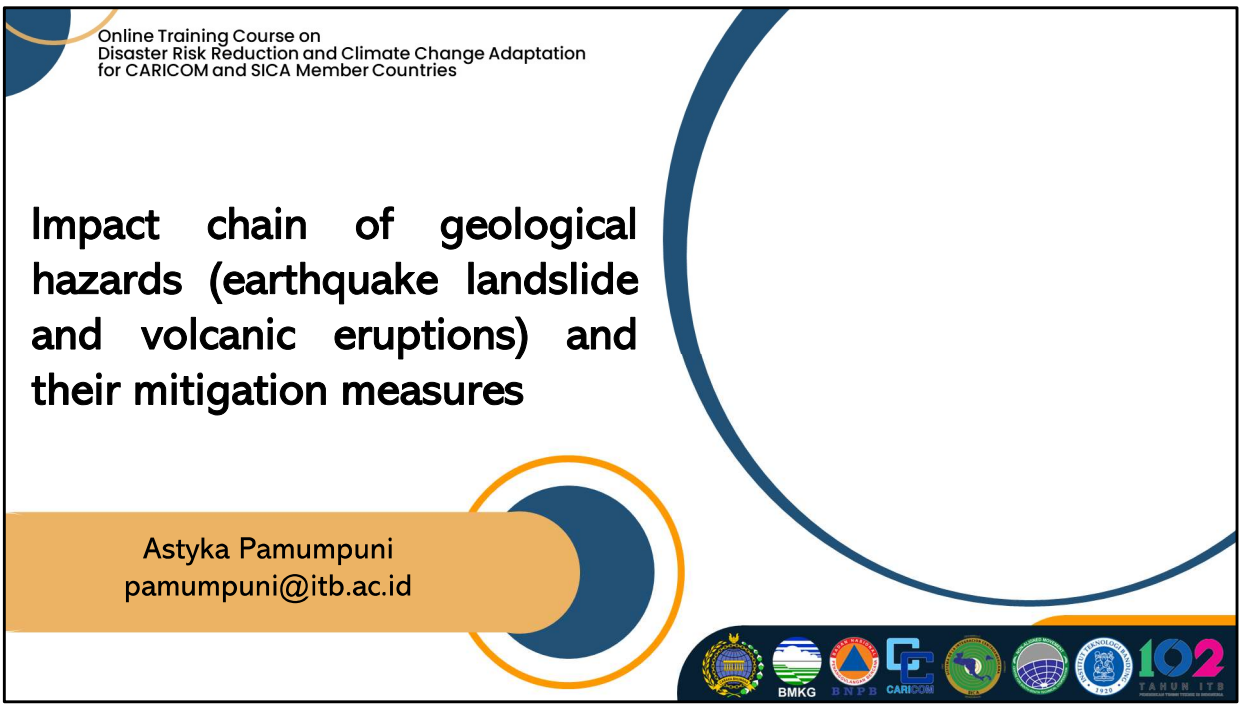
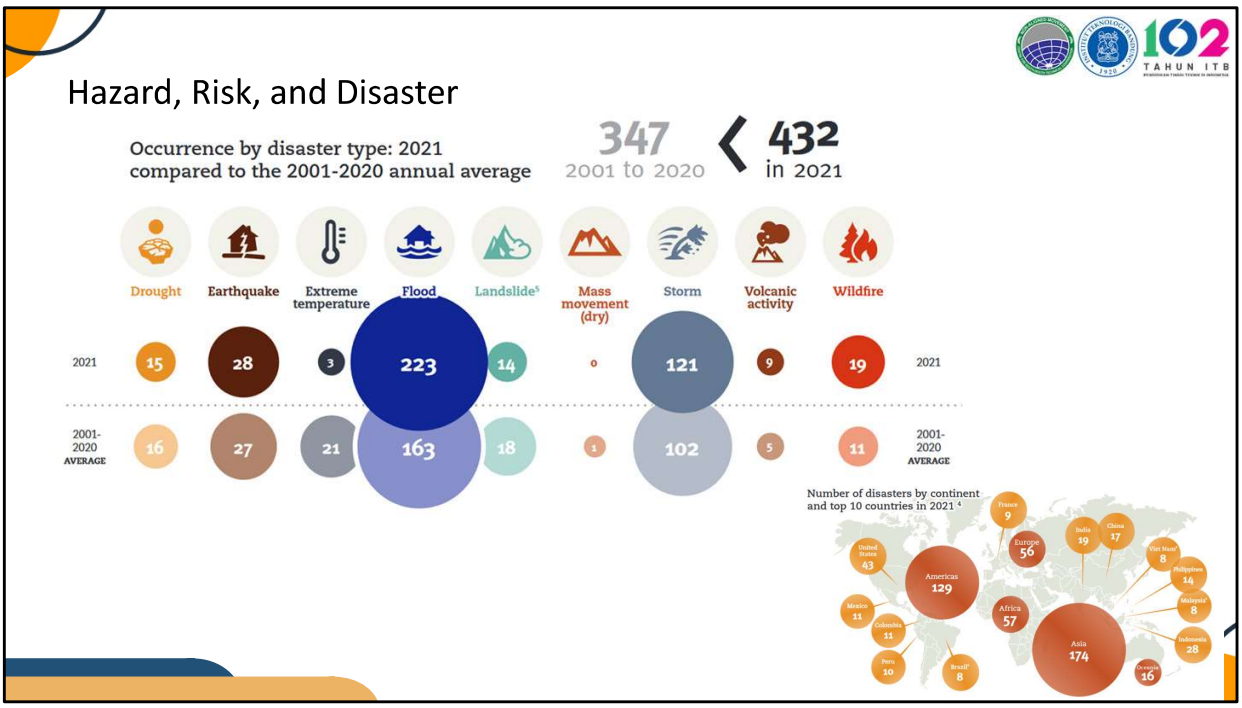

Online Training Course on
Disaster Risk Reduction and Climate Change Adaptation
for CARICOM and SICA Member Countries
Impact chain of geological hazards (earthquake landslide and volcanic eruptions) and their mitigation measures
Astyka Pamumpuni
pamumpuni@itb.ac.id
BMKG
BNPB
CARICOM
102
TAHUN ITB

Outline

- Hazard, Risk, and Disaster
- Tectonic and geological hazards
- Geological Hazards and Analysis
  - Earthquake
  - Volcanic
  - Landslides
  - Tsunami
- Summary

