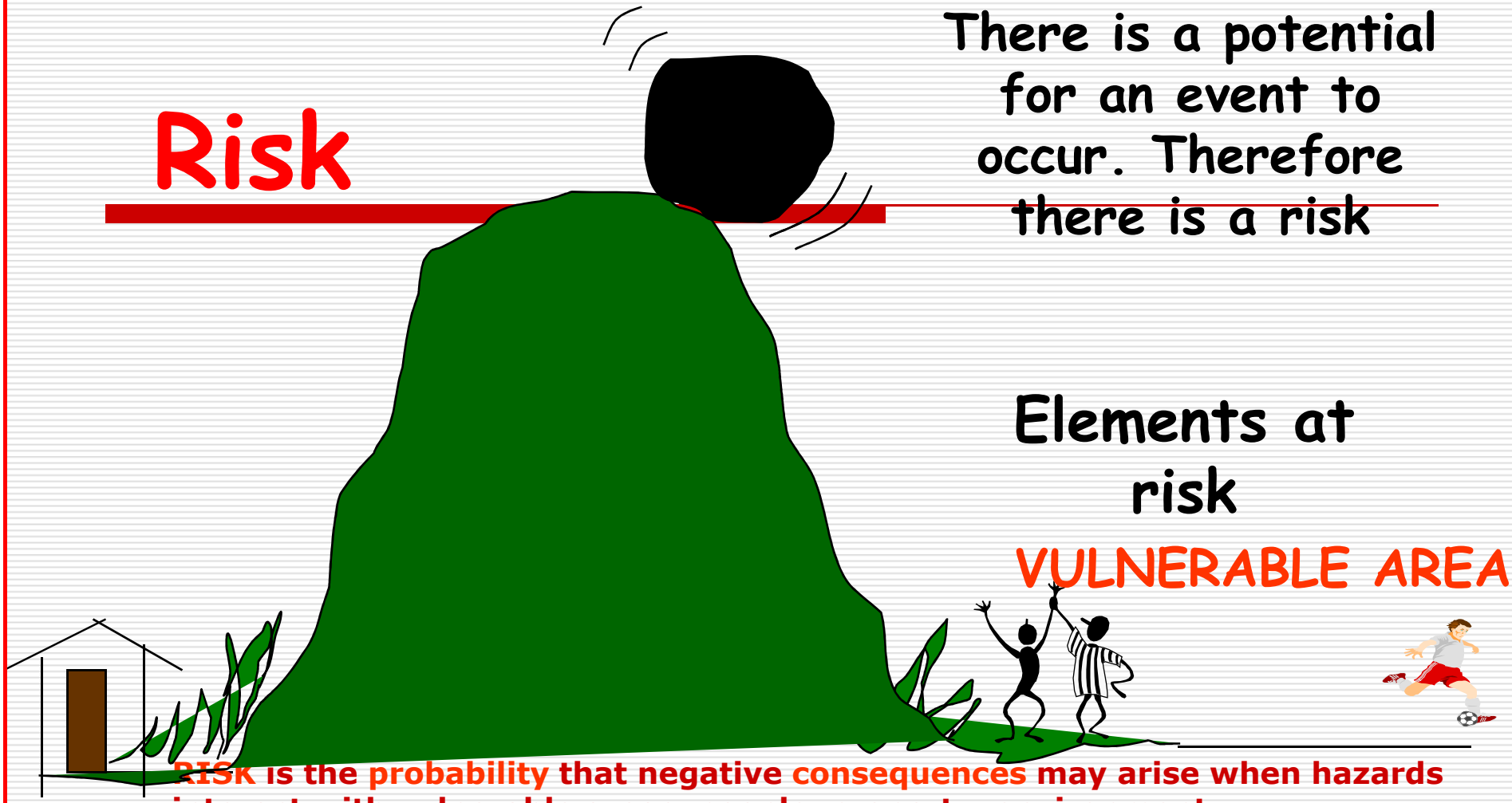
Risk

There is a potential for an event to occur. Therefore there is a risk

Elements at risk

VULNERABLE AREA



RISK is the probability that negative consequences may arise when hazards interact with vulnerable areas, people, property, environment.
RISK is a concept which describes a potential set of consequences that may [illegible] circumstances.

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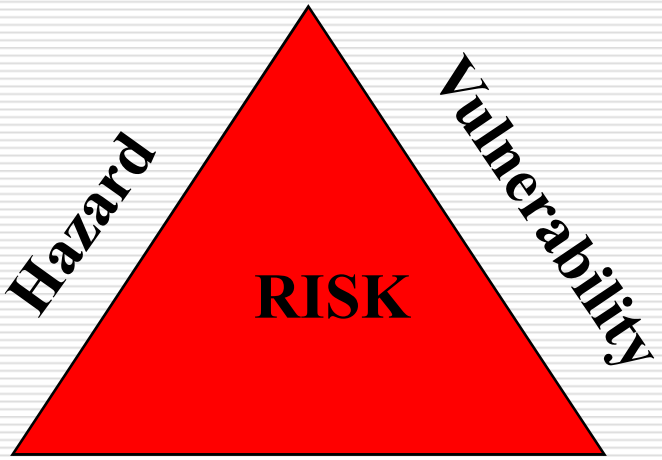
Concepts of the Risk and its Analysis:

The Risk Triangle:



Risk is a combination of the interaction of hazard, exposure, and vulnerability, which can be represented by the three sides of a triangle.

If any one of these sides increases, the area of the triangle increases, hence the amount of risk also increases.

If any one of the sides reduces, the risk reduces.

If we can eliminate one side there is no risk.

Parameters of Risk

Hazards are the source of risks

Hazards create risks by exposing pre-existing vulnerabilities

The risk that a community faces is mitigated by its level of preparedness, response and recovery or readiness

. The methodology for risk assessment

The methodology involves six steps as follows:

i. Define the geographic area to be studied.
ii. Identify the type and amount of data needed to complete the risk assessment.
iii. Identify the potential hazard(s) within the risk area.
iv. Identify vulnerability.
v. Prepare an inventory of elements at risk.
vi. Apply hazard specific damage functions to the inventory to determine direct damage quantitatively or rank potential damage qualitatively.
vii. Apply loss functions to damage results to estimate level of financial, personal, or property losses quantitatively or rank potential losses qualitatively.

HOW TO DEFINE POSSIBLE ELEMENTS AT RISK

Consequence	Measure	Tangible	Intangible
Deaths	No. of People	Loss of active individuals.	Social and psychological effects of remaining community.
Injuries	No. of people % disability	Medical Costs loss of productivity. Temporary loss of economic activity.	Social and psychological effects of relatives & injured, pain & recovery.

Continued…..

Consequence	Measure	Tangible	Intangible
Physical Damage	No. of damaged houses, structures etc., agricultural areas. Level of damage %	Replacement costs, rehabilitation & repairs cost.	Cultural losses, Social effects.
Emergency operations	No. of man-days Equipment and resources hours.	Mobilisation costs Investments in preparedness measurers.	Stress & overwork of relief workers.

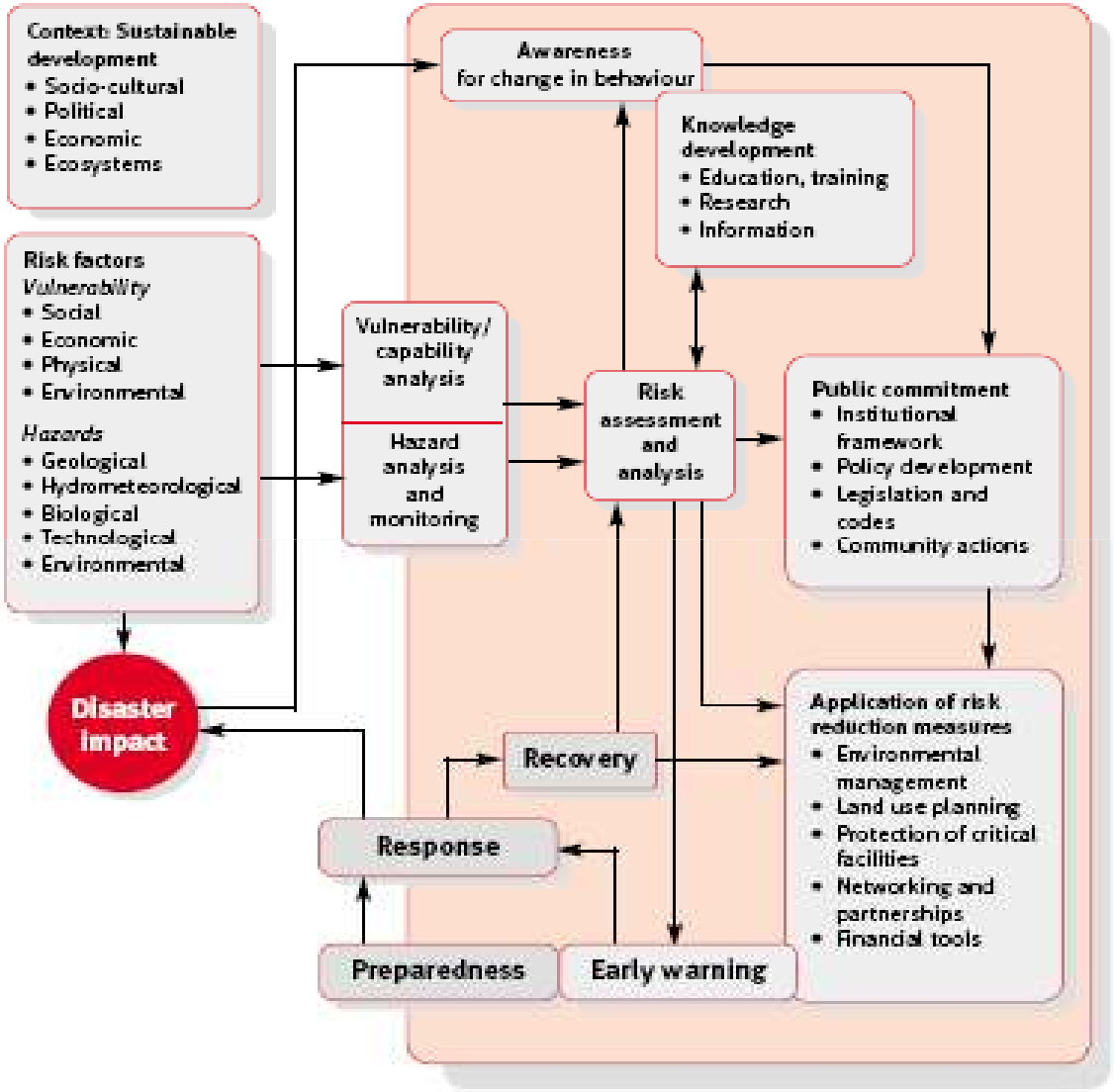
Continued…..

Consequence	Measure	Tangible	Intangible
Disruption of Economy	No. of lost working days, value of production lost.	Cost of lost productivity.	Opportunities competitiveness reputation.
Social Disruption	No. of displaced, No. of homeless.	Cost for temporary housing, relief, health care.	Psychological, social contacts cohesion morale.
Environmental Impact	Scale & Severity	Maintenance & repair cost.	Health risks, Future disaster risk.

Continued…..

Figure 1.1

A framework for disaster risk reduction



Living with Risk: A Global View of Disaster Reduction Initiatives (Geneva: UN International Strategy for Disaster Reduction, 2002), p. 23.

RISK ANALYSIS

- 'Risk analysis' is employed in its broadest sense to include:
- Risk assessment
  - involves identifying sources of potential harm, assessing the likelihood that harm will occur and the consequences if harm does occur.
- Risk management
  - evaluates which risks identified in the risk assessment process require management and selects and implements the plans or actions that are required to ensure that those risks are controlled.
- Risk communication
  - involves an interactive dialogue between stakeholders and risk assessors and risk managers which actively informs the other processes.
- **Risk analysis = risk assessment + risk management + risk communication**

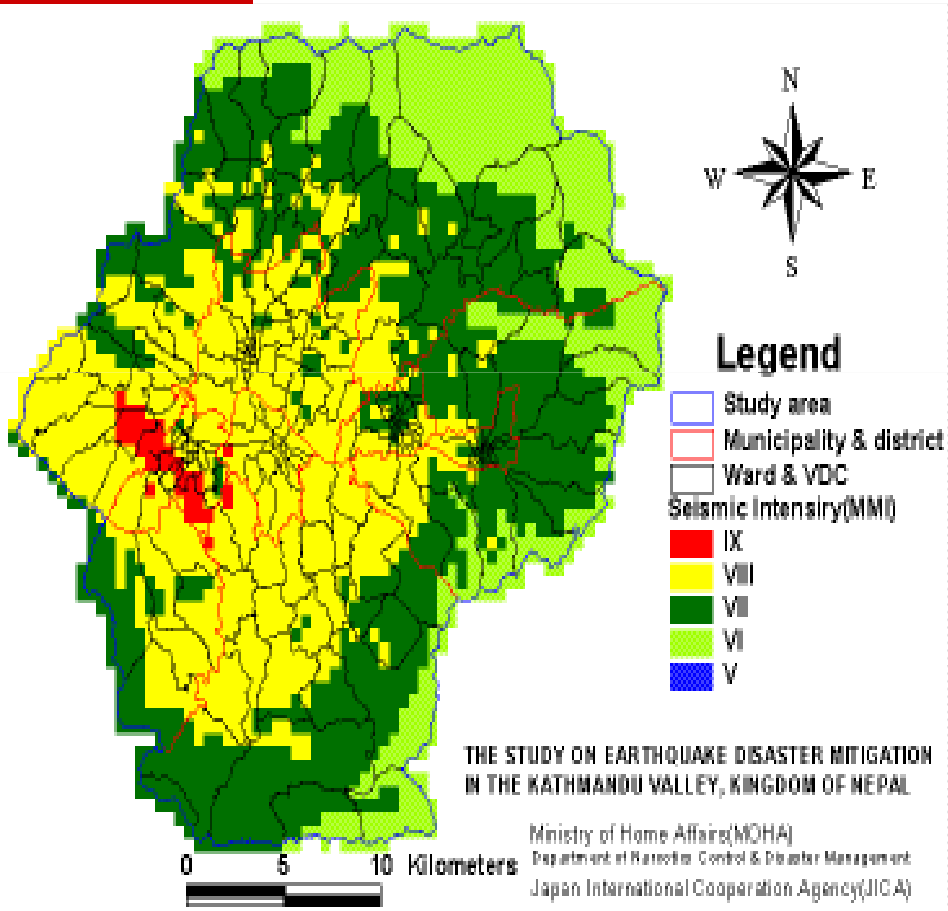
KONSEP PENYELENGGARAAN PENANGGULANGAN BENCANA

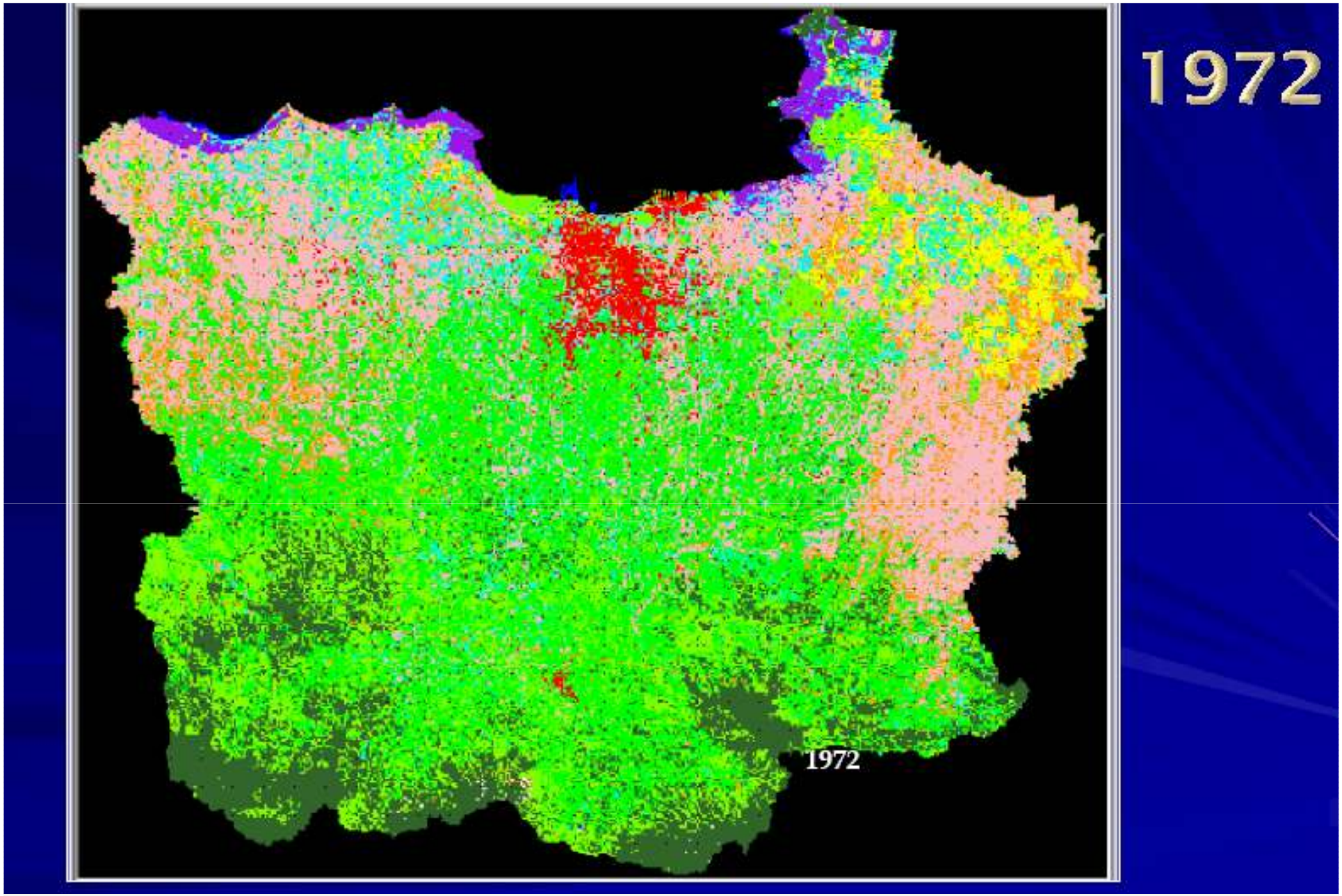
Adalah serangkaian upaya yang meliputi :

- penetapan kebijakan yang berisiko timbulnya bencana
- kegiatan pencegahan bencana
- Kegiatan tanggap darurat
- Kegiatan rehabilitasi dan rekonstruksi

TAHAPAN PENYELENGGARAAN PB

- TAHAP PRA BENCANA
- SAAT TANGGAP DARURAT
- PASCA BENCANA




1972
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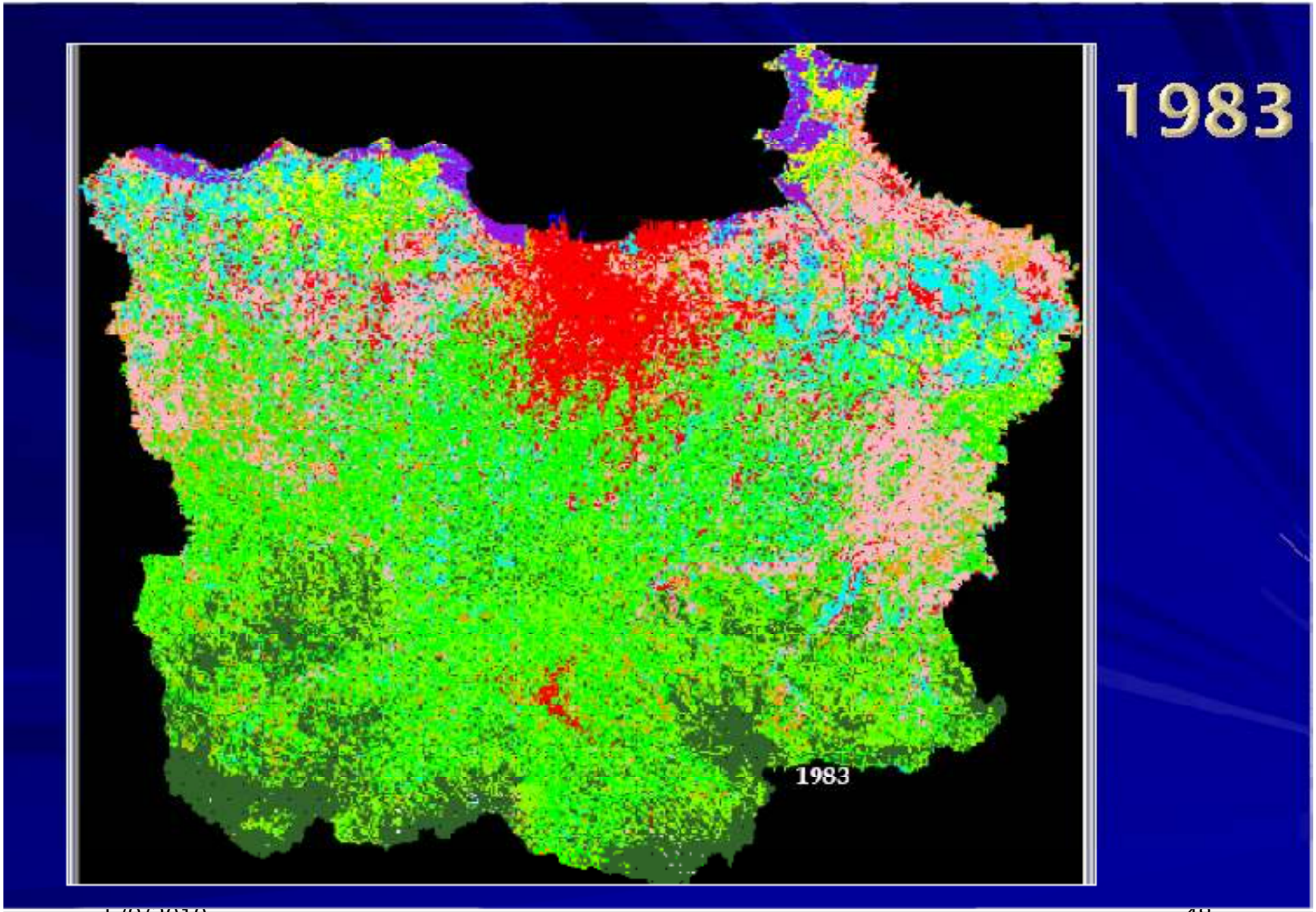
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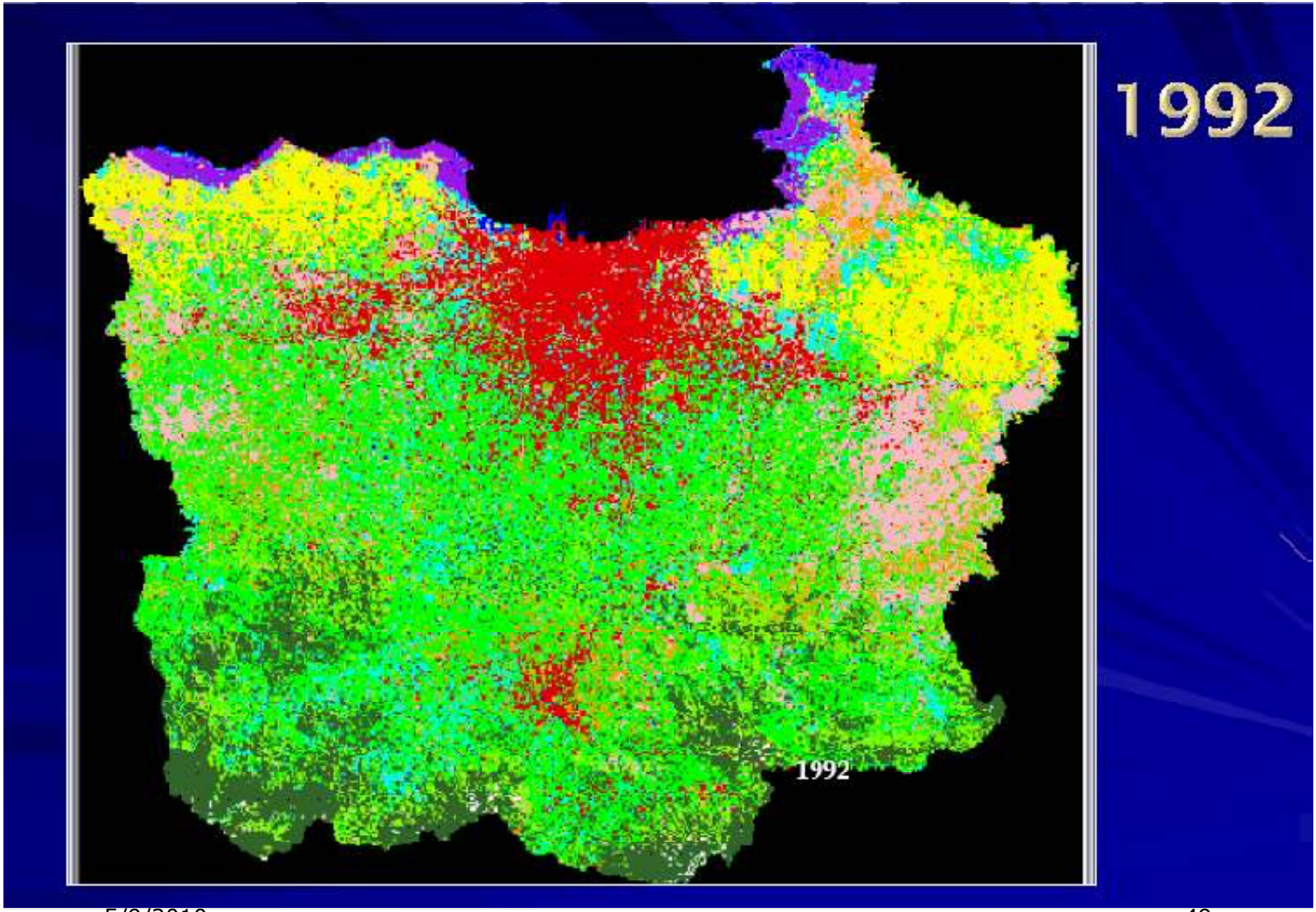
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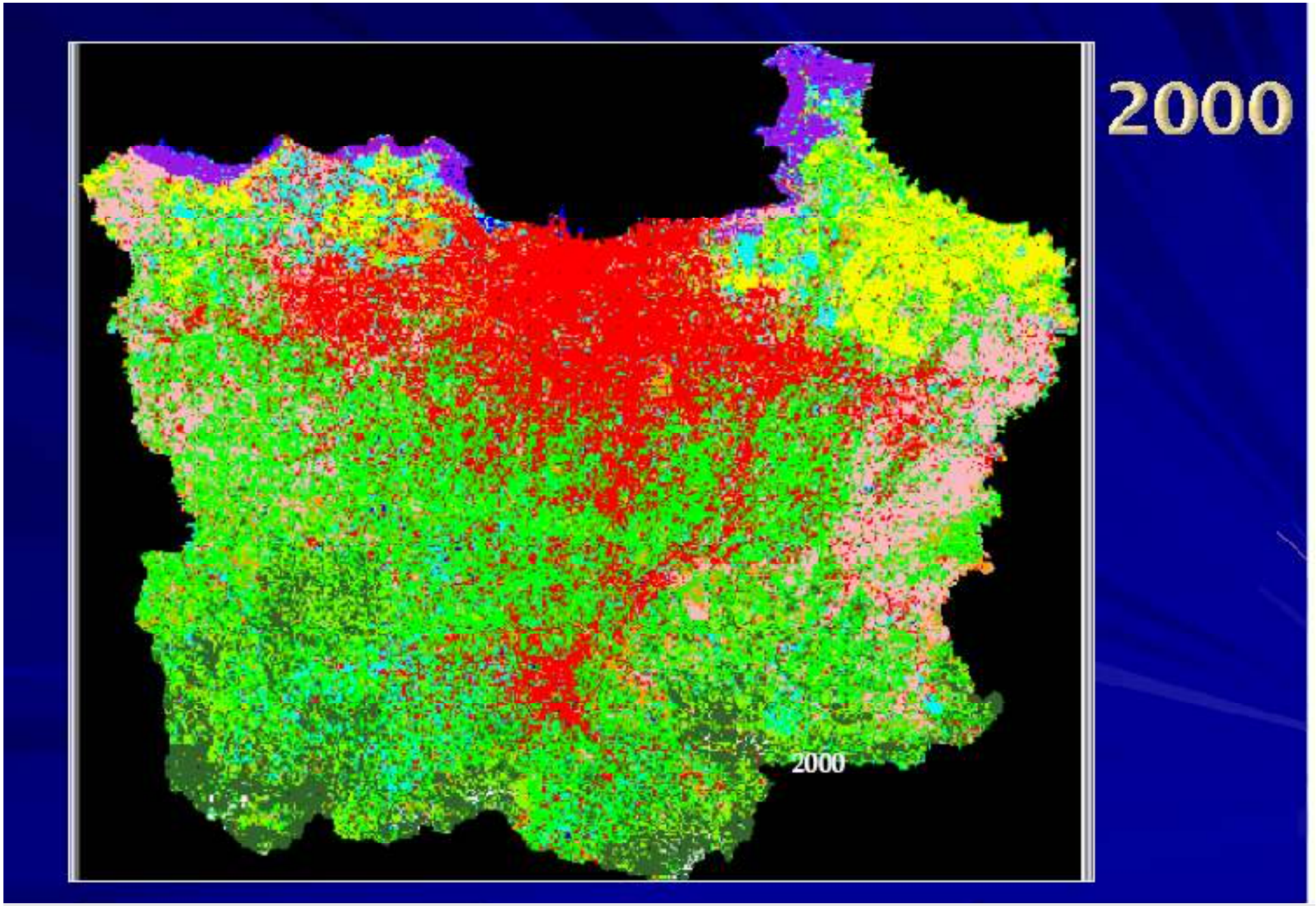
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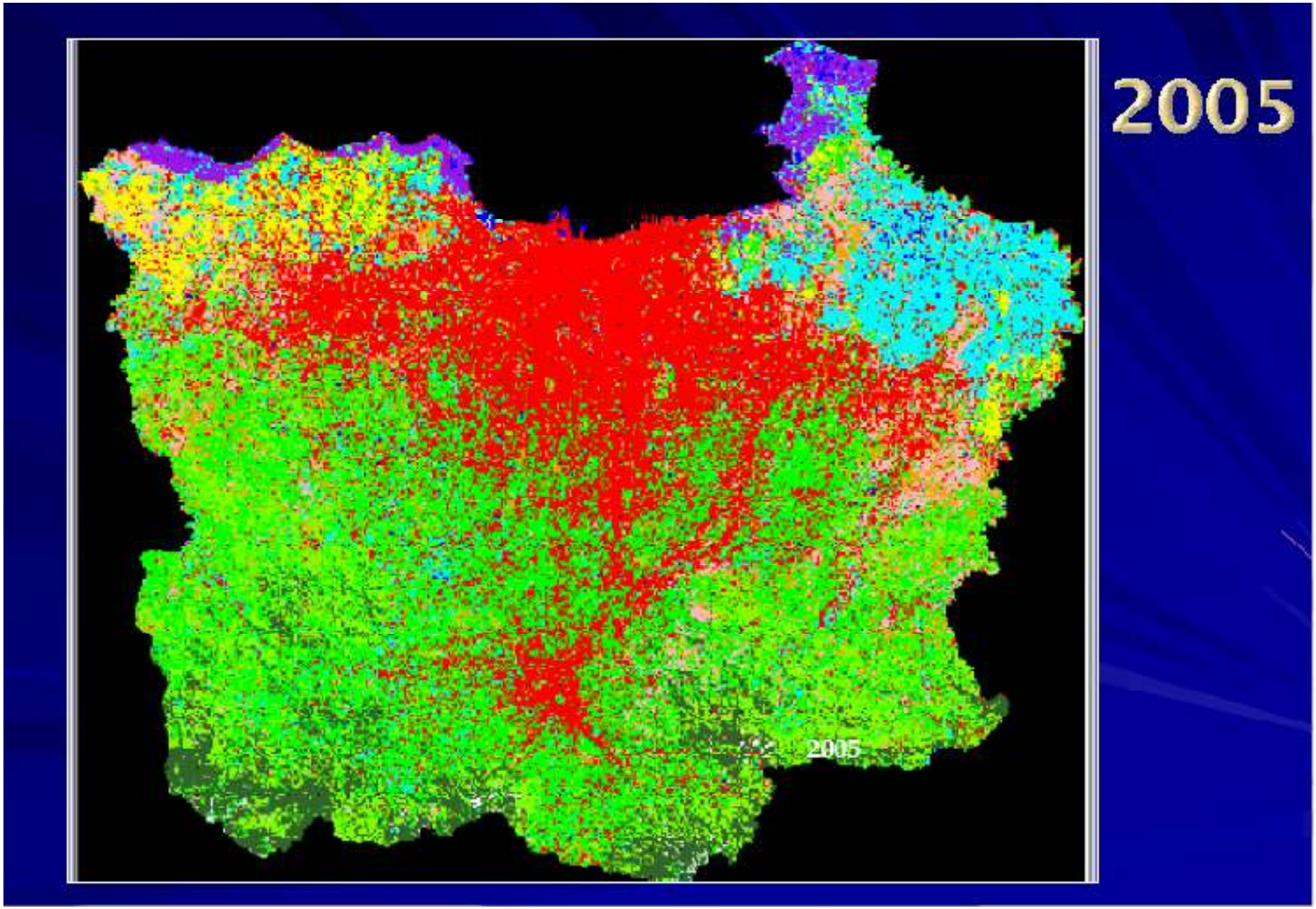
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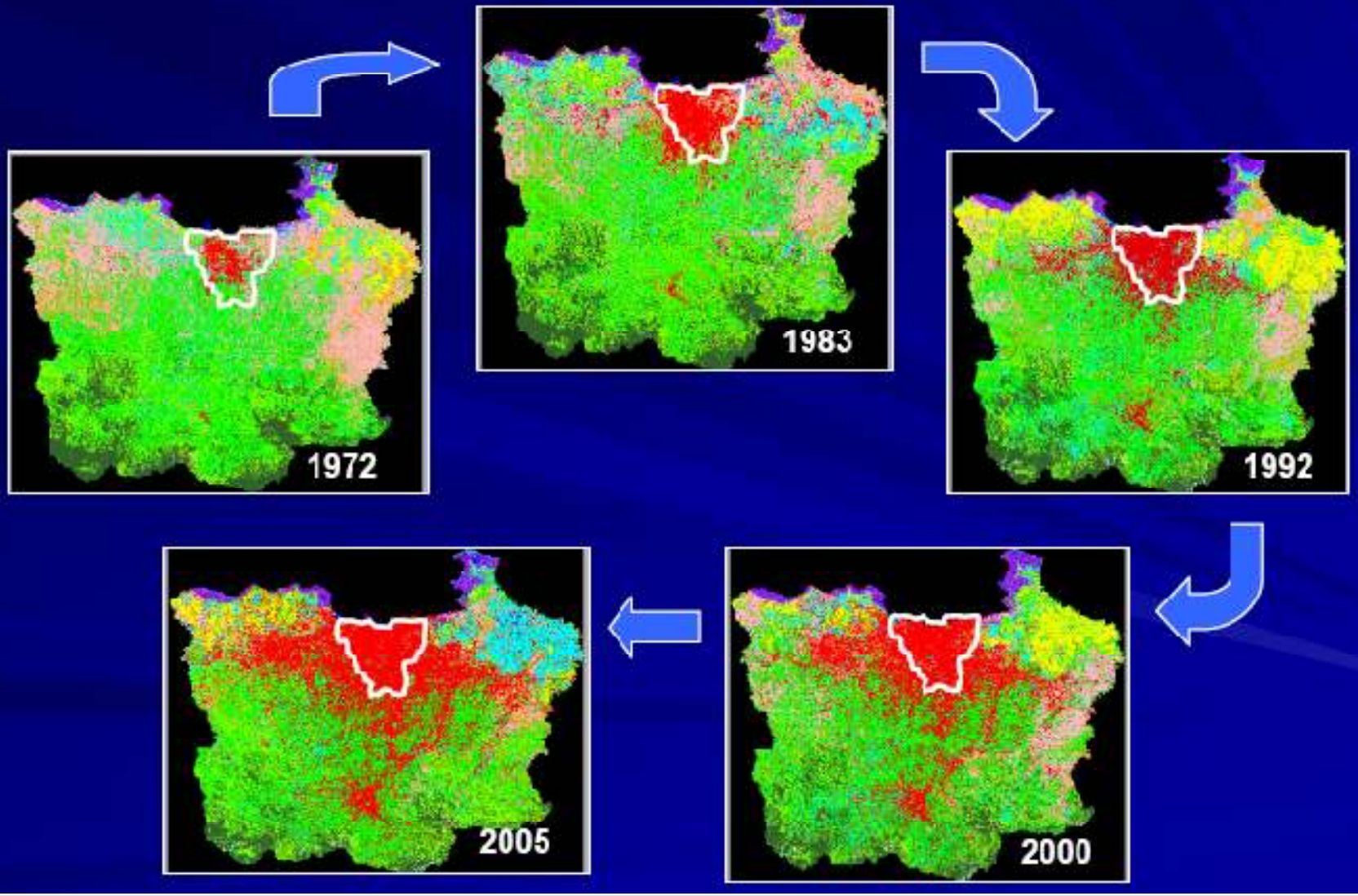
PERKEMBANGAN KAWASAN PERKOTAAN DI JABODETABEK