Hazard, Risk, and Disaster



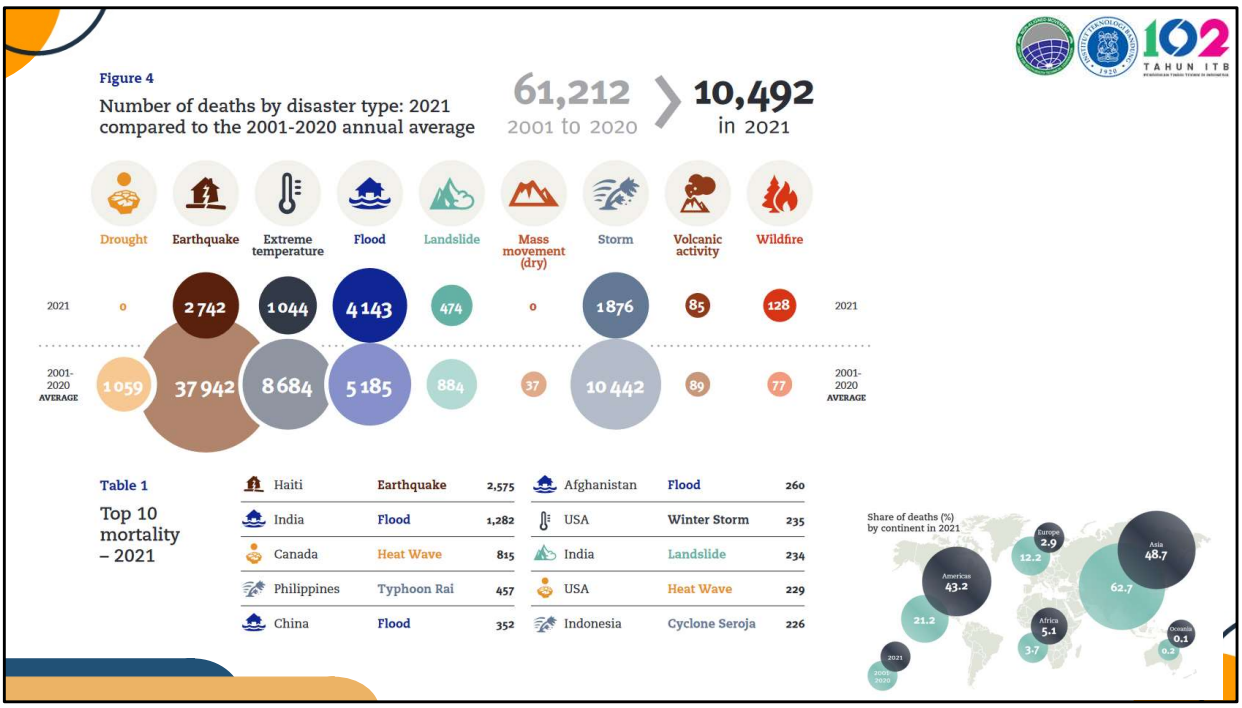
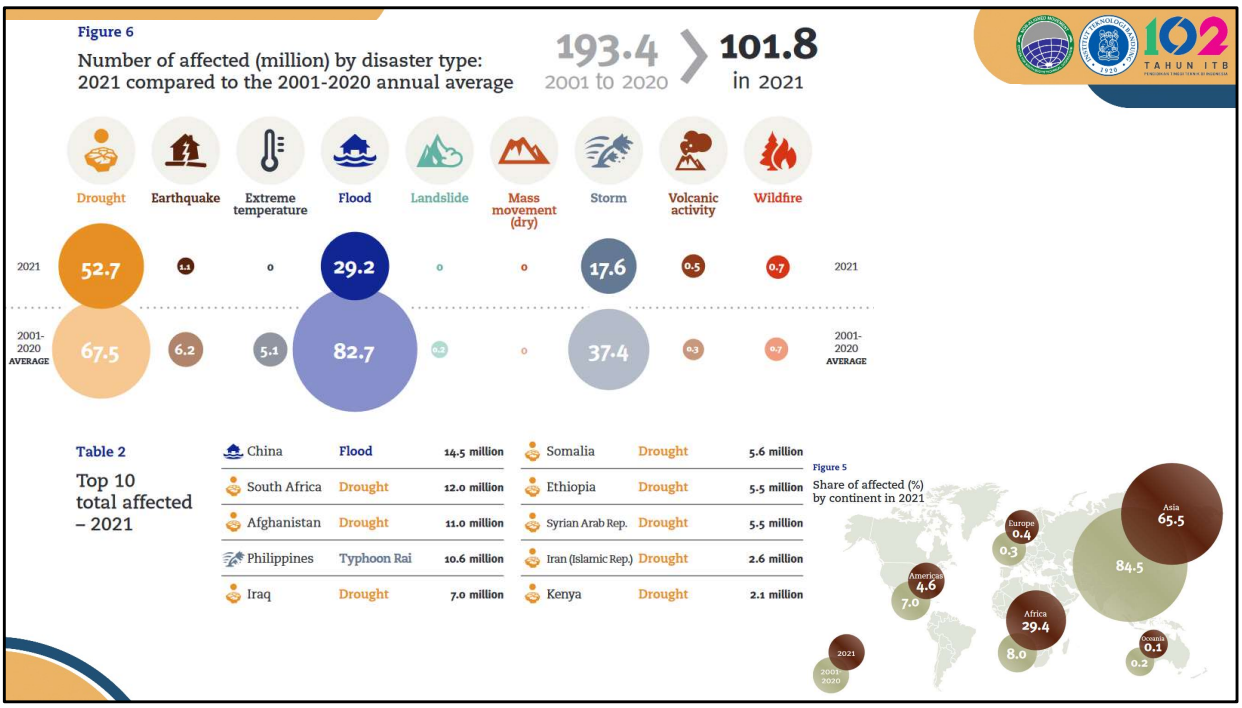