Pencegahan bencana?

- Serangkaian kegiatan yang dilakukan untuk mengurangi atau menghilangkan risiko bencana, melalui
  - Pengurangan ancaman (hazard) bencana
  - Pengurangan kerentanan (vulnerability) pihak yang terancam bencana

Risiko bencana

- Adalah potensi kerugian yang ditimbulkan akibat bencana pada suatu wilayah dan kurun waktu tertentu.
- Akibat bencana berupa :
  - Kematian
  - Luka/sakit
  - Jiwa terancam/hilangnya rasa aman
  - Kerusakan lingkungan
  - Gangguan kegiatan masyarakat

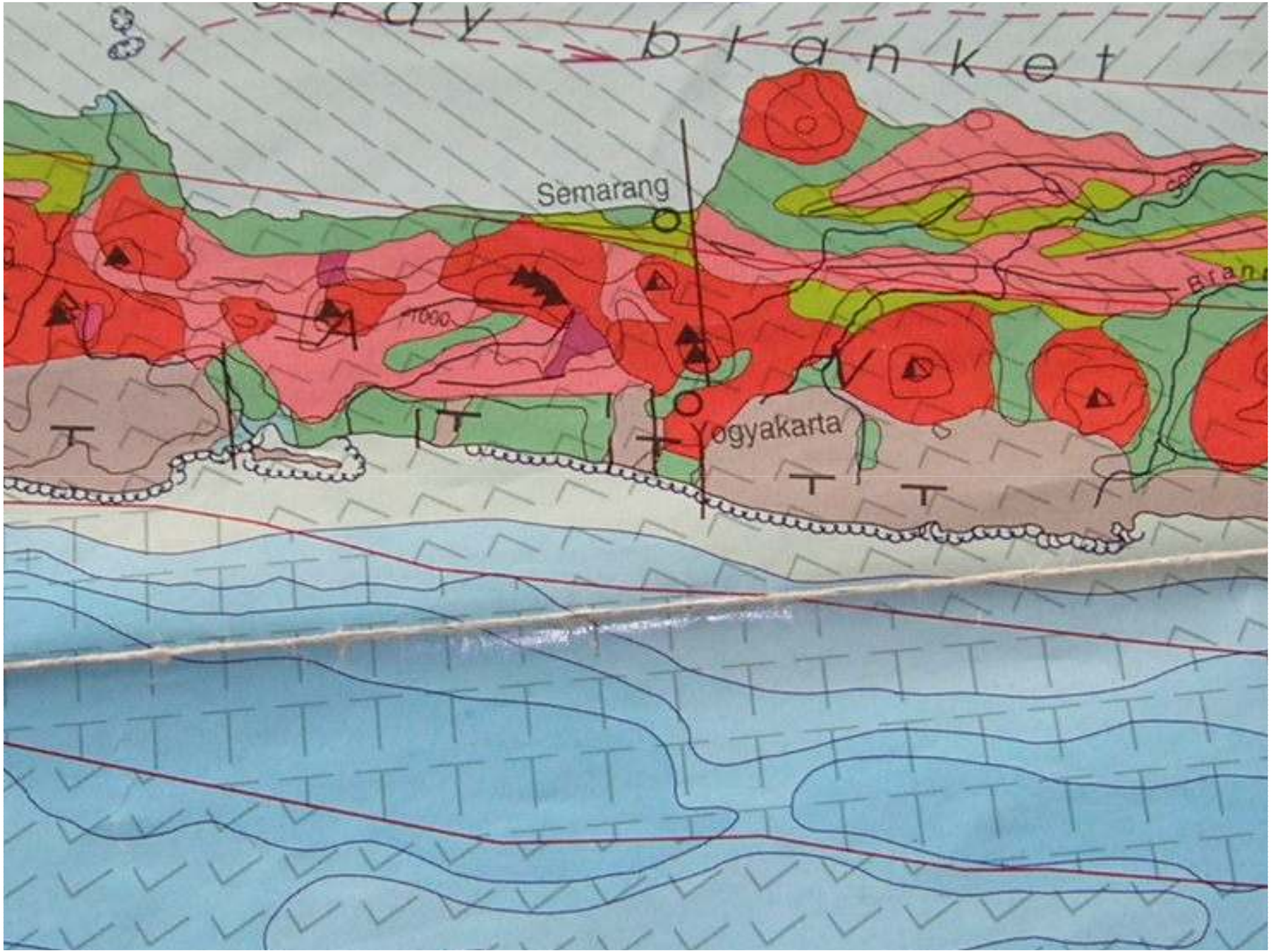
TUJUAN
Penyelenggaraan PB

- Untuk menjamin terselenggaranya PB yang dilaksanakan secara -
  - Terencana
  - Terpadu
  - Terkoordinasi
  - Menyeluruh

  Dalam memberikan perlindungan kepada masyarakat dari ?

  ANCAMAN, RISIKO, DAN DAMPAK BENCANA


clay blanket
JAVA SEA
Holocene clay blanket
Madura
Semarang
Surabaya
Yogyakarta
Christmas Island


clay blanket
Semarang
Yogyakarta

PERENCANAAN PB (DISASTER MANAGEMENT PLANNING)

- Pengenalan dan pengkajian ancaman bencana;
- Pemahaman tentang kerentanan masyarakat;
- Analisis kemungkinan dampak bencana;
- Pilihan tindakan pengurangan risiko bencana;
- Penentuan mekanisme kesiapan dan penanggulangan dampak bencana; dan
- Alokasi tugas, kewenangan, dan sumberdaya yang tersedia.

PENGURANGAN RISIKO BENCANA

- Adalah kegiatan untuk mengurangi ancaman dan kerentanan serta meningkatkan kemampuan masyarakat dalam menghadapi bencana

Cakupan kegiatan pengurangan risiko bencana :

- Pengenalan dan pemantauan risiko bencana ;
- Perencanaan partisipatif PB;
- Pengembangan budaya sadar bencana;
- Peningkatan komitmen terhadap pelaku PB;
- Penerapan upaya fisik, non fisik, dan pengaturan PB.

RENCANA AKSI PENGURANGAN RISIKO BENCANA

- Dimaksudkan untuk melakukan upaya pengurangan risiko bencana.

- Rencana aksi pengurangan risiko bencana terdiri dari :
  - Rencana Aksi Nasional Pengurangan Risiko Bencana (RAN-PRB)
  - Rencana Aksi Daerah Pengurangan Risiko Bencana (RAD-PRB)

  RAN MAUPUN RAD-PRB HARUS DIKOORDINASIKAN/SINKRONISASI DENGAN BIDANG PERENCANAAN DAERAH.

- Bila di daerah ada kegiatan pembangunan yang berpotensi menimbulkan bencana?

- Maka, setiap kegiatan yang mempunyai risiko tinggi menimbulkan bencana, WAJIB dilengkapai dengan DOKUMEN ANALISIS RISIKO BENCANA yang dilakukan oleh Pemrakarsa.

- BNPB dan/atau BPBD melakukan pemantauan dan evaluasi atas pelaksanaan analisis risiko bencana dan dikoordinasikan bersama instansi/lembaga terkait.

- Persyaratan ANALISIS RISIKO BENCANA terhadap pembangunan yang mempunyai risiko tinggi
  - Harus terintegrasi dalam ANALISIS MENGENAI DAMPAK LINGKUNGAN ATAU DALAM PERENCANAAN TATA RUANG.

PERINGATAN DINI

- Pengamatan gejala alam;
- Analisis hasil pengamatan gejala alam;
- Pengambilan keputusan;
- Penyebarluasan informasi tentang peringatan; dan
- Pengambilan tindakan oleh masyarakat.

MITIGASI BENCANA

- Perencanaan dan pelaksanaan penataan ruang yang berdasarkan pada analisis risiko bencana;
- Pengaturan bangunan, infrastruktur, dan tata bangunan, dan
- Penyelenggaraan pendidikan, pelatihan, dan penyuluhan secara konvensional maupun modern.

SAAT TANGGAP DARURAT

- Pengkajian secara cepat dan tepat terhadap lokasi, kerusakan, kerugian dan sumberdaya;
- Penentuan status keadaan darurat bencana;
- Pemenuhan kebutuhan dasar;
- Perlindungan terhadap kelompok rentan, dan
- Pemulihan dengan segera prasarana dan sarana vital.

Kemudahan akses saat tanggap darurat?

- Pengerahan SDM, peralatan, logistik;
- Urusan imigrasi, cukai, karantina;
- Perizinan;
- Pengadaan barang dan jasa;
- Pengelolaan/pertanggungjawaban uang dan/atau barang;
- Penyelamatan; dan
- BNPB/BPBD → Komando memerintahkan instansi/lembaga

PASCA BENCANA

- REHABILITASI
- REKONSTRUKSI

REHABILITASI

- Perbaikan prasaran/sarana umum dan lingkungan daerah bencana;
- Pemberian bantuan perbaikan rumah masyarakat;
- Pemulihan sosial psikologis;
- Pelayanan kesehatan;
- Rekonsiliasi dan resolusi konflik;
- Pemulihan sosekbud, keamanan/tertiban/fungsi pemerintahan/pelayanan publik.

REKONSTRUKSI

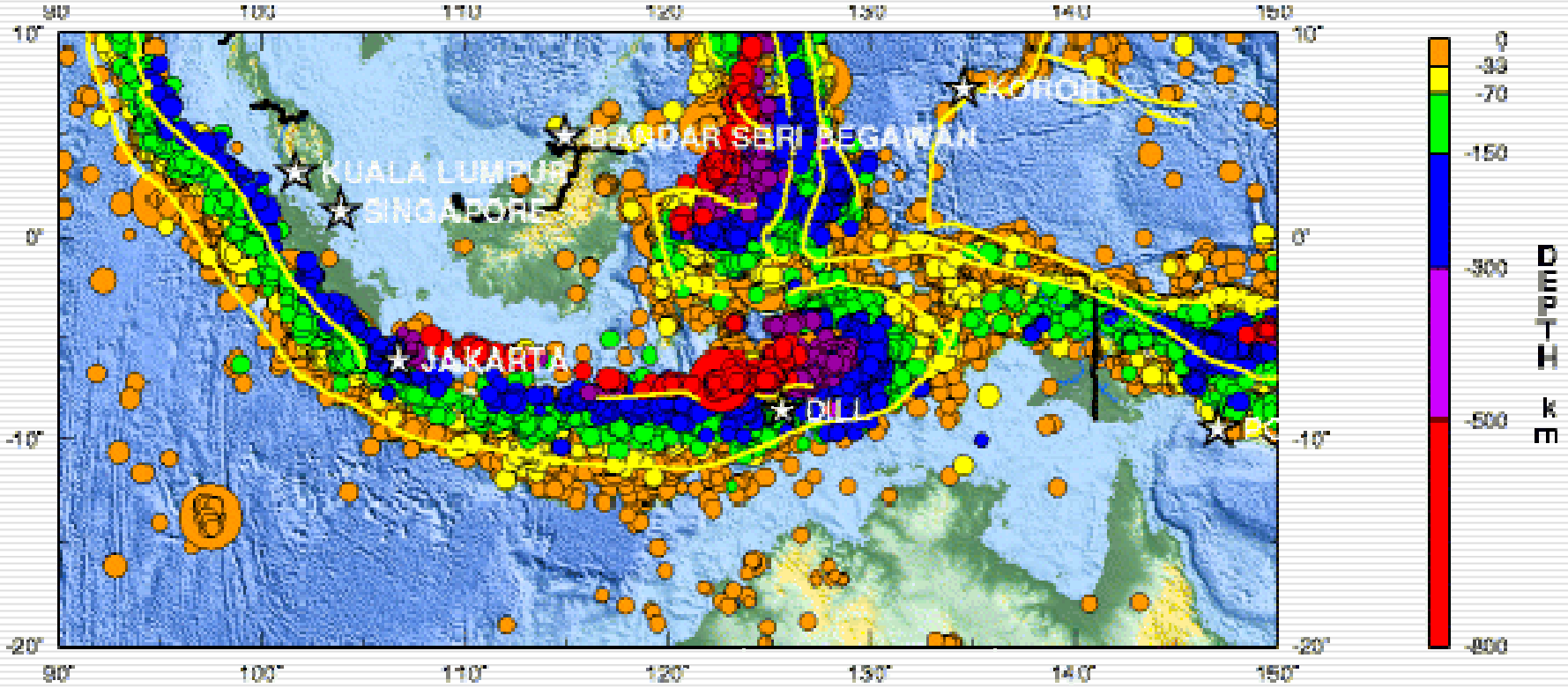
- Pembangunan kembali prasaran/sarana/kehidupan sosial masy;
- Penetapan rancang bangun
- Partisipasi dan peran lembaga dan dunia usaha dan masy
- Peningkatan kondisi sosekbud/fungsi pelayanan publik/umummasy.