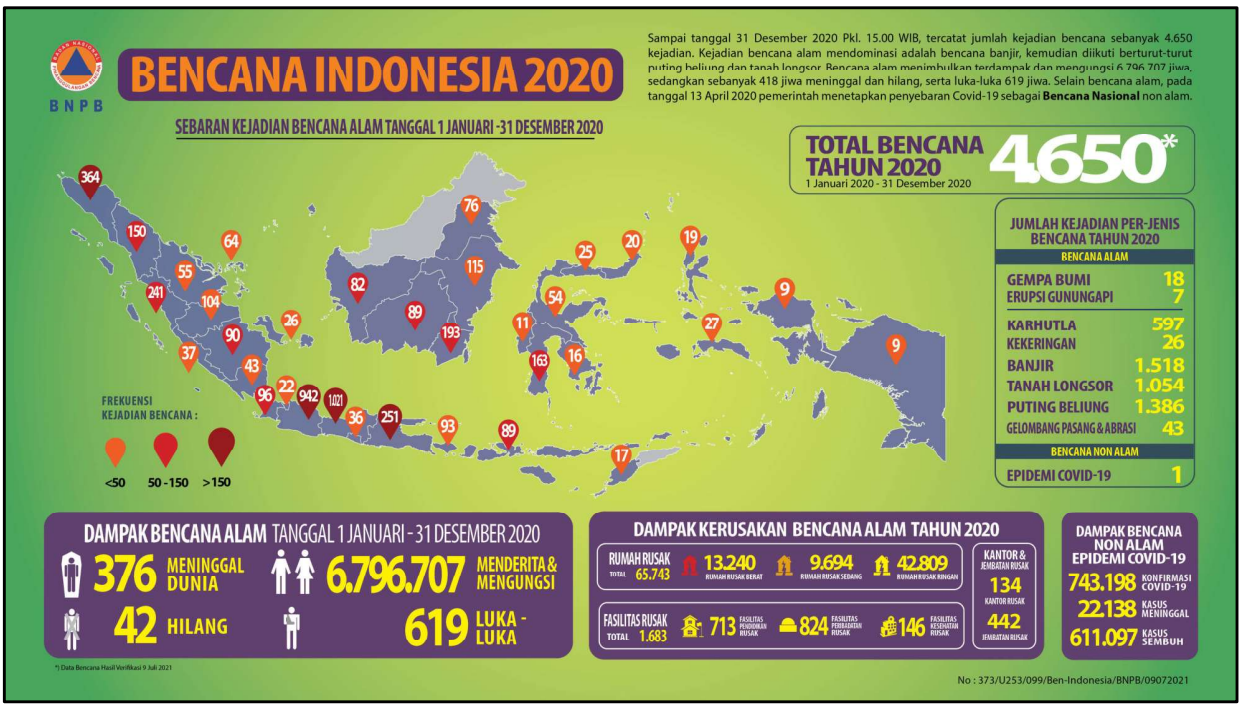
Figure 4
Number of deaths by disaster type: 2021 compared to the 2001-2020 annual average
61,212
2001 to 2020
10,492
in 2021
Drought
Earthquake
Extreme temperature
Flood
Landslide
Mass movement (dry)
Storm
Volcanic activity
Wildfire
2021
0
2 742
1 044
4 143
474
0
1 876
85
128
2021
2001-2020 AVERAGE
1 059
37 942
8 684
5 185
884
37
10 442
89
77
2001-2020 AVERAGE
Table 1
Top 10 mortality – 2021
Haiti Earthquake 2,575
India Flood 1,282
Canada Heat Wave 815
Philippines Typhoon Rai 457
China Flood 352
Afghanistan Flood 260
USA Winter Storm 235
India Landslide 234
USA Heat Wave 229
Indonesia Cyclone Seroja 226
Share of deaths (%) by continent in 2021
Europe 2.9
12.2
Asia 48.7
62.7
Americas 43.2
21.2
Africa 5.1
3-7
Oceania 0.1
0.2
2021
2001-2020

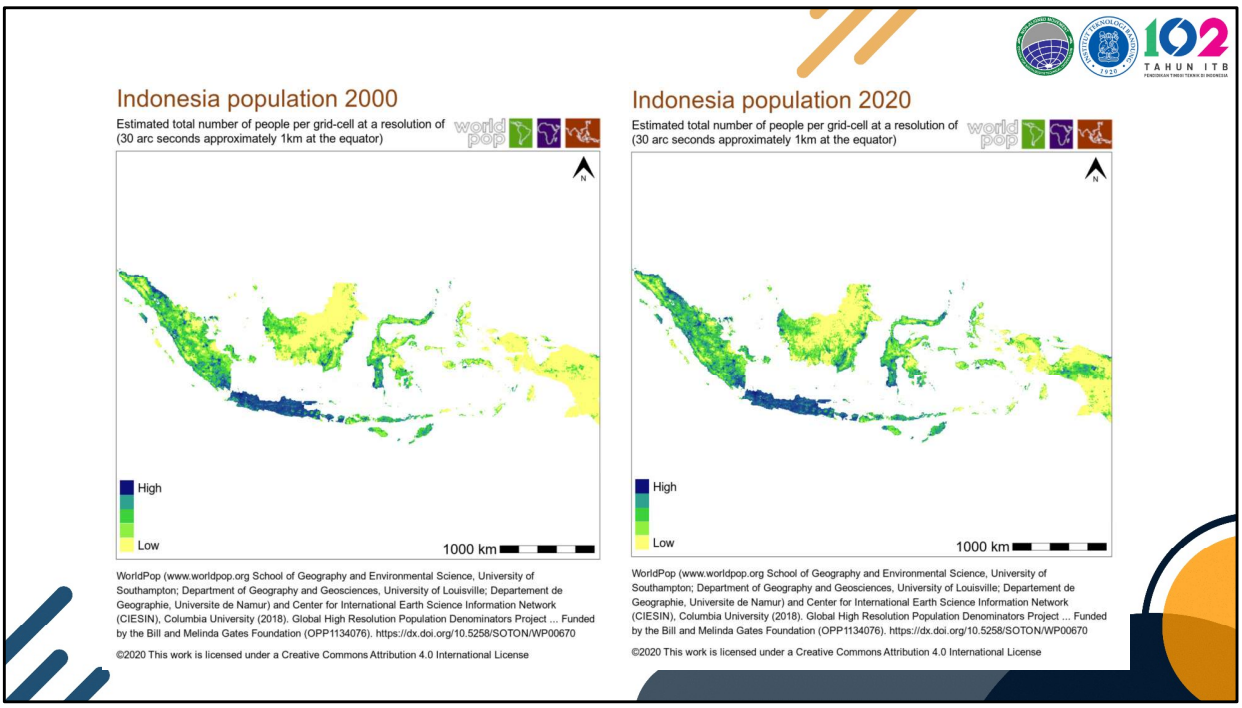


As floods and storms are the most common hazards, the number of people affected is huge. Drought is even less common, but the effect is widely felt.
Some slow or small events are common and less dramatic, but a lot of people are affected.
Dramatic hazards (such as volcanoes and earthquakes) affect a smaller number of people but are deadly.

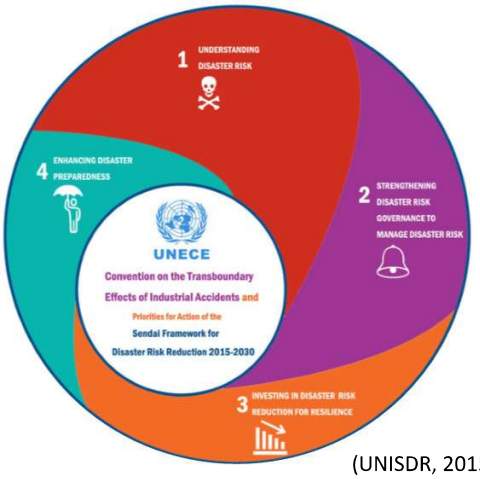
Disaster in Indonesia 2018

In 2018, Indonesia experience Lombok Earthquake, Palu Earthquake, and Krakatau Tsunami. More than 2000 people lost their life from Palu earthquake (tsunami, liquefaction) alone.