PEMANTAUAN DAN EVALUASI

- Pemantauan penyelenggaraan PB terhadap proses pelaksanaan penyelenggaraan PB

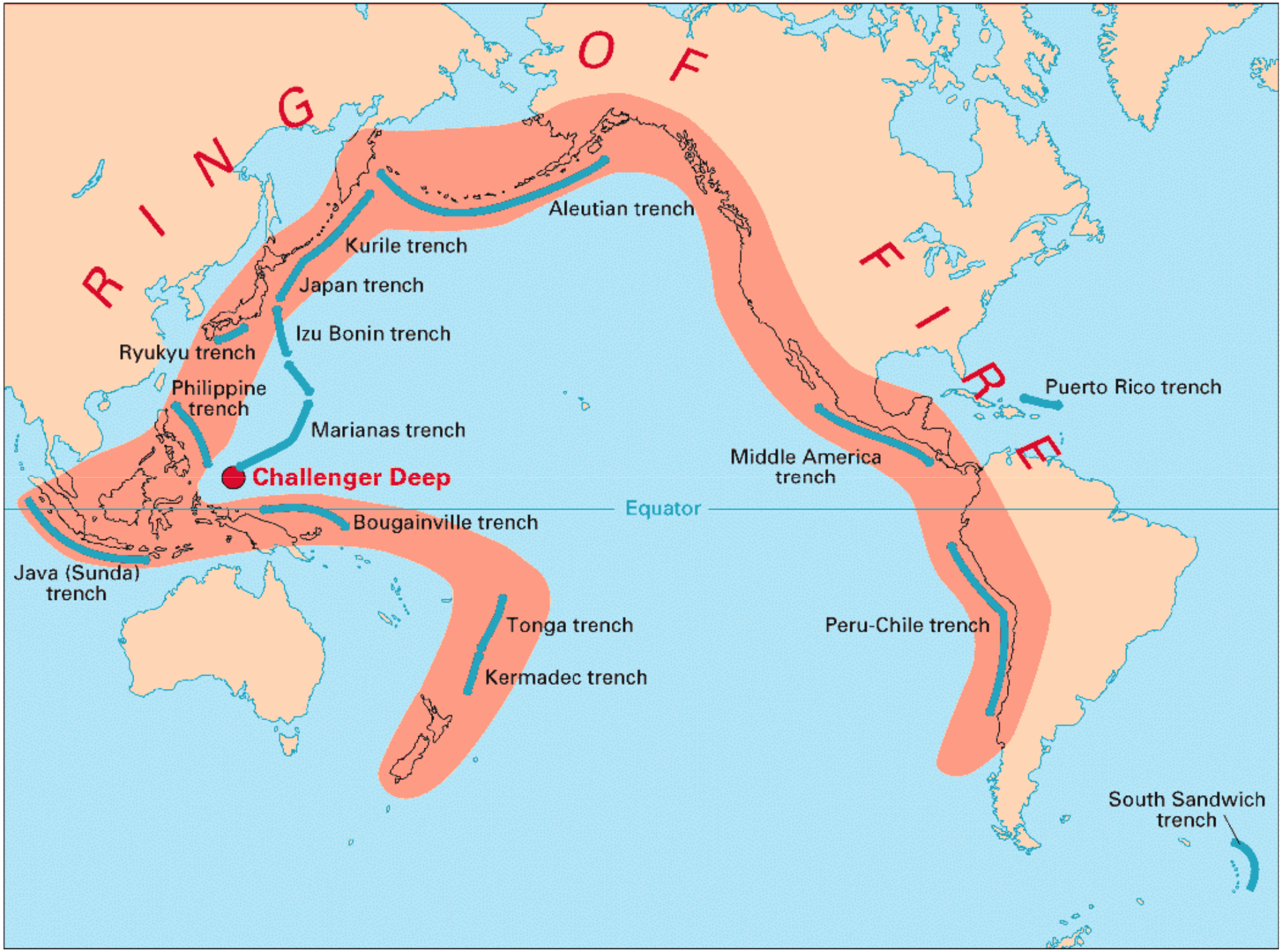
- Evaluasi penyelenggaraan PB dilakukan dalam rangka pencapaian standard minimum dan peningkatan kinerja PB.

Potensi gempabumi (earthquake)

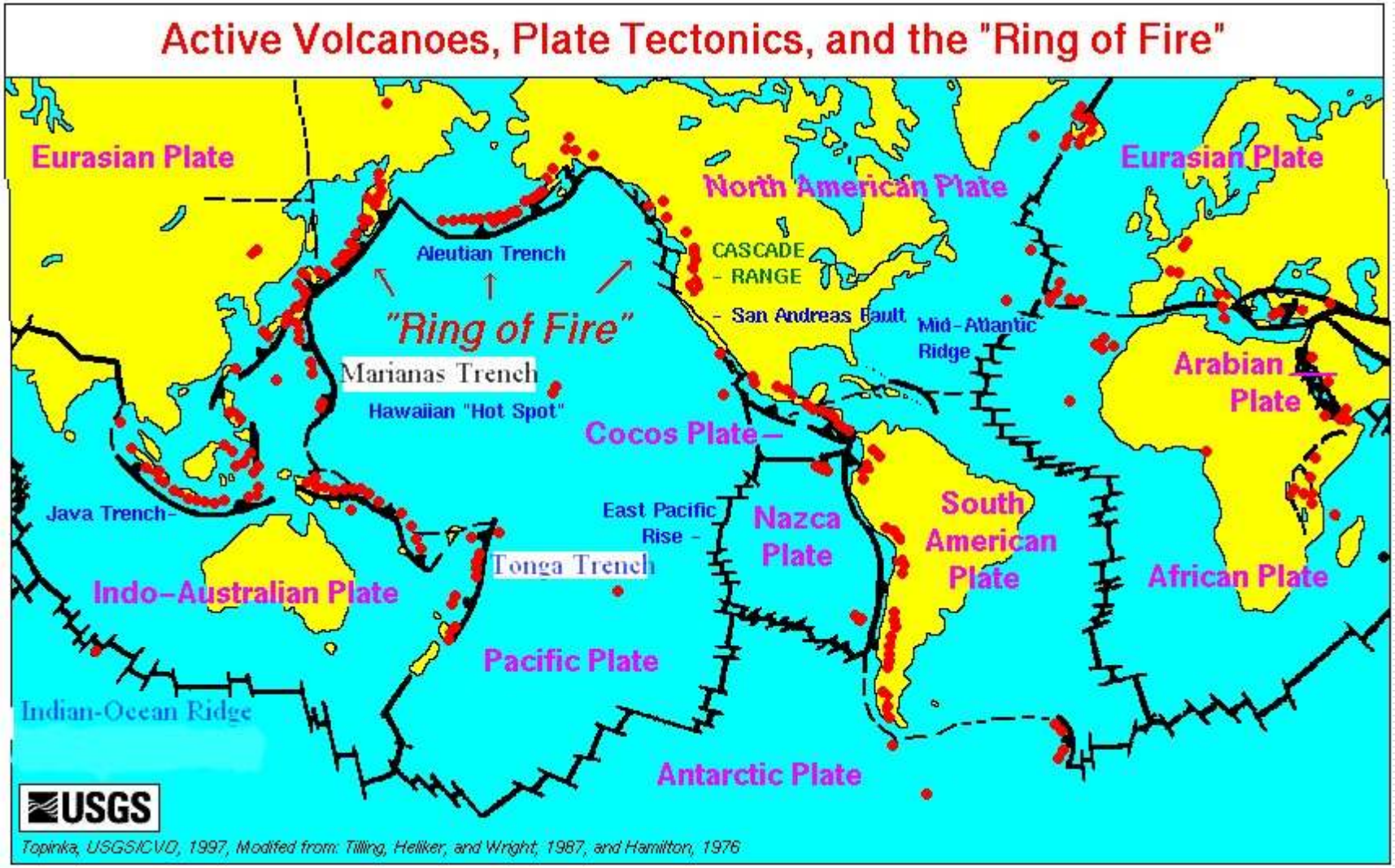


Seismicity of Indonesia, 1990 - 2000

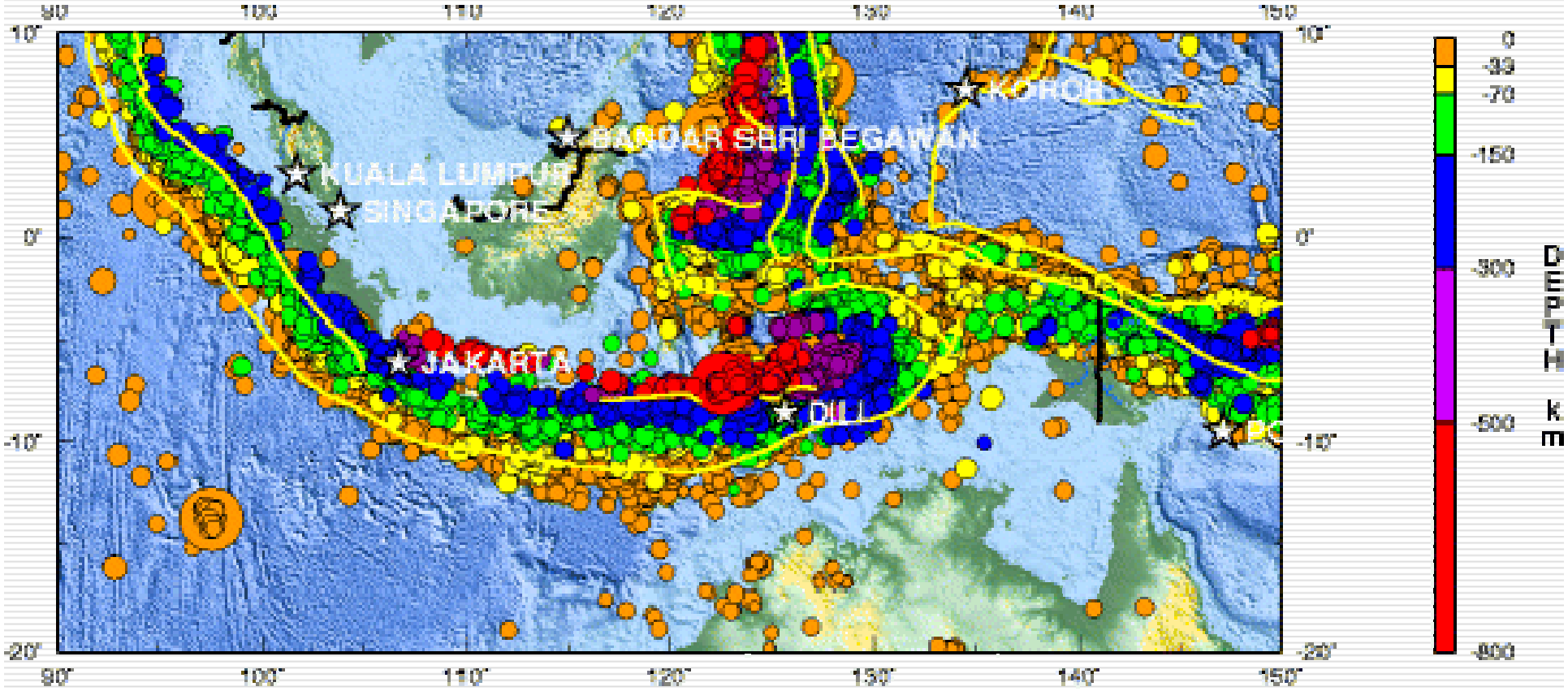
Teori lempeng tektonik


RING OF FIRE
Aleutian trench
Kurile trench
Japan trench
Izu Bonin trench
Ryukyu trench
Philippine trench
Marianas trench
Challenger Deep
Bougainville trench
Java (Sunda) trench
Tonga trench
Kermadec trench
Middle America trench
Puerto Rico trench
Peru-Chile trench
South Sandwich trench
Equator

Geographic Distribution



Kegempaan di Indonesia 1990-2000



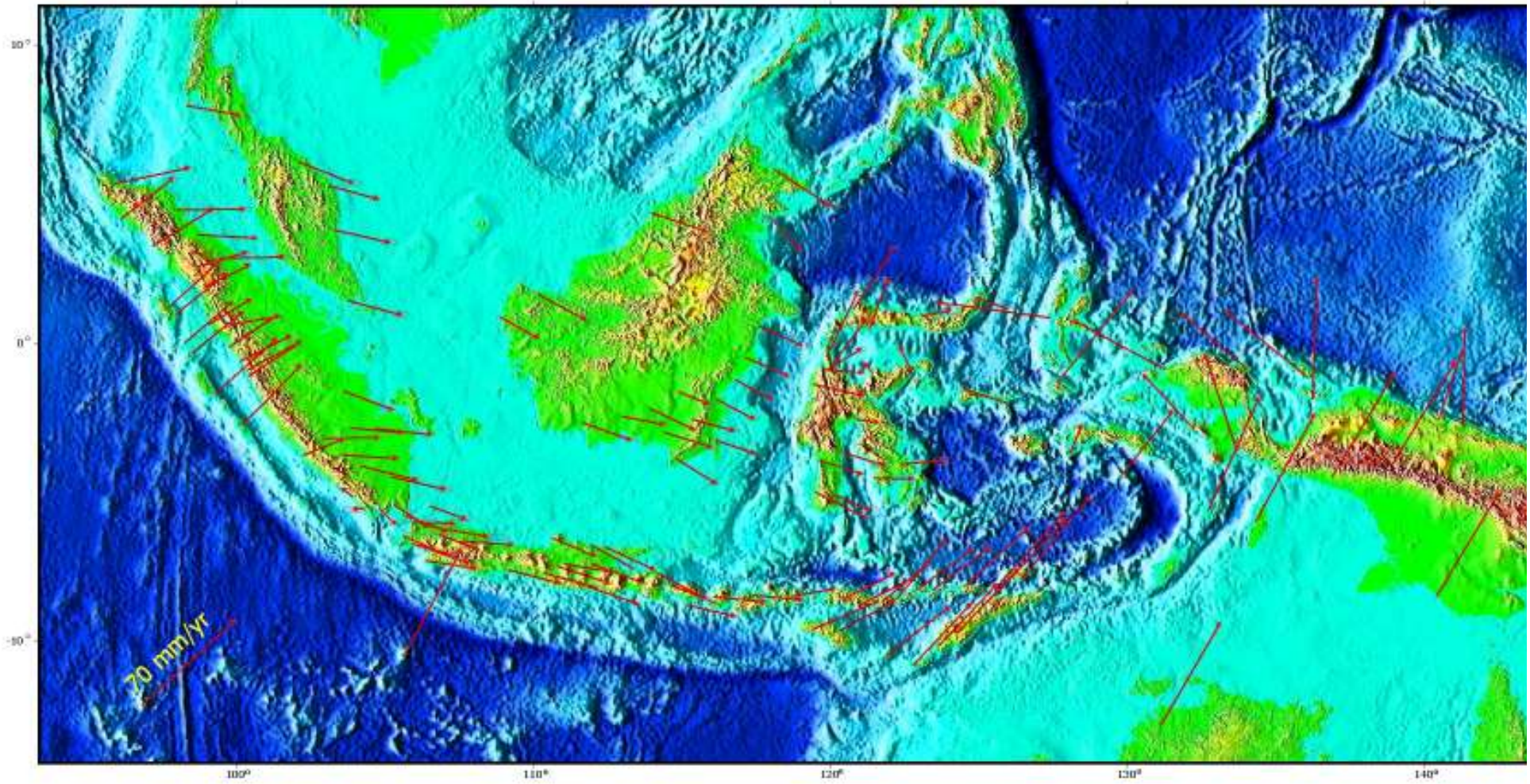
Seismicity of Indonesia, 1990 - 2000

DATA GEMPA DI DUNIA

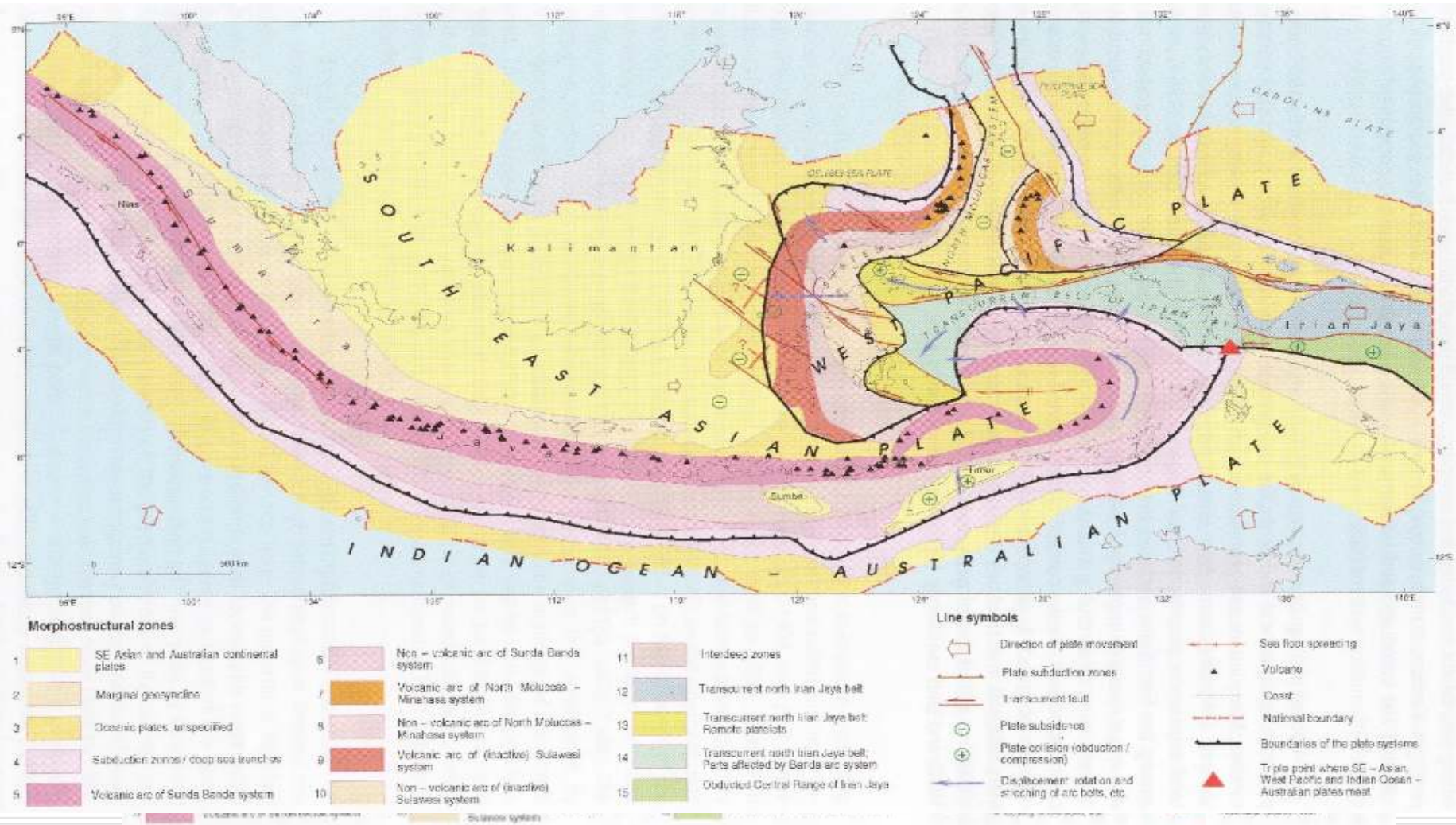
Magnitude (SR)	Jumlah kejadian/tahun	Keterangan
> 8,5	0,3	Sangat besar
8-8,4	1	Sangat besar
7,5-7,9	3	Sangat besar
7-7,4	15	Besar
6-6,9	56	Besar/Kuat
6-6,5	210	Kuat
5-5,9	800	Sedang
4-4,9	6.200	Ringan
3-3,9	49.000	Kecil
2-2,9 (0-1,9)	350.000 (3.000.000)	Sangat kecil

Present day horizontal plate motion in Indonesia In ITRF2000

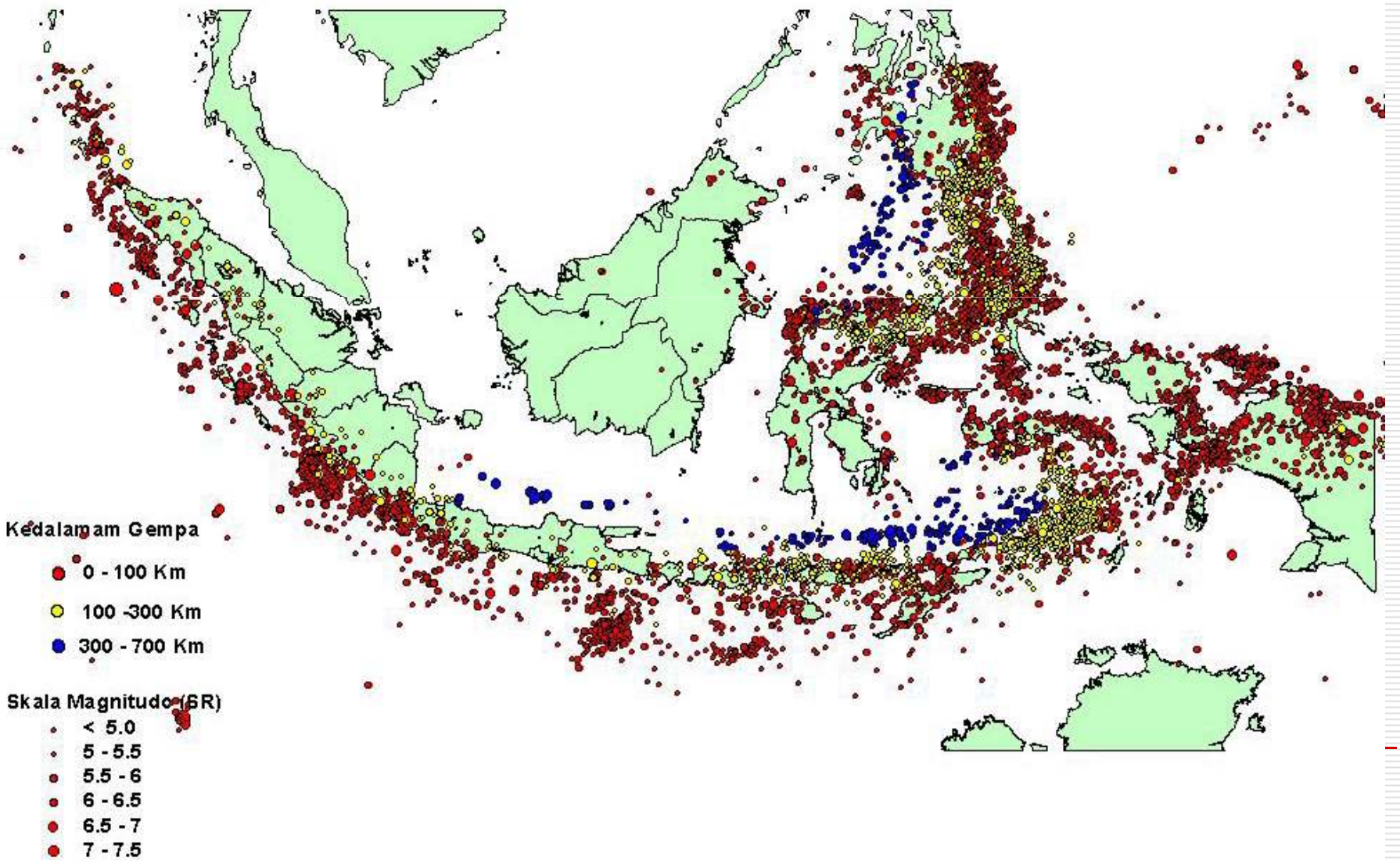
KEDUDUKAN DIY DALAM LEMPENG TEKTONIK



LEMPENG TEKTONIK DI INDONESIA



GEMPA TIDAK SELALU DIIKUTI TSUNAMI



Possible Tsunami-genic Earthquake

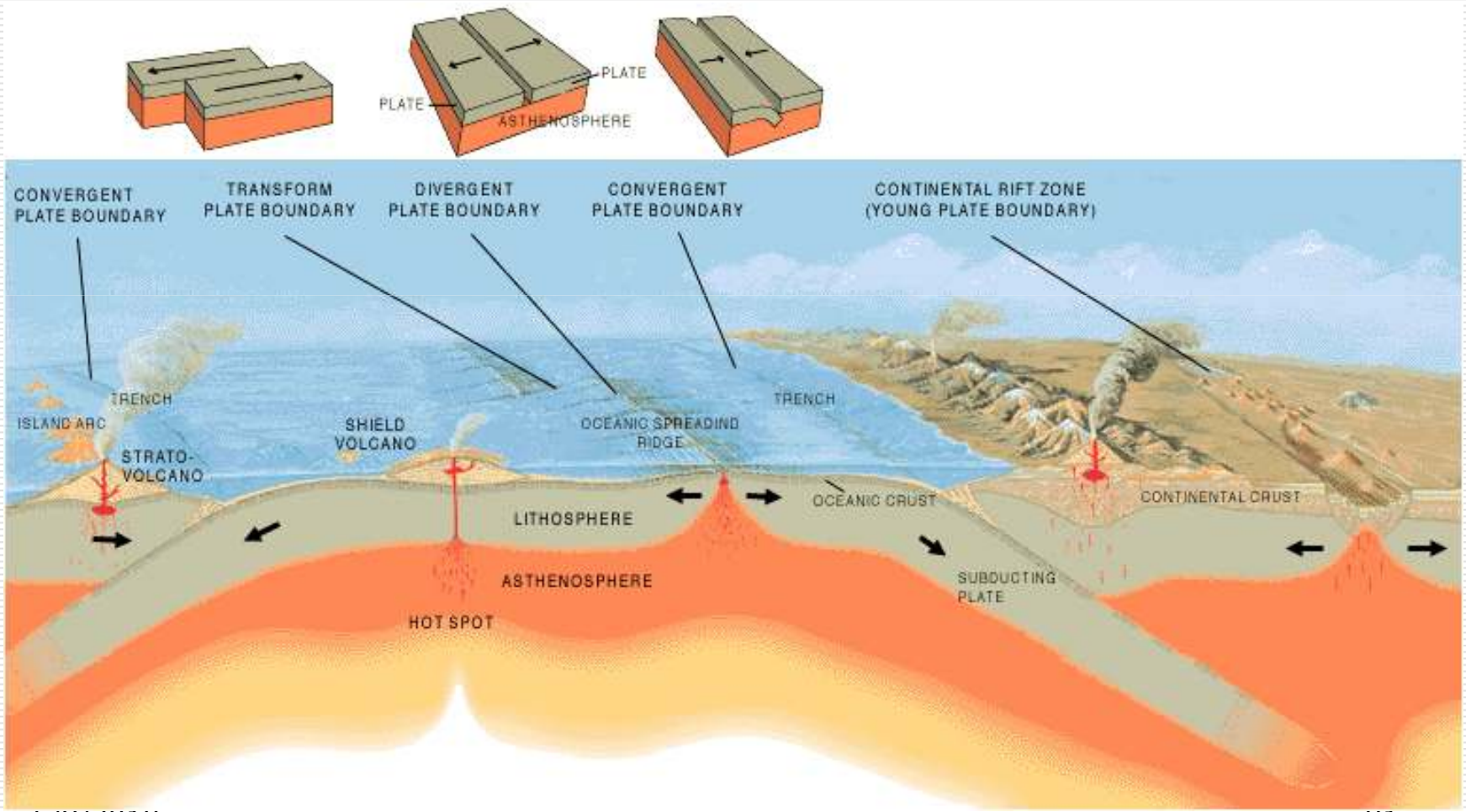
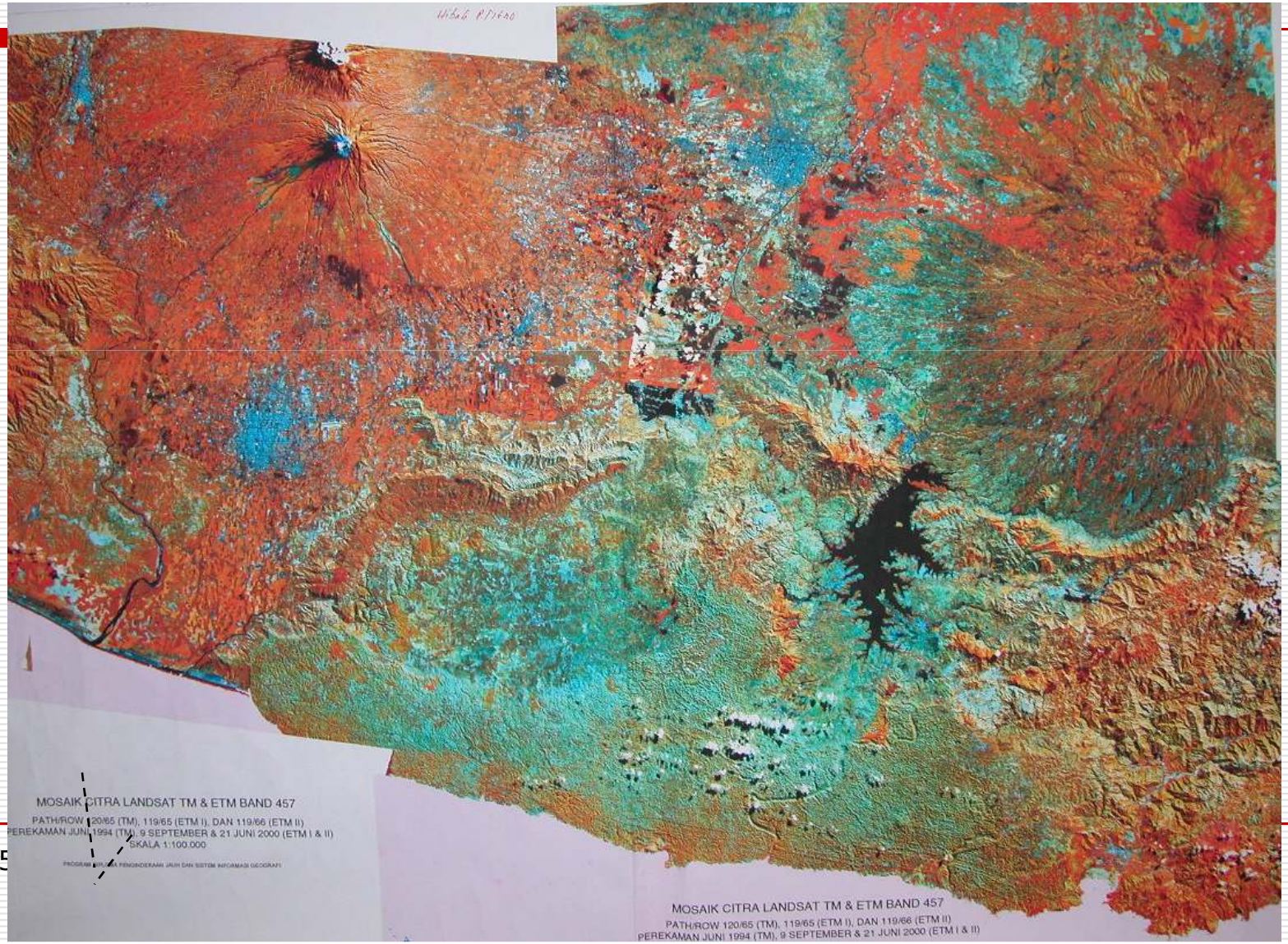
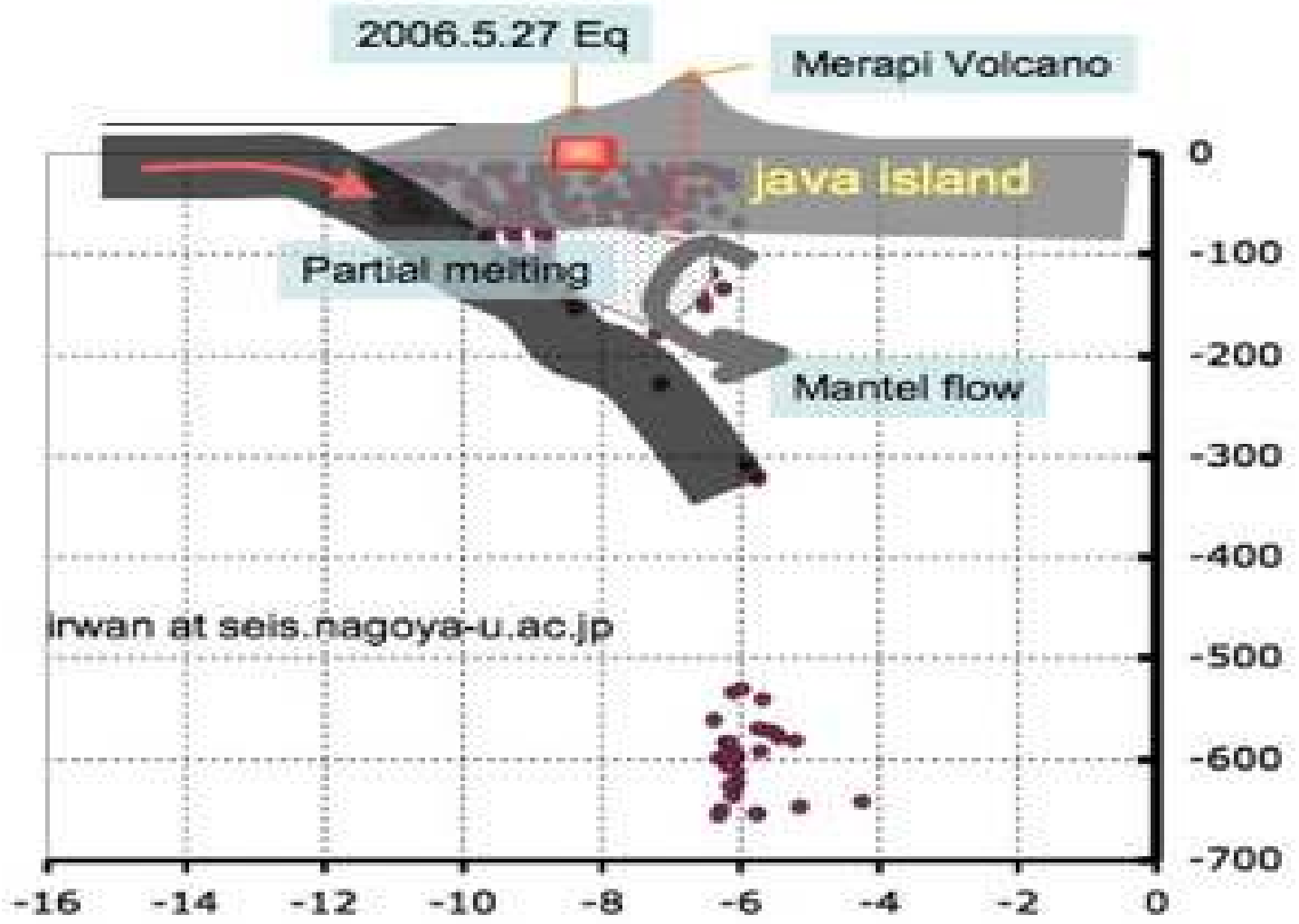