BNPB
BENCANA INDONESIA 2020
Sampai tanggal 31 Desember 2020 Pkl. 15.00 WIB, tercatat jumlah kejadian bencana sebanyak 4.650 kejadian. Kejadian bencana alam mendominasi adalah bencana banjir, kemudian diikuti berturut-turut puting beliung dan tanah longsor. Bencana alam menimbulkan terdampak dan mengungsi 6.796.707 jiwa, sedangkan sebanyak 418 jiwa meninggal dan hilang, serta luka-luka 619 jiwa. Selain bencana alam, pada tanggal 13 April 2020 pemerintah menetapkan penyebaran Covid-19 sebagai **Bencana Nasional** non alam.
SEBARAN KEJADIAN BENCANA ALAM TANGGAL 1 JANUARI -31 DESEMBER 2020
TOTAL BENCANA TAHUN 2020
1 Januari 2020 - 31 Desember 2020
4650*
JUMLAH KEJADIAN PER-JENIS BENCANA TAHUN 2020
BENCANA ALAM
GEMPA BUMI 18
ERUPSI GUNUNGAPI 7
KARHUTLA 597
KEKERINGAN 26
BANJIR 1.518
TANAH LONGSOR 1.054
PUTING BELIUNG 1.386
GELOMBANG PASANG & ABRASI 43
BENCANA NON ALAM
EPIDEMI COVID-19 1
FREKUENSI KEJADIAN BENCANA :
<50
50 - 150
>150
364
150
64
55
241
104
90
37
43
96
22
942
1021
36
251
93
89
26
82
76
115
89
193
11
54
163
16
25
20
17
19
9
27
9
DAMPAK BENCANA ALAM TANGGAL 1 JANUARI - 31 DESEMBER 2020
376 MENINGGAL DUNIA
6.796.707 MENDERITA & MENGUNGSI
42 HILANG
619 LUKA - LUKA
DAMPAK KERUSAKAN BENCANA ALAM TAHUN 2020
RUMAH RUSAK TOTAL 65.743
13.240 RUMAH RUSAK BERAT
9.694 RUMAH RUSAK SEDANG
42.809 RUMAH RUSAK RINGAN
FASILITAS RUSAK TOTAL 1.683
713 FASILITAS PENDIDIKAN RUSAK
824 FASILITAS PERIBADATAN RUSAK
146 FASILITAS KESEHATAN RUSAK
KANTOR & JEMBATAN RUSAK
134 KANTOR RUSAK
442 JEMBATAN RUSAK
DAMPAK BENCANA NON ALAM EPIDEMI COVID-19
743.198 KONFIRMASI COVID-19
22.138 KASUS MENINGGAL
611.097 KASUS SEMBUH
*) Data Bencana Hasil Verifikasi 9 Juli 2021
No : 373/U253/099/Ben-Indonesia/BNPB/09072021



The population density of Indonesia is still concentrated in Java, making it more prone to natural hazards event.

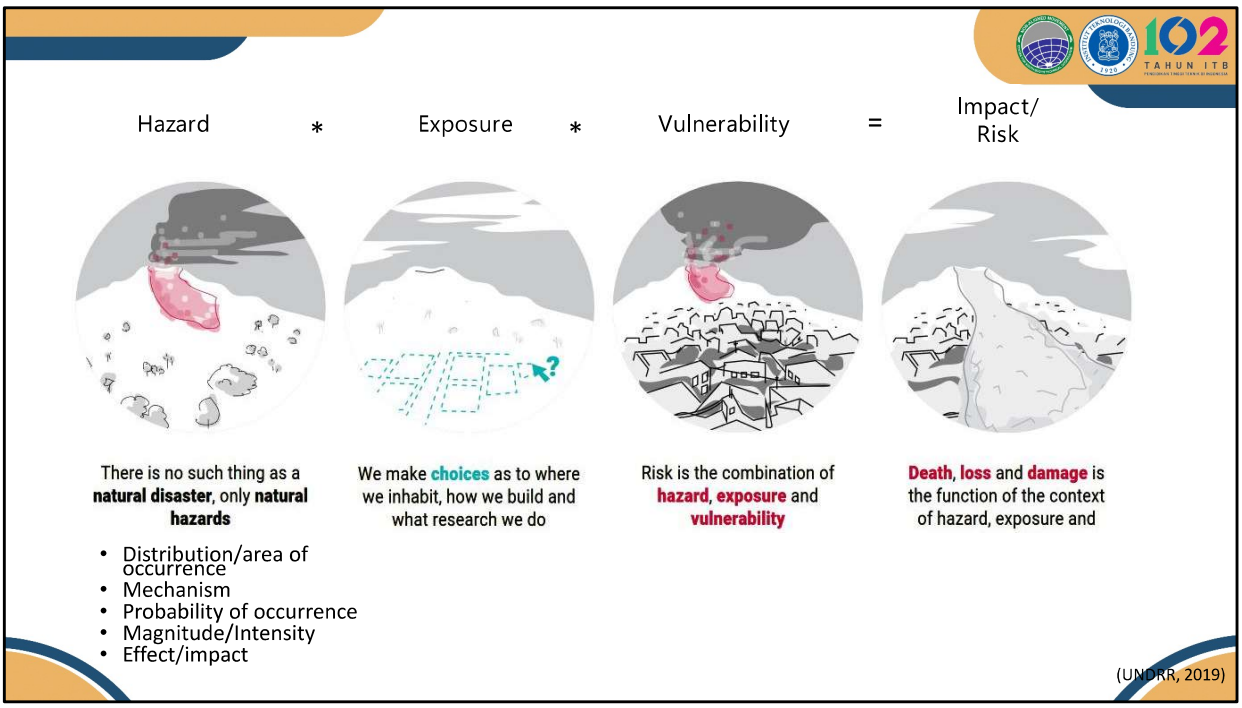


(UNISDR, 2015)

The Sendai Framework sets four specific priorities for action:

1. **Understanding disaster risk;**
2. Strengthening disaster risk **governance** to manage disaster risk;
3. Investing in disaster risk reduction for **resilience**;
4. Enhancing disaster preparedness for effective response, and to "**Build Back Better**" in recovery, rehabilitation and reconstruction.

Sendai Framework set Understanding disaster risk as the first action needed in disaster risk reduction. It is like facing a ghost if we do mitigation efforts without proper understanding of the risk



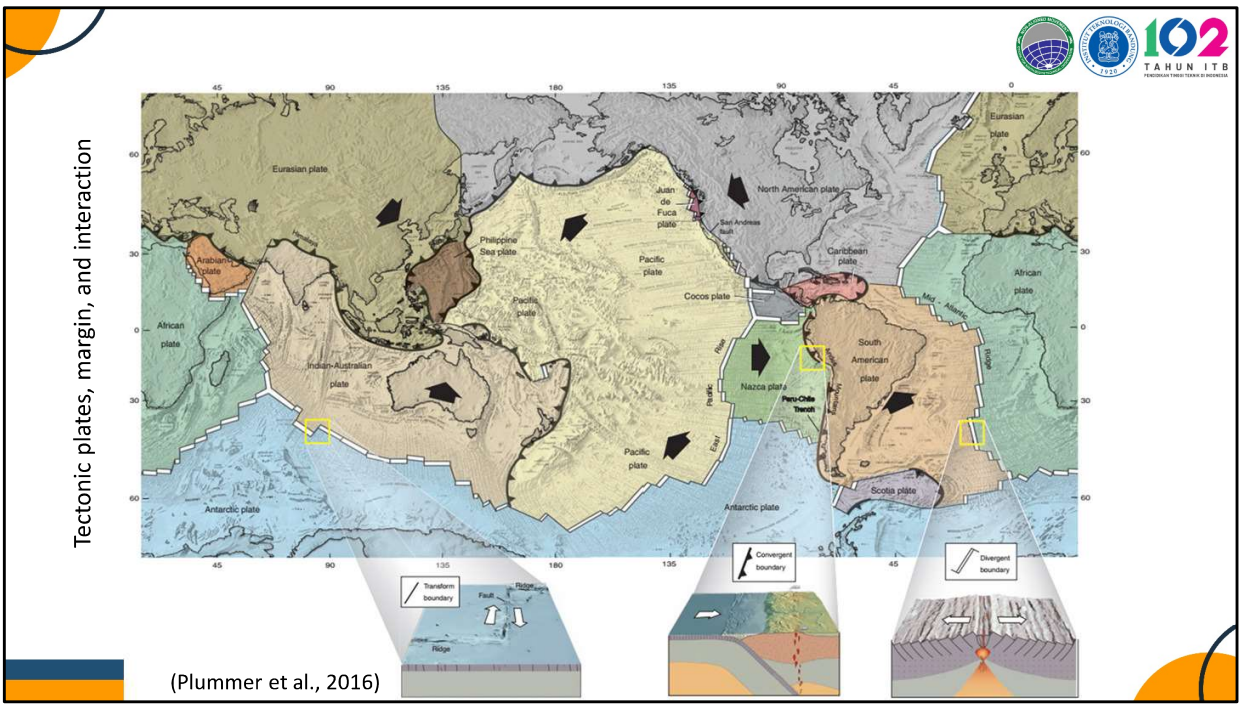
Hazard – A process, phenomenon or human activity that may cause loss of life, injury or other health impacts, property damage, social and economic disruption or environmental degradation
Risk – The potential loss of life, injury, or destroyed or damaged assets which could occur to a system, society or a community in a specific period of time
Exposure – The situation of people, infrastructure, housing, production capacities and other tangible human assets located in hazard-prone areas
Vulnerability – The conditions determined by physical, social, economic and environmental factors or processes which increase the susceptibility of an individual, a community, assets or systems to the impacts of hazards
Impact – is the result of a hazard event (people's lives and livelihoods): lives, houses, environment, infrastructure, livelihoods, etc.

Natural hazards are only natural hazards. Earthquakes, volcanic eruptions, landslides, etc. are geological phenomena that happened all the time even before humans exist.

We make choices to expose ourselves to natural hazards and face the risk with a lack of preparedness. Then death, loss, and damage are what we get.

Disaster (impact) is the function of hazards, exposure, and vulnerability. Hazard as a

natural phenomenon is something we can not reduce, but we can choose where we stay and what we prepared. If no one gets hurt or anything is damaged, a natural hazard is just a natural phenomenon. Once people lost their lives, or something is damaged, it is a disaster.



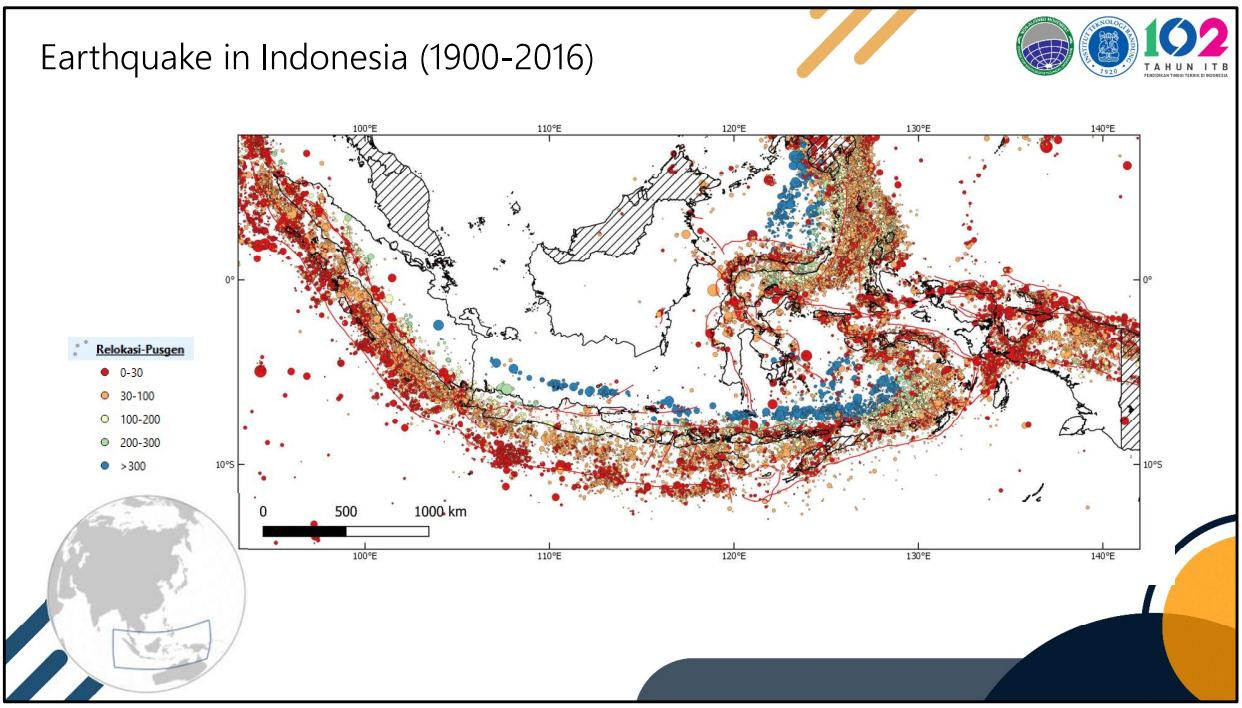
(Plummer et al., 2016)

Earth is made up of core, mantle, and crust. Crust and some upper part of the mantle is stiff and rigid “floating” on hotter asthenosphere.

More than 12 lithospheric plates move around create different interactions, slide past, collide, and spread apart each other.

As plates interact, subducted, collided, spread apart, and slide past, earthquakes and volcanoes are the most common direct hazard in plate boundary

Natural hazards/disasters are directly or indirectly related to each other. Mountain buildings made by tectonic force, create high terrain and cause landslides. While mountains also influence weather and climate that may produce flood hazards. Plate tectonics create earthquakes and volcanoes that can also produce tsunamis.

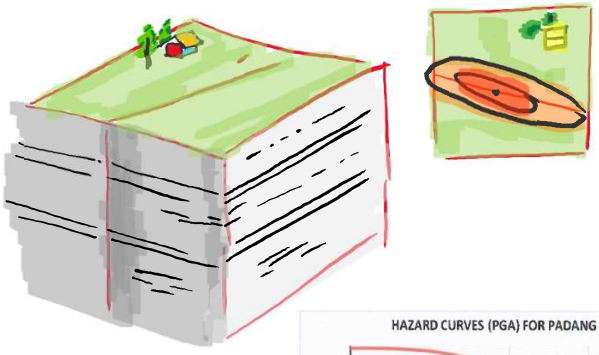


The Eastern part of Indonesia is an area with complex tectonic and is prone to earthquakes. Earthquake locations follow the trace of the plate margin.