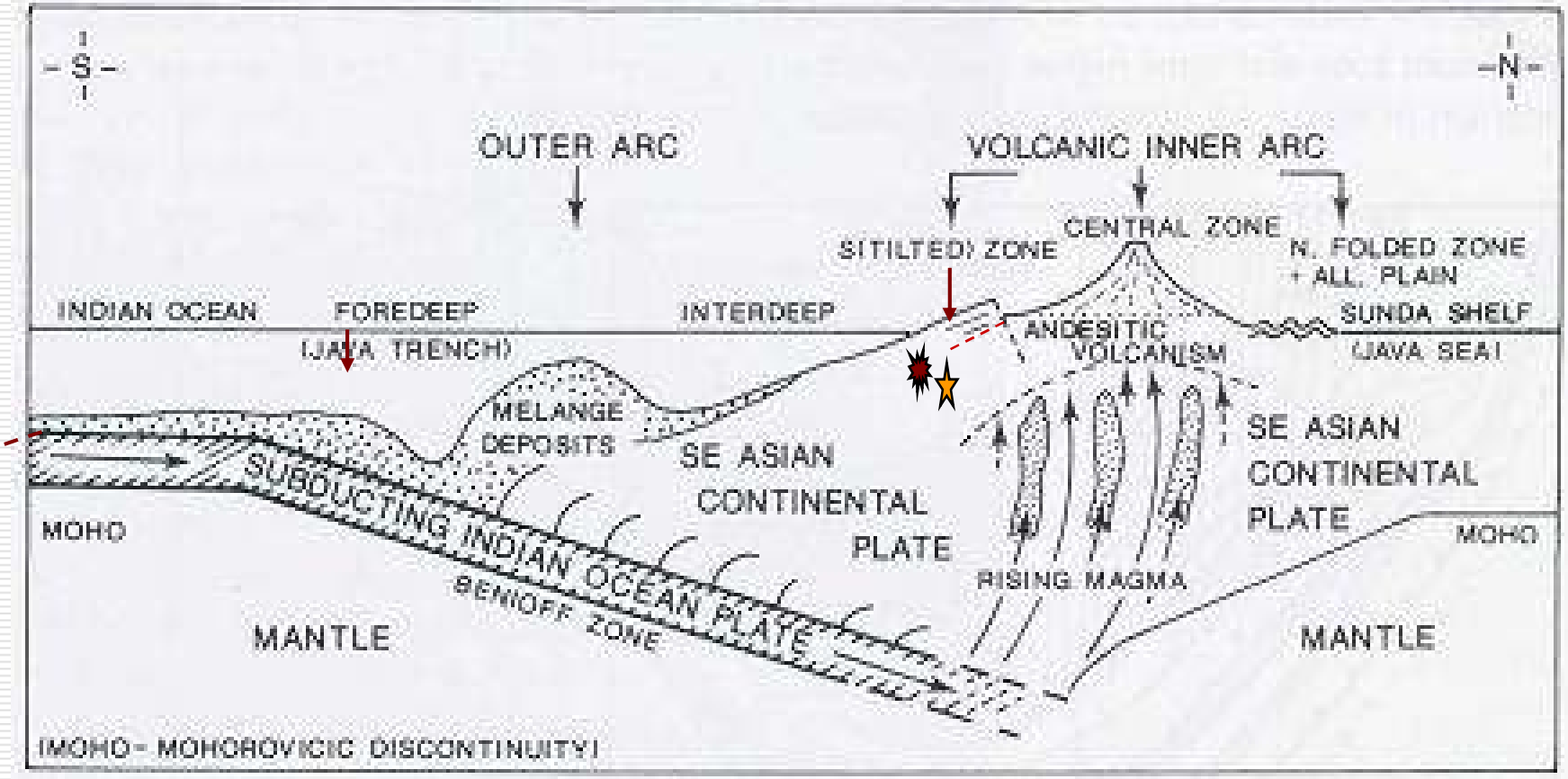
Foto Satelit (Landsat TM)
Sebagian DIY dan Jateng Bagian Selatan



FAKTOR PENYEBAB



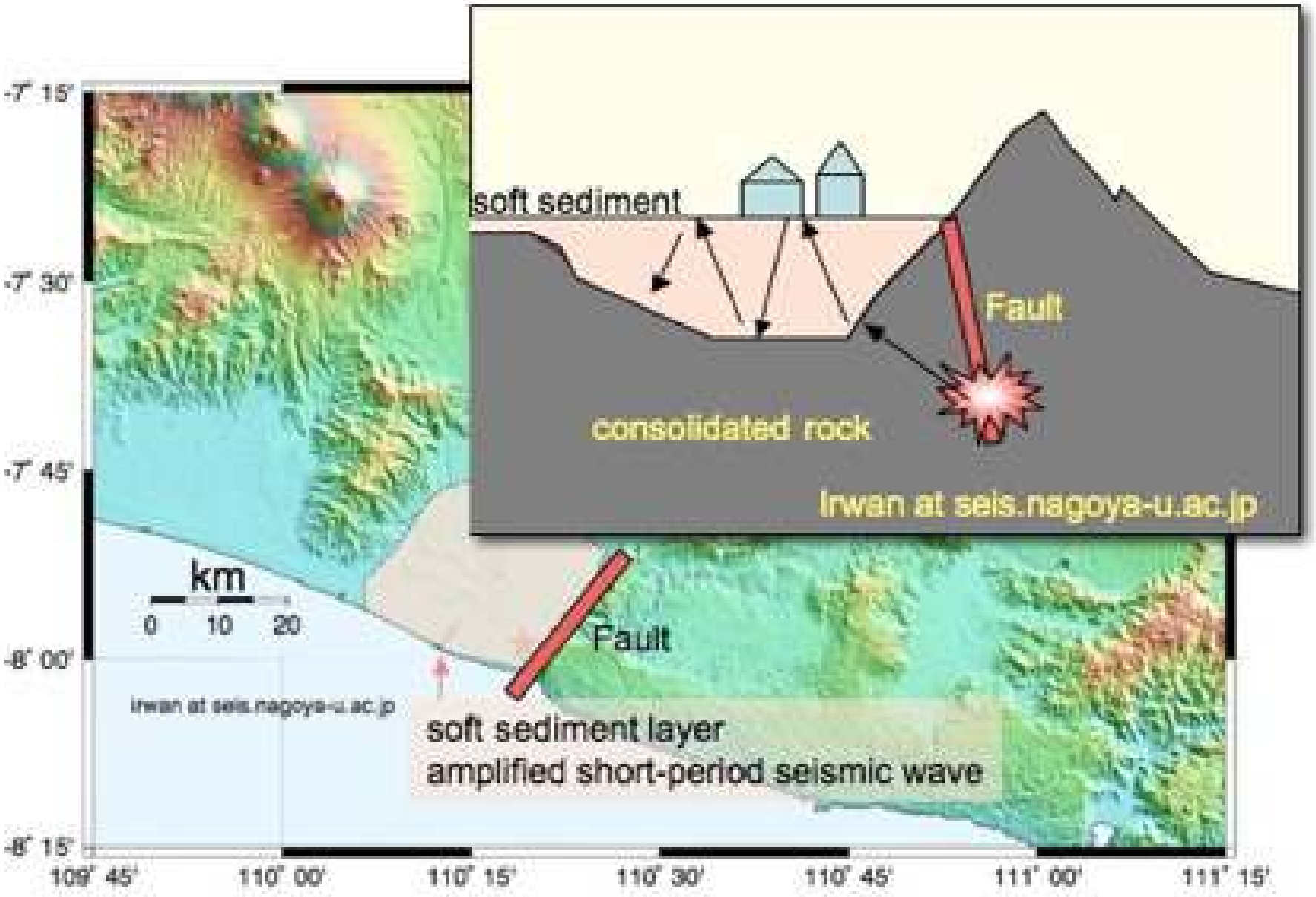
Penampang melintang pertemuan lempeng tektonik di selatan P. Jawa (Sutikno, 2006)

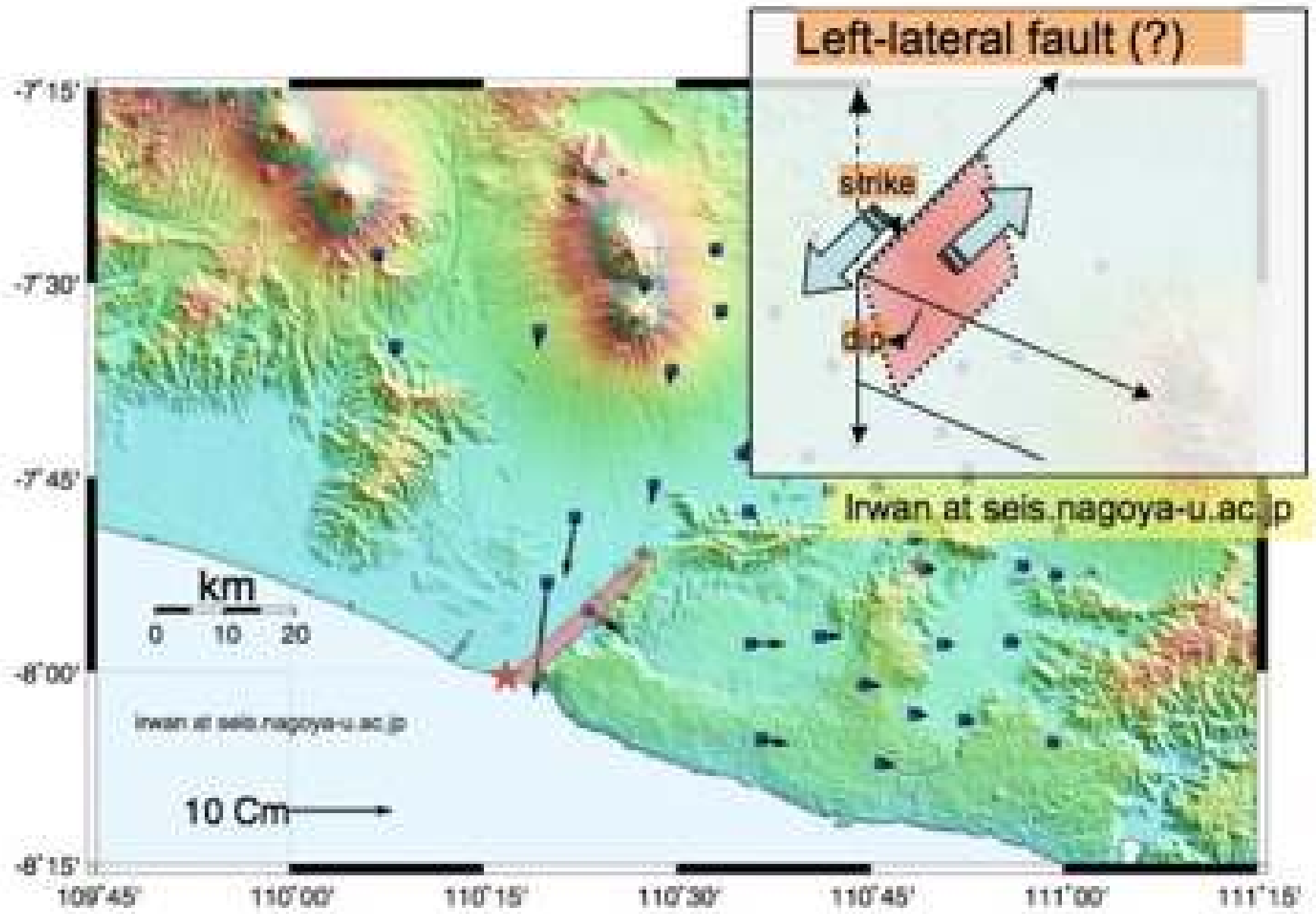


Pusat gempa sumber dari BMG (kedalaman 33 km tidak terskalakan)

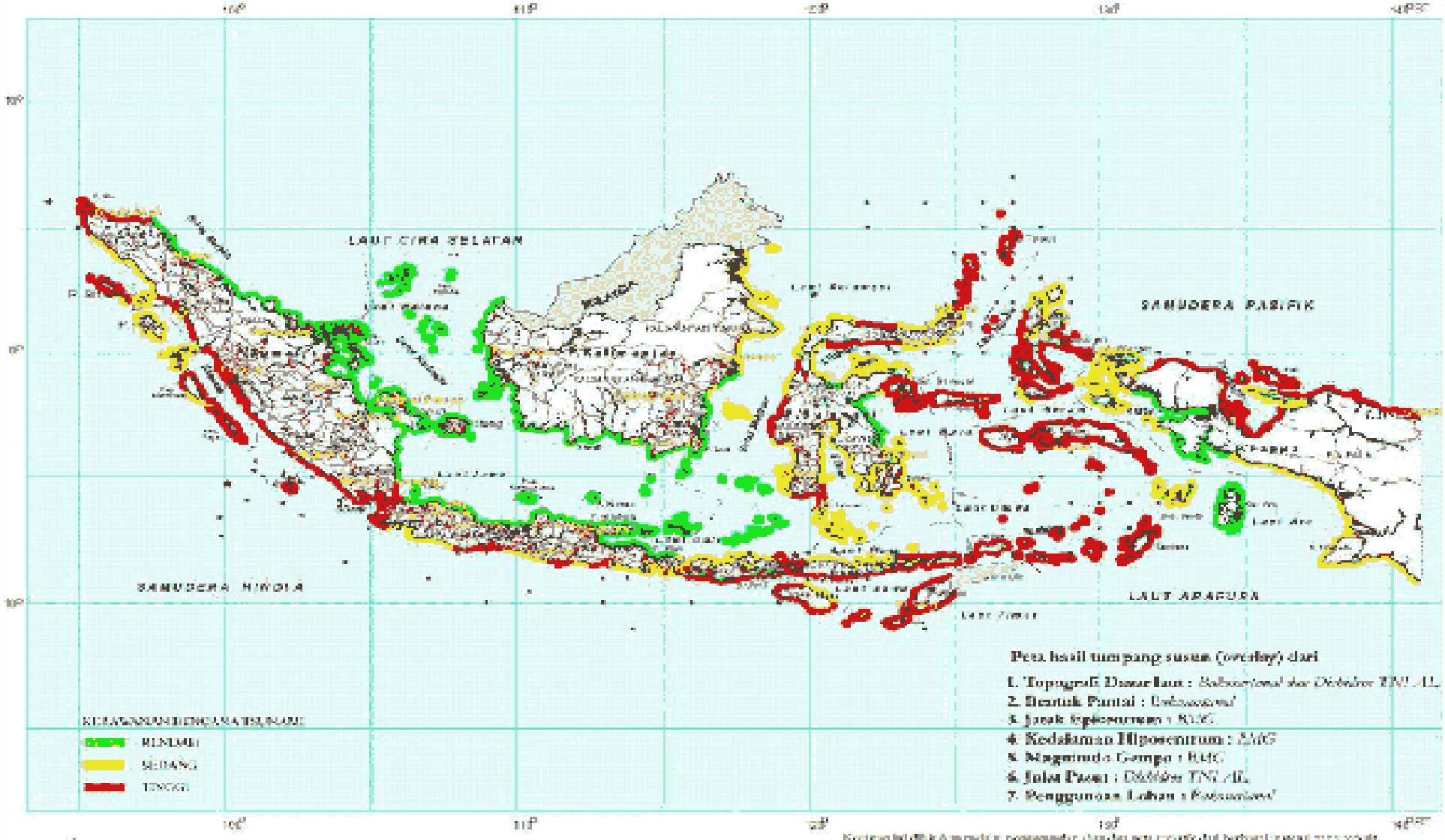
Pusat gempa dari USGS (kedalaman 35 km tidak terskalakan)

Posisi relatif sesar Opak zona daerah yang terlanda gempa


soft sediment
Fault
consolidated rock
Irwan at seis.nagoya-u.ac.jp
km
0 10 20
Fault
Irwan at seis.nagoya-u.ac.jp
soft sediment layer
amplified short-period seismic wave
-7° 15'
-7° 30'
-7° 45'
-8° 00'
-8° 15'
109° 45'
110° 00'
110° 15'
110° 30'
110° 45'
111° 00'
111° 15'


Left-lateral fault (?)
strike
dip
Irwan at seis.nagoya-u.ac.jp
km
0 10 20
Irwan at seis.nagoya-u.ac.jp
10 Cm
-7°15'
-7°30'
-7°45'
-8°00'
-8°15'
109°45'
110°00'
110°15'
110°30'
110°45'
111°00'
111°15'

PETA TINGKAT KERAWANAN BENCANA TSUNAMI INDONESIA



Badan Koordinasi Survei dan Pemetaan Nasional
(BAKOSURTANAL)

TAHAP PRA BENCANA

- DALAM SITUASI TIDAK TERJADI BENCANA

- DALAM SITUASI TERDAPAT POTENSI BENCANA

SITUASI TIDAK TERJADI BENCANA

- Perencanaan PB;
- Pengurangan risiko bencana;
- Pencegahan;
- Pemaduan dalam perencanaan pembangunan;
- Persyaratan analisis risiko bencana;
- Pelaksanaan dan penegakan rencana tata ruang;
- Pendidikan dan pelatihan; dan
- Persyaratan standard teknis PB.

DALAM SITUASI TERDAPAT POTENSI TERJADI BENCANA

- Kesiapsiagaan;
- Peringatan dini; dan
- Mitigasi bencana;

Modelling Pyroclastic flow Bebeng River

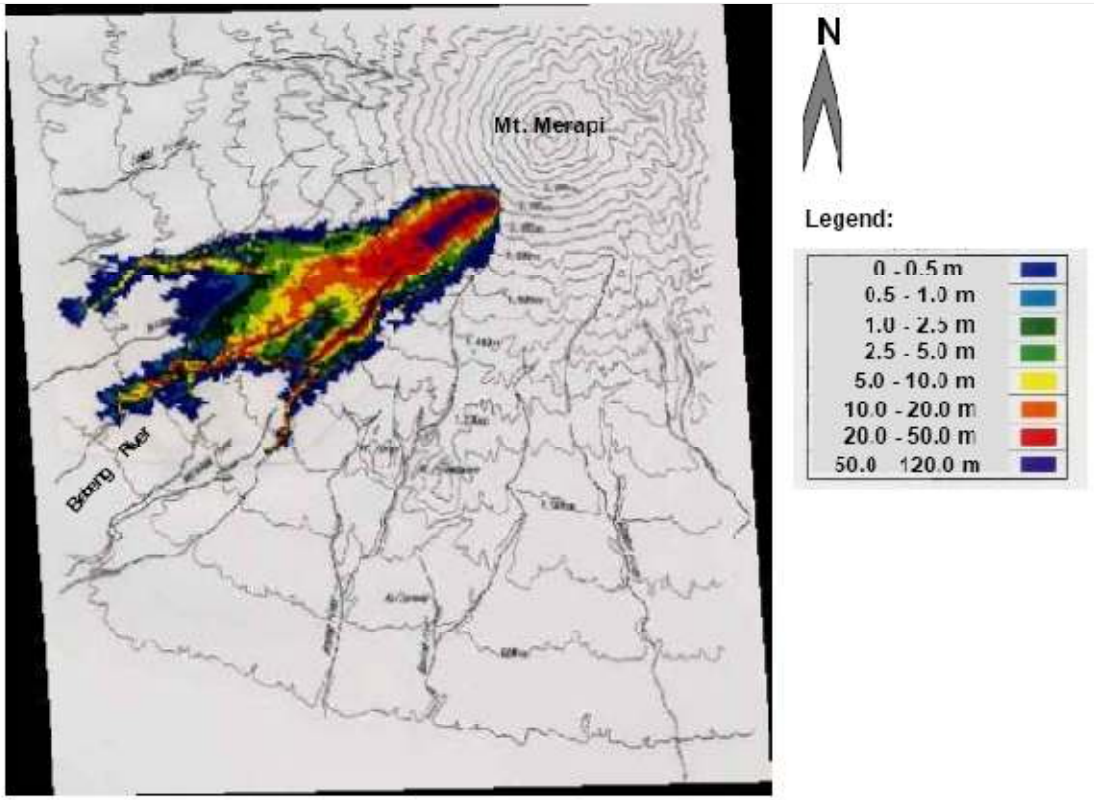


Fig. 5.2 Image of Case 1 (*Bebeng River* and legend; 25-m raster and geocoded)

Hazards : Pyroclastic flow Boyong river

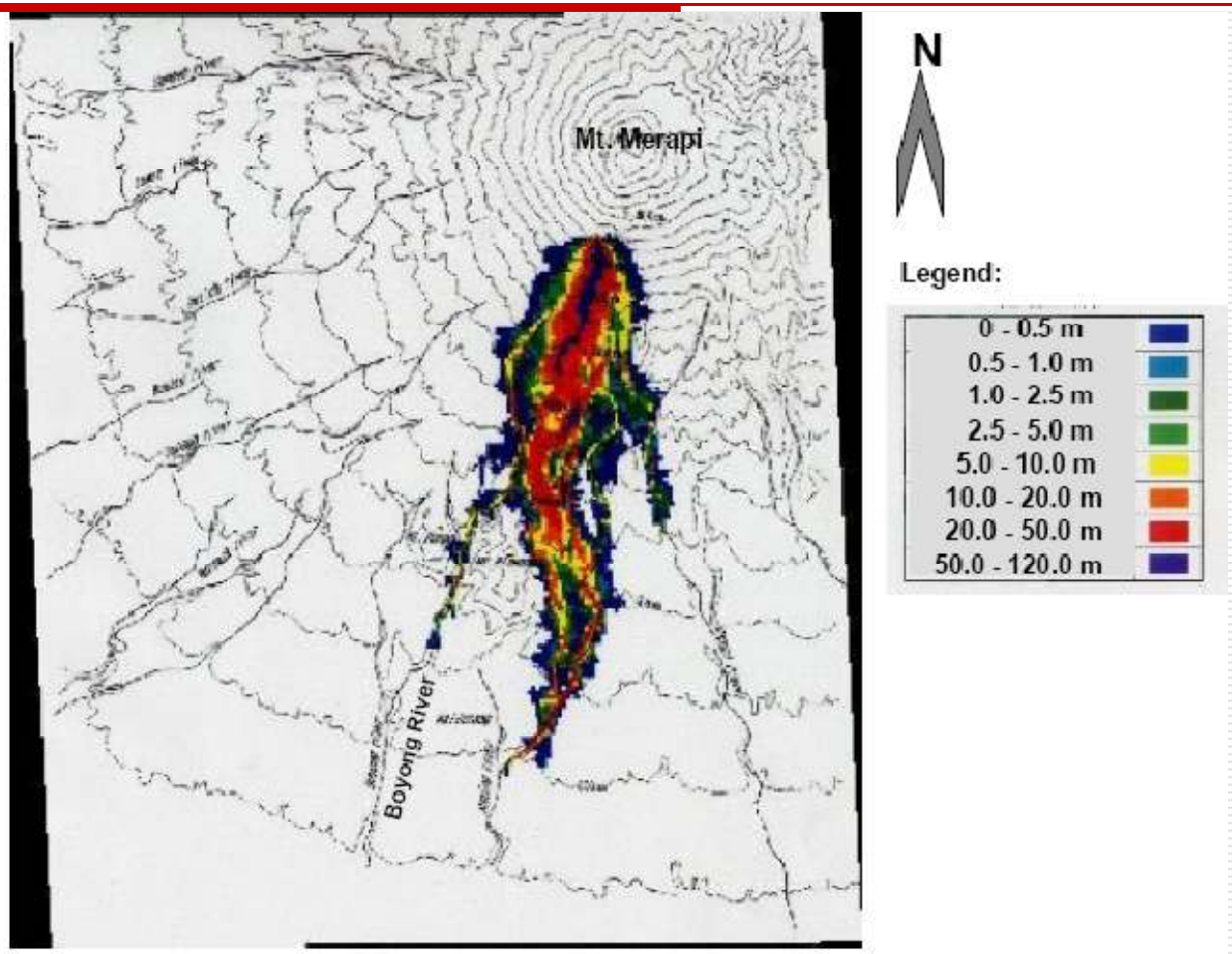


Fig. 5.3 Image of Case 2a (*Boyong River* in thickness and legend; 25-m raster and geocoded)

Modelling pyroclastic flow Boyong river

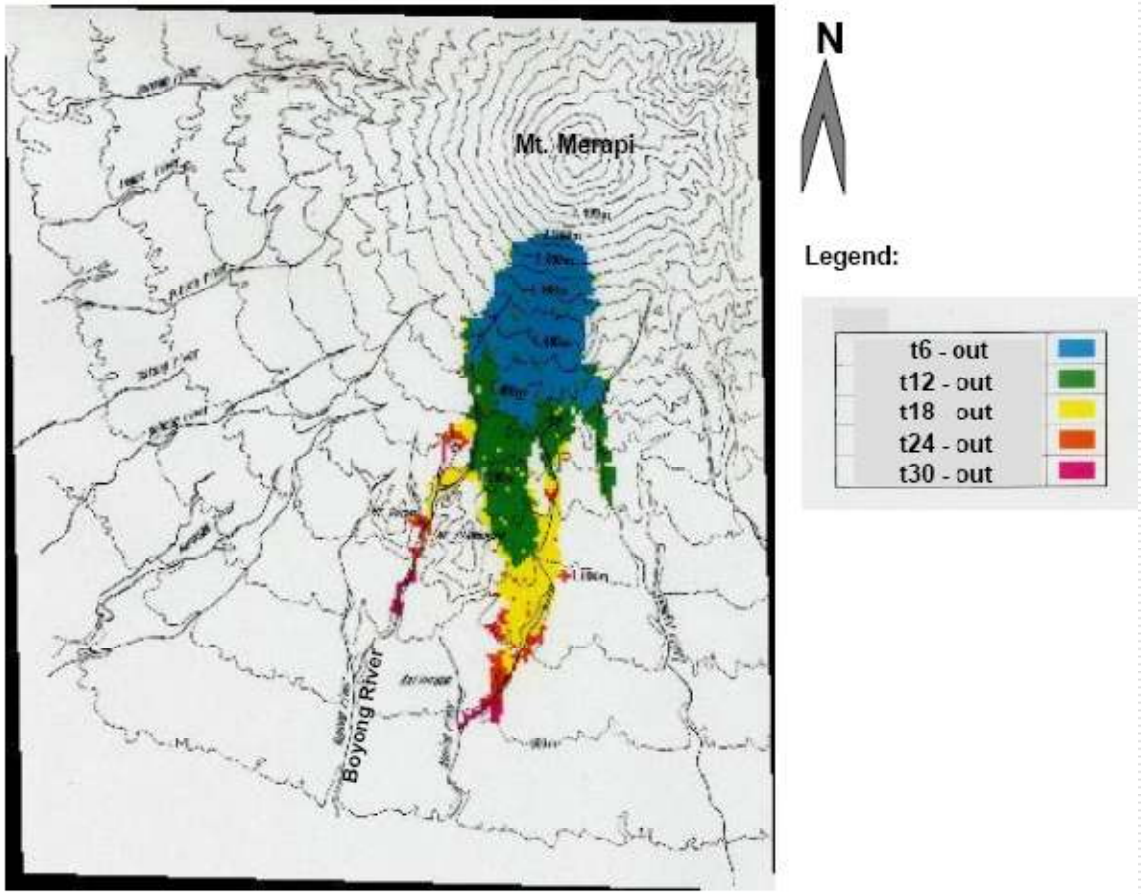
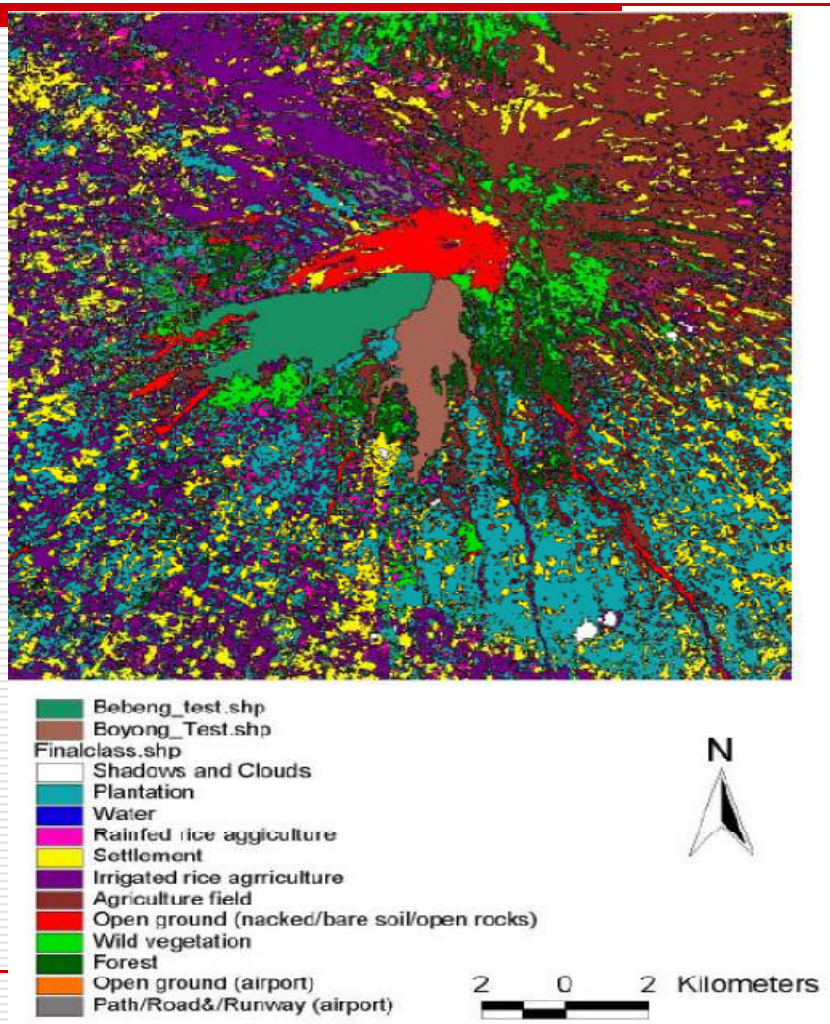


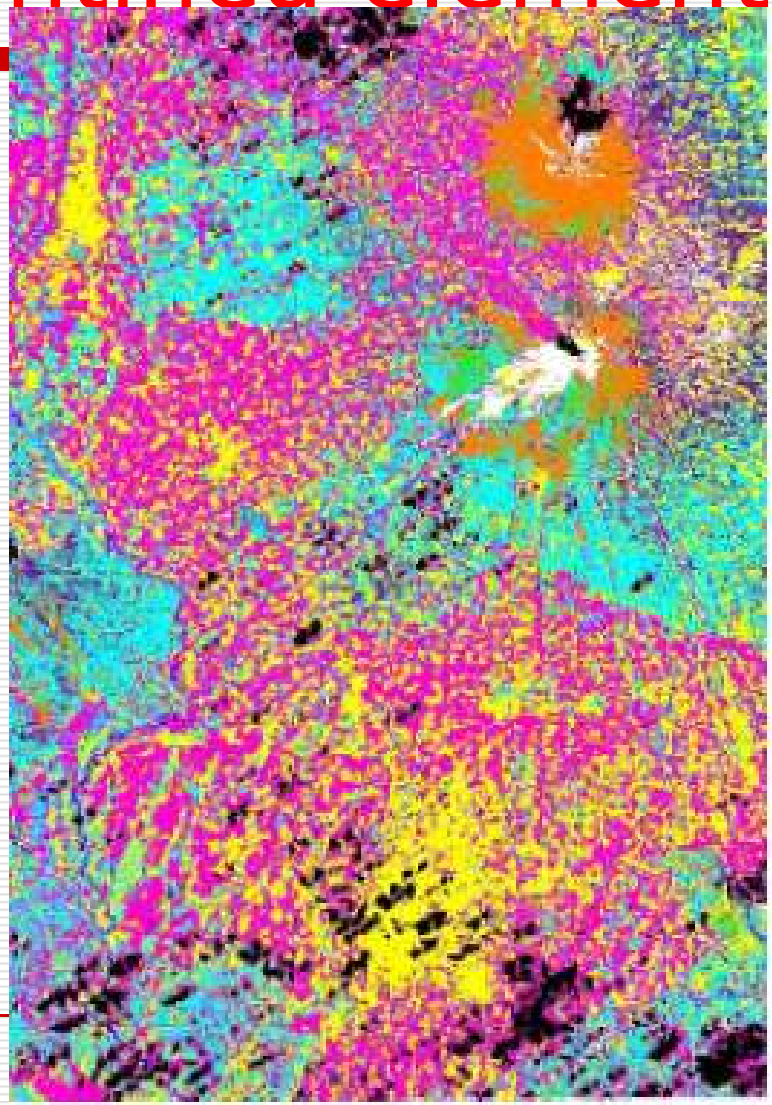
Fig. 5.4 Image of Case 2b (*Boyong River* in time interval and legend; 25-m raster and geocoded)