Example of ground rupture (top left), small liquefaction (right top, bottom right, and bottom center), uplifted coral (bottom left)

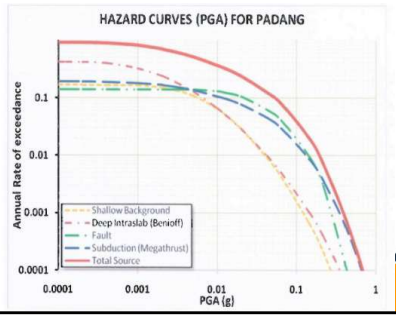
Example of liquefaction following Palu earthquake in 2018 (left)
Surface rupture showing vertical displacement more than 3.5m (right)

Earthquake Hazard Analysis

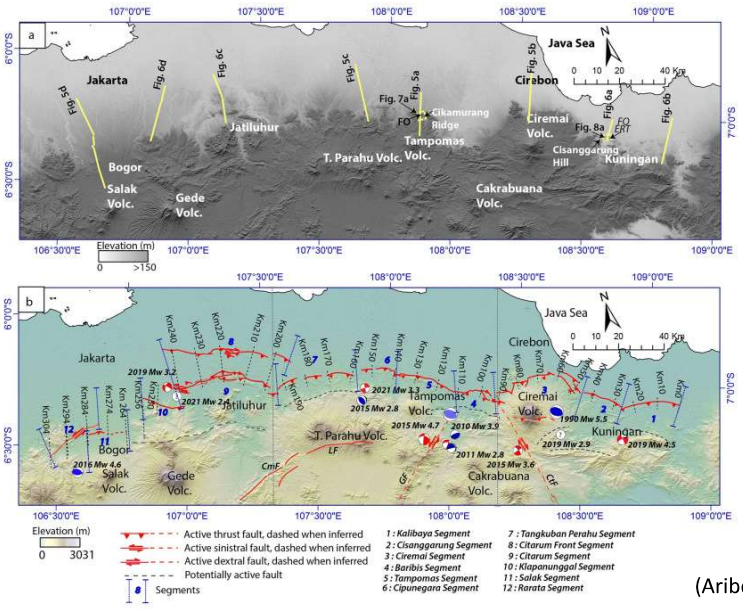


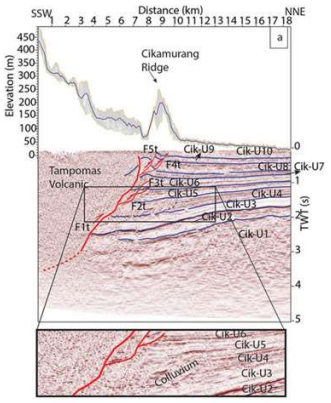
- Deterministic based – DSHA
- Probabilistic based – PSHA

  determine the annual probability (or rate) of exceeding some level of earthquake ground shaking at a site, for a range of intensity levels