Landuse map of Merapi volcano

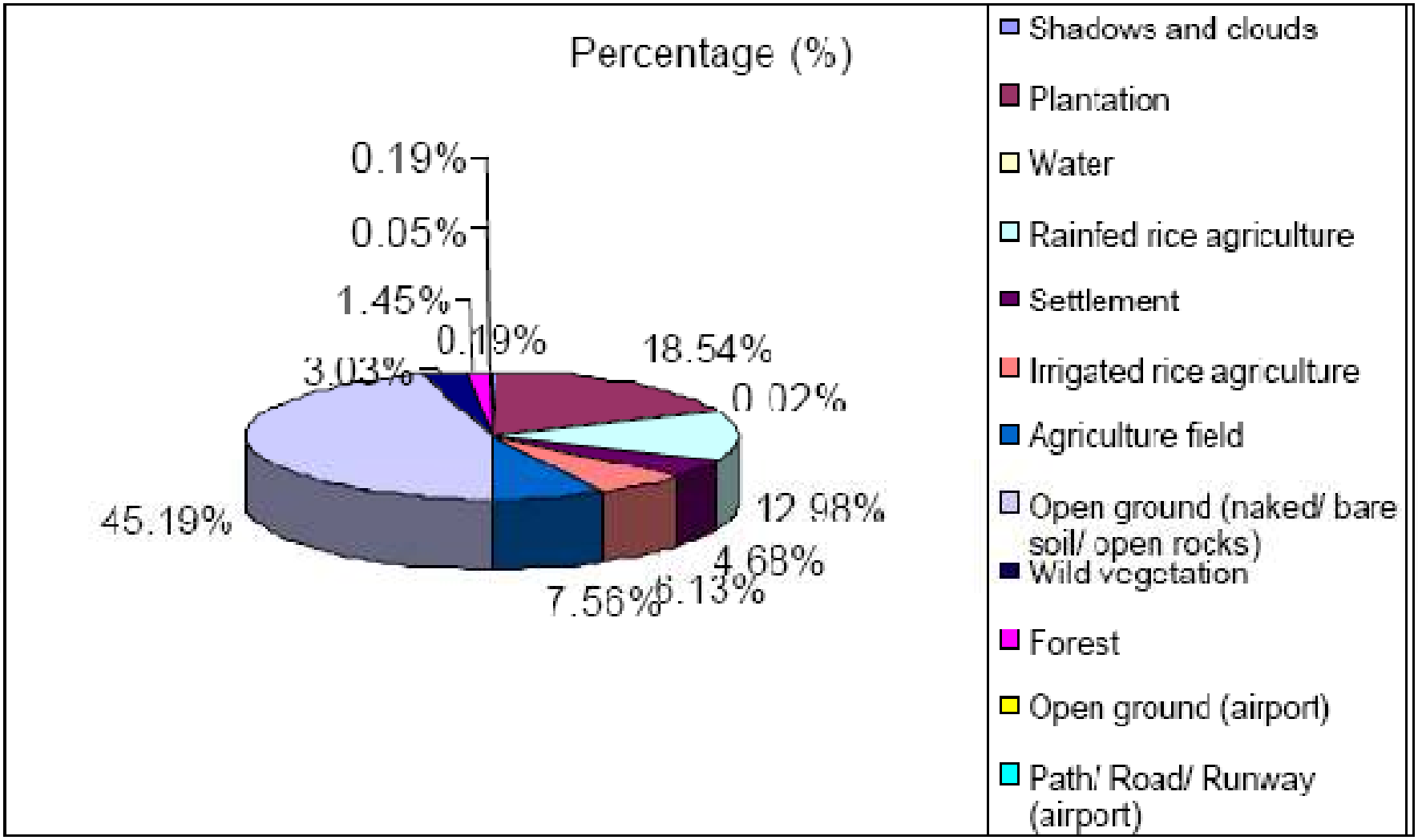


. 6.2 Case Studies (1 & 2) overlayed in landuse classification from LANDSAT TM 2001 both (APRIL and JULY)

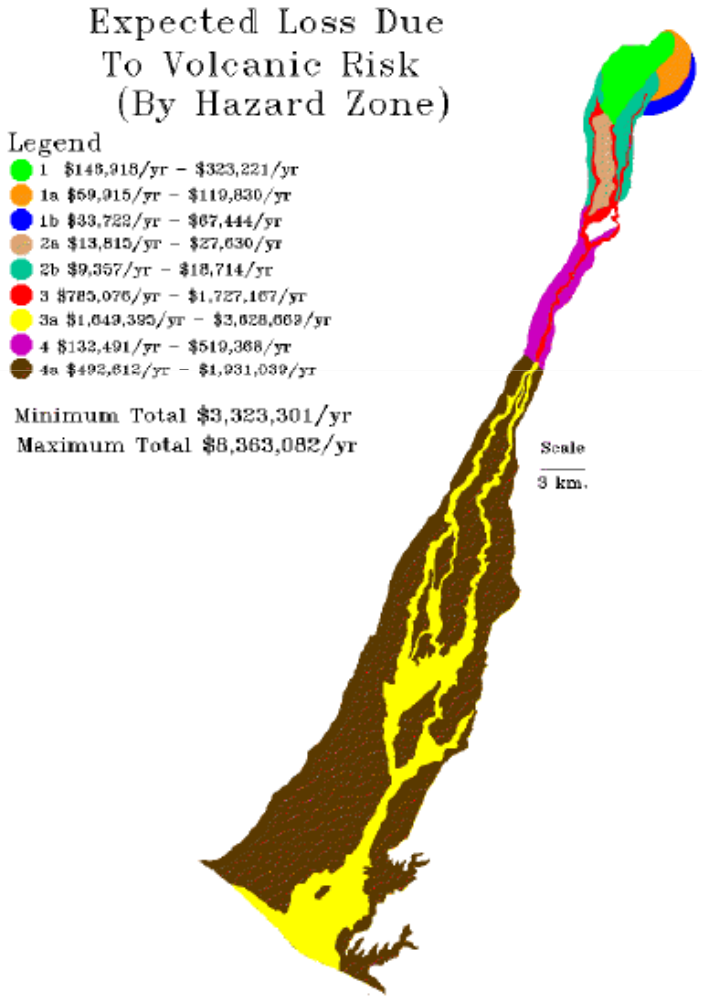
Identified element at RISK?



Percentage of landuse surrounding Merapi volcano



Risk Map of Volcanic Area



Santa Maria volcano, Guatemala

Volcanic Risk Maps

- Volcanic Risk Maps allow for the calculation of the economic impact of an active volcano in 'dollar' terms
- These maps are useful for disaster preparedness planning, because the real cost of the impact of a volcanic eruption can be compared with costs of mitigation and monitoring effects.

Population at Risk around Merapi

Table 1 Population at Risk: population density and growth around Merapi, 1976-1995

Zone of interest	No of Villages	Area (km^2)	Population (1976)	Population (1995)	Population Density	Population growth (%) (1990-5)
Elevation > 200 m asl	296	949.0	206 600	1 083 400	1399	3.6
Elevation > 500 m asl	89	374.5	-	258 200	690	3.0
Forbidden Zone	32	186.4	40 800	79 100	424	3.9
First Danger Zone	37	100.8	72 600	114 800	1139	3.6
Second Danger Zone	-	-	93 200	-	-	

Source: Thouret and Lavigne (2005)

Contoh:
Penataan Ruang Pasca Tsunami

Evacuation Shelter Building Planning for Tsunami-prone area; a Case Study of Meulaboh City, Indonesia

Amin Budiarjo
UPLA.2 – 2004/2006

Supervisors:
Ms. Monika Kuffer M.Sc.
Drs. M.C.J. Damen

5/9/2010

Tsunami-survived Buildings Characteristics

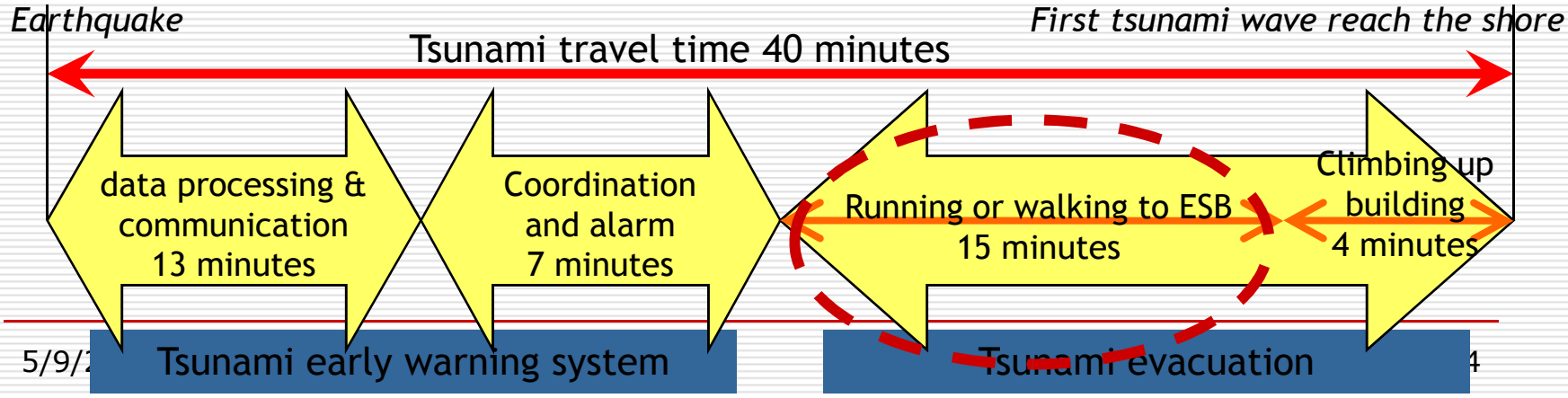
- Location: located outside 200m range from the shore
- Orientation: building mass not block the wave flows
- Facade and openings: large percentage of openings in ground floor or at tsunami-reached floor
- Engineered: planned and designed in accordance with building regulation
- Construction: good construction quality

Estimation of population distribution

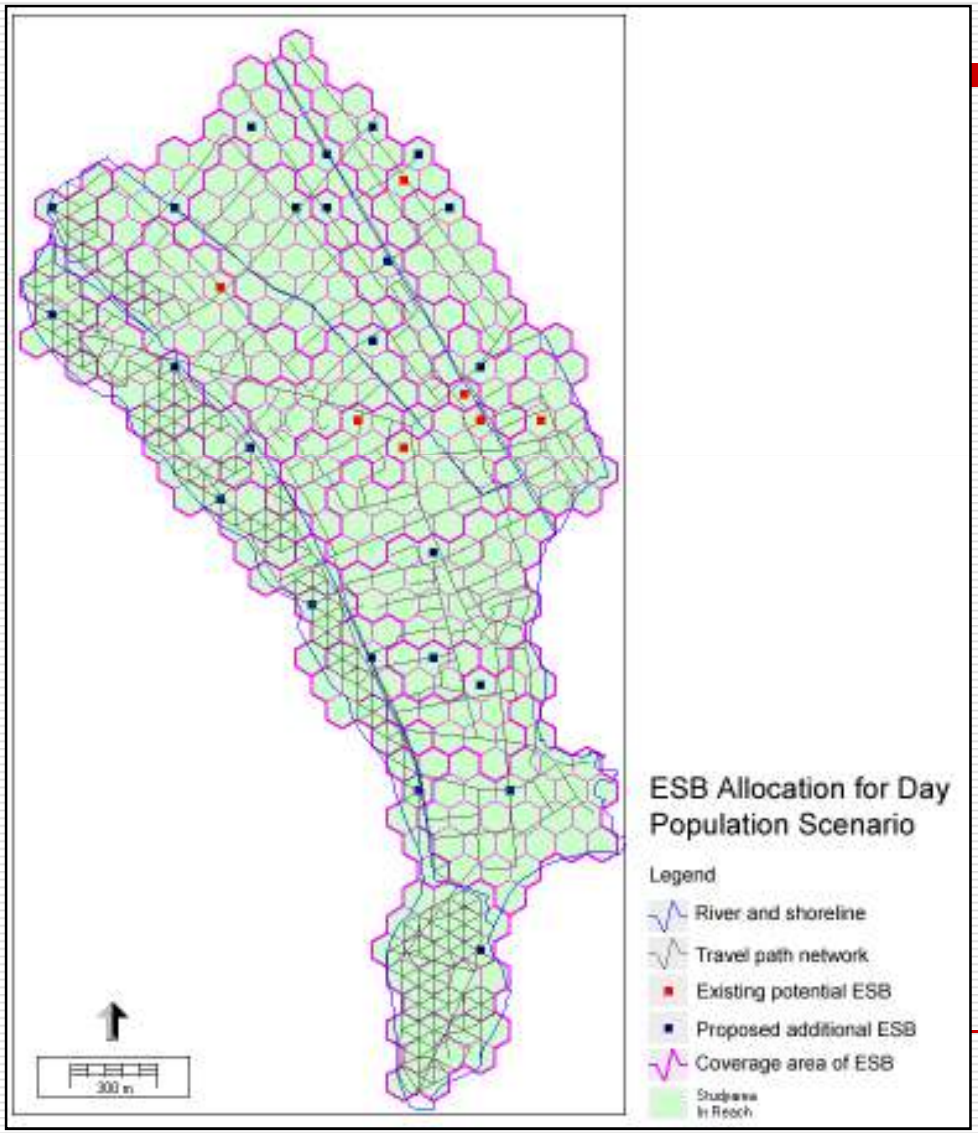
- Evacuation Shelter Building (ESB) Allocation Modeling:
- Population data April 2005
- Calculated per tessellation of 1ha hexagon overlaid on Quickbird and Ikonos images before & after tsunami.
- Masterplan, buffer zone & relocation are taken into consideration.
- Population distribution in day and night scenarios
- Residential use: house * pop/hh
- Other uses / facilities
  - Architectural design space requirement
  - Field observation
  - Building mass typology

Travel components

- Path
  - Road network (acquired from satellite images and field survey)
  - Off road passable path (virtual network at buffer zone)
- Speed
  - 0.751m/s, slowest speed during evacuation (Sugimoto, 2005)
  - Speed distinction between sea-ward and inland-ward directions
- Time constraint
  - Dec. 26 tsunami travel time for Meulaboh: **40 minutes** (Yalciner, 2005)
  - Seismic data processing and communication: 13 minutes (Bmbf, 2005)
  - Disaster management coordination & alarm: 8 minutes (assumption)
  - → *evacuation time: 19 minutes*



ESB allocation - day population



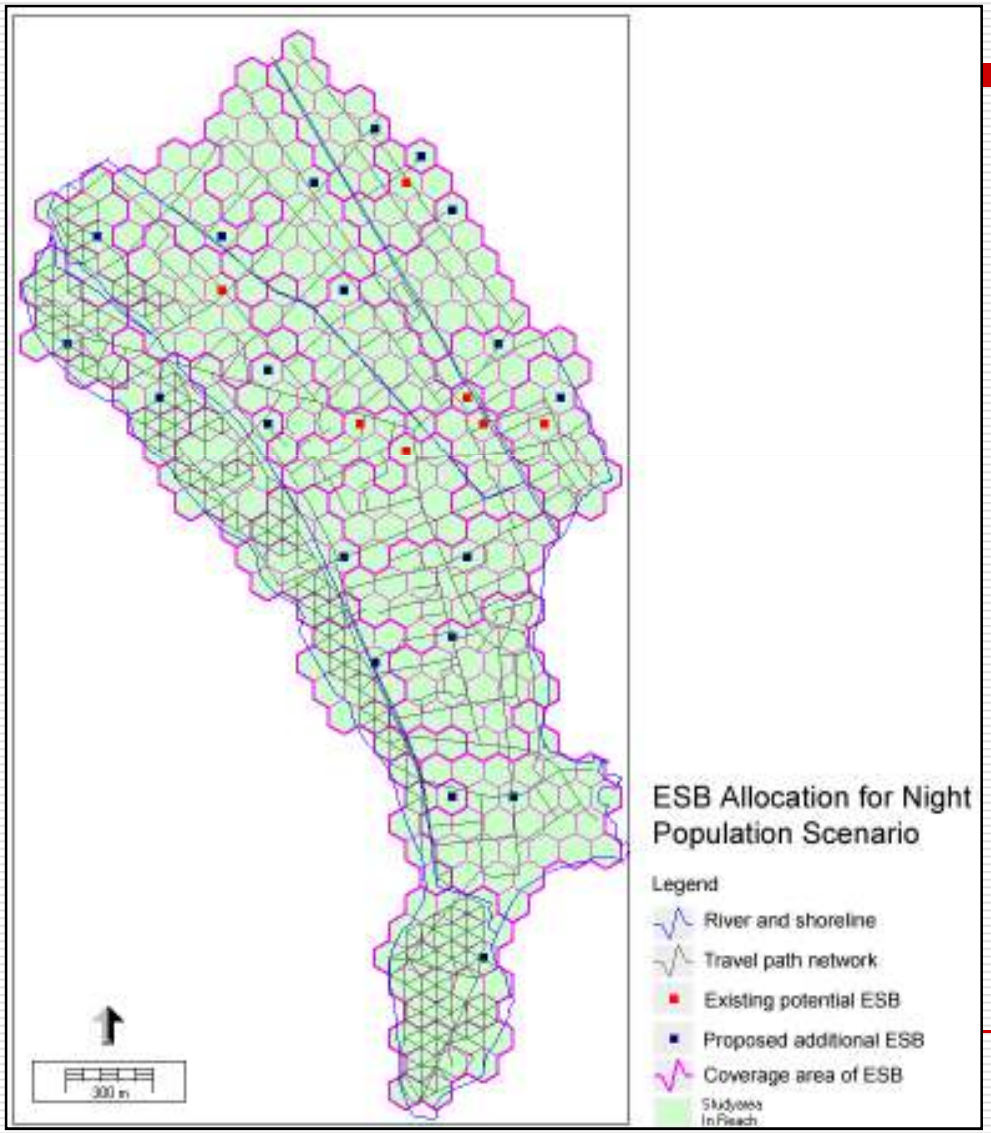
Modeling:

- Population distribution: population number in day scenario
- Expansion Model from the existing potential ESB *maximizing population coverage*

Result:

- 7 existing potential ESB and 25 additional ESB
- Longest travel time: 688s

ESB allocation - night population



Modeling:

- Population distribution: population number in night scenario
- Expansion Model from the existing potential ESB with *maximizing population coverage*

Result:

- 7 existing potential ESB and 20 additional ESB
- Longest travel time: 718s

Evacuation Shelter Building Planning - Meulaboh Final ESB allocation

Modeling:

- Population: maximum population in day or night scenario
- Reduction Model on the results (proposed allocation) of day and night scenarios with *least effect on population coverage*

Result:

- 7 exiting potential ESB and 20 additional ESB
- Longest travel time: 14 min 12”