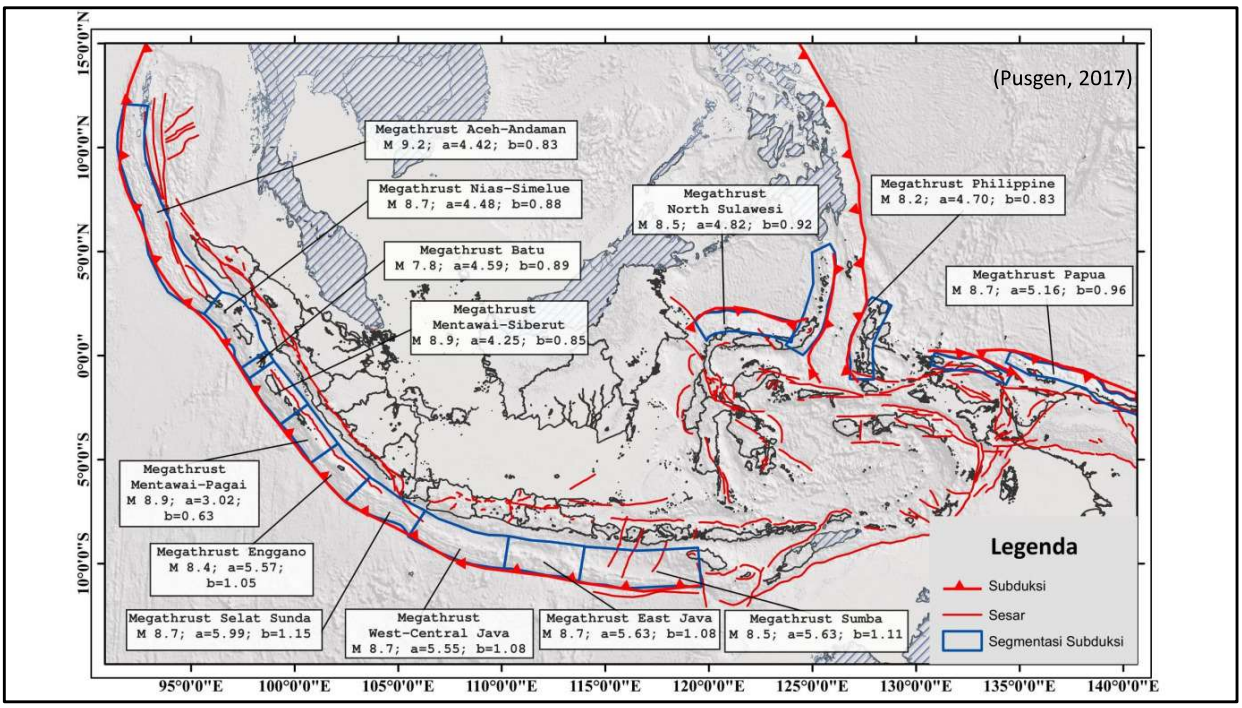


Active Fault Identification

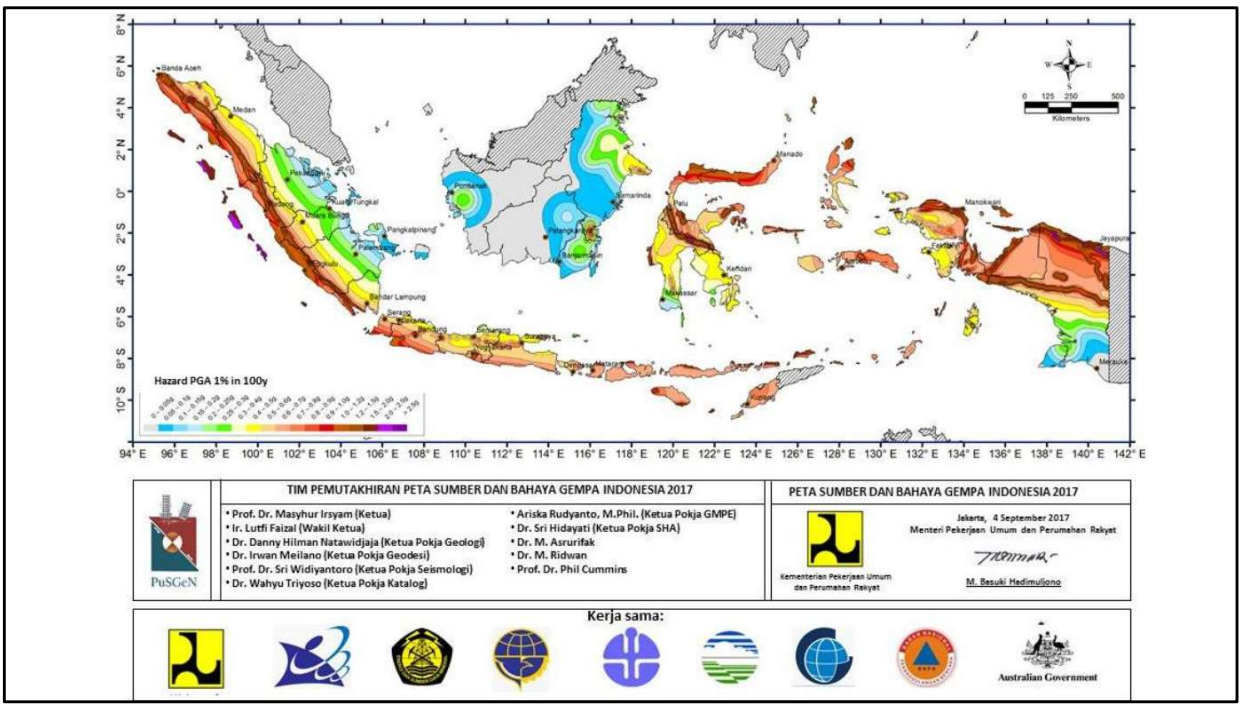




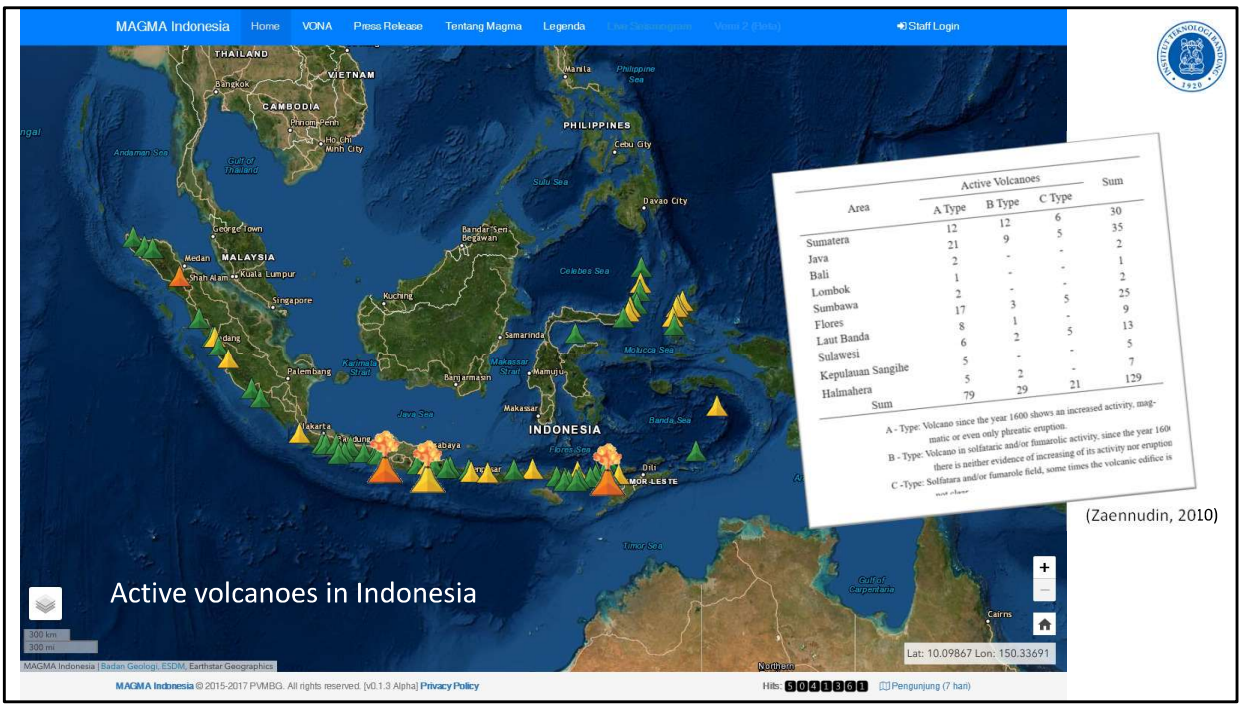
(Aribowo et al., 2022)



Map of earthquake sources in Indonesia as input in seismic hazard analysis



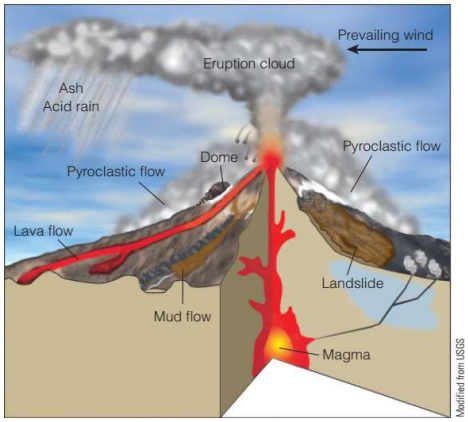
Ground acceleration as a result of probabilistic seismic hazard analysis.



(Zaennudin, 2010)

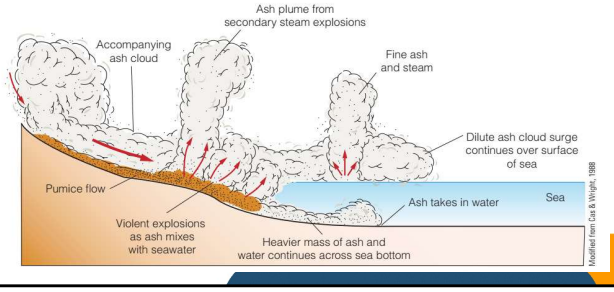
Active volcano in Indonesia. Indonesia has 129 active volcanoes, distribute from west to east.

Volcano hazards



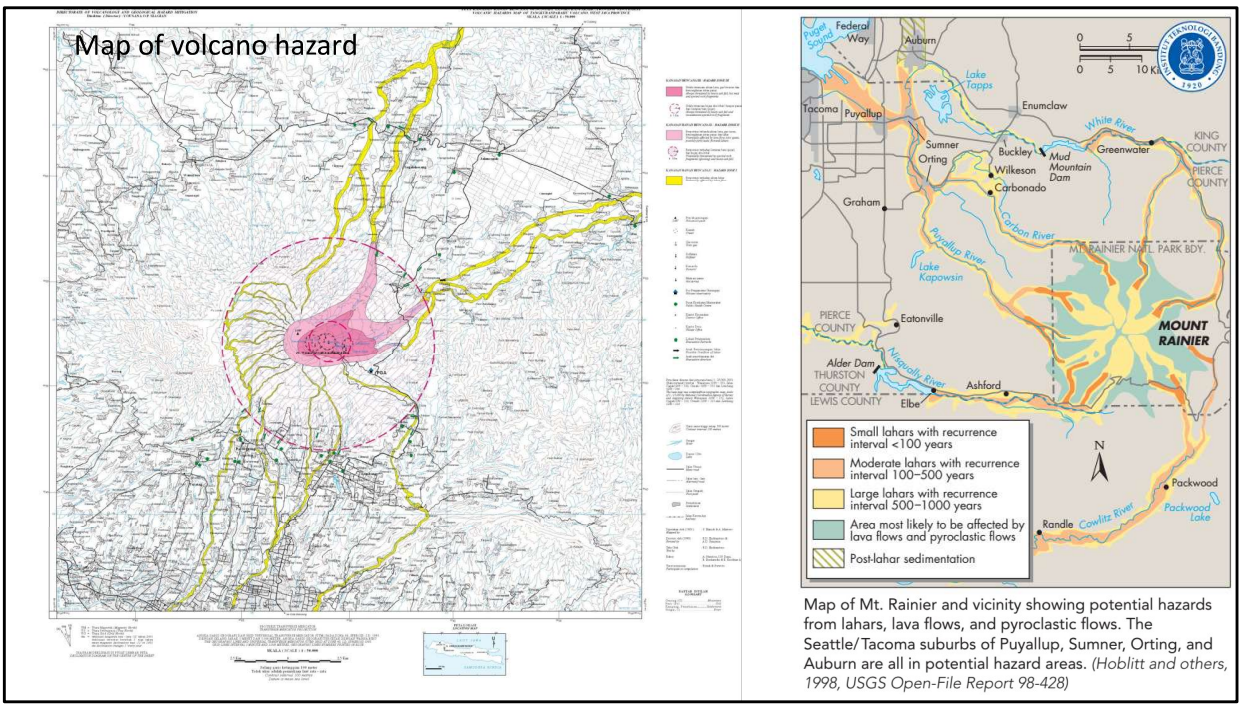
(Hyndman & Hyndman, 2017)

- **Lava flows**
- **Pyroclastic**
  - **neu ardente**
  - **ash fall**
- **Volcanic gases**
- **Mud flows**
- **Lahar**
- **Landslide and tsunami**



Volcano activity produce hazards from lava flows to tsunami and landslide.

Example of volcano hazards, pyroclastic flows, lahar, toxic gas, ash fall



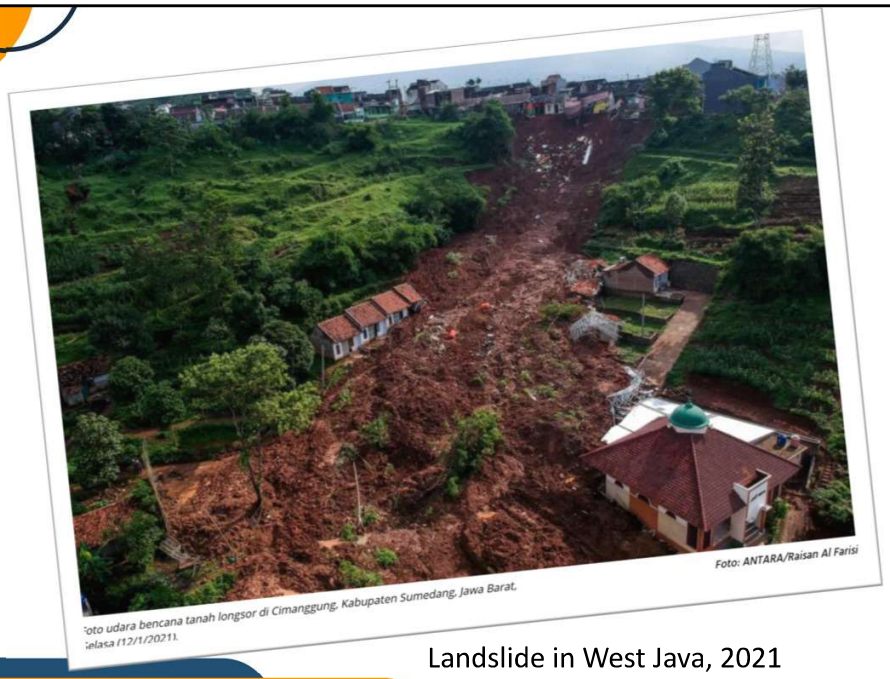
Map of Mt. Rainier and vicinity showing potential hazards from lahars, lava flows, and pyroclastic flows. The Seattle/Tacoma suburbs of Puyallup, Sumner, Orting, and Auburn are all in potential hazard areas. *(Hoblitt and others, 1998, USGS Open-File Report 98-428)*

Map of volcano hazard

Map of volcano hazard

Map of volcano hazard

Monitoring active volcano

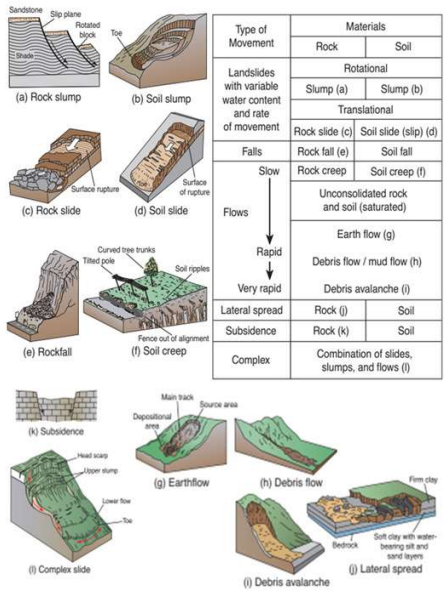


Landslide Hazard

Landslide in West Java, 2021

Earthquake induced landslide > debris flows, Palu 2018

Landslide Hazards and Landslide Susceptibility Analysis Methods



Type of Movement	Materials	
	Rock	Soil
Landslides with variable water content and rate of movement	Rotational	
	Slump (a)	Slump (b)
	Translational	
	Rock slide (c)	Soil slide (slip) (d)
Falls	Rock fall (e)	Soil fall
Flows: Slow	Rock creep	Soil creep (f)
Flows: Slow	Unconsolidated rock and soil (saturated)	
Flows: Rapid	Earth flow (g)	
Flows: Rapid	Debris flow / mud flow (h)	
Flows: Very rapid	Debris avalanche (i)	
Lateral spread	Rock (j)	Soil
Subsidence	Rock (k)	Soil
Complex	Combination of slides, slumps, and flows (l)	

Heuristic

Preliminary study
Using the experience of experts in conducting investigations or creating landslide susceptibility zoning maps based on geomorphological analysis or weighting of each parameter.

Statistic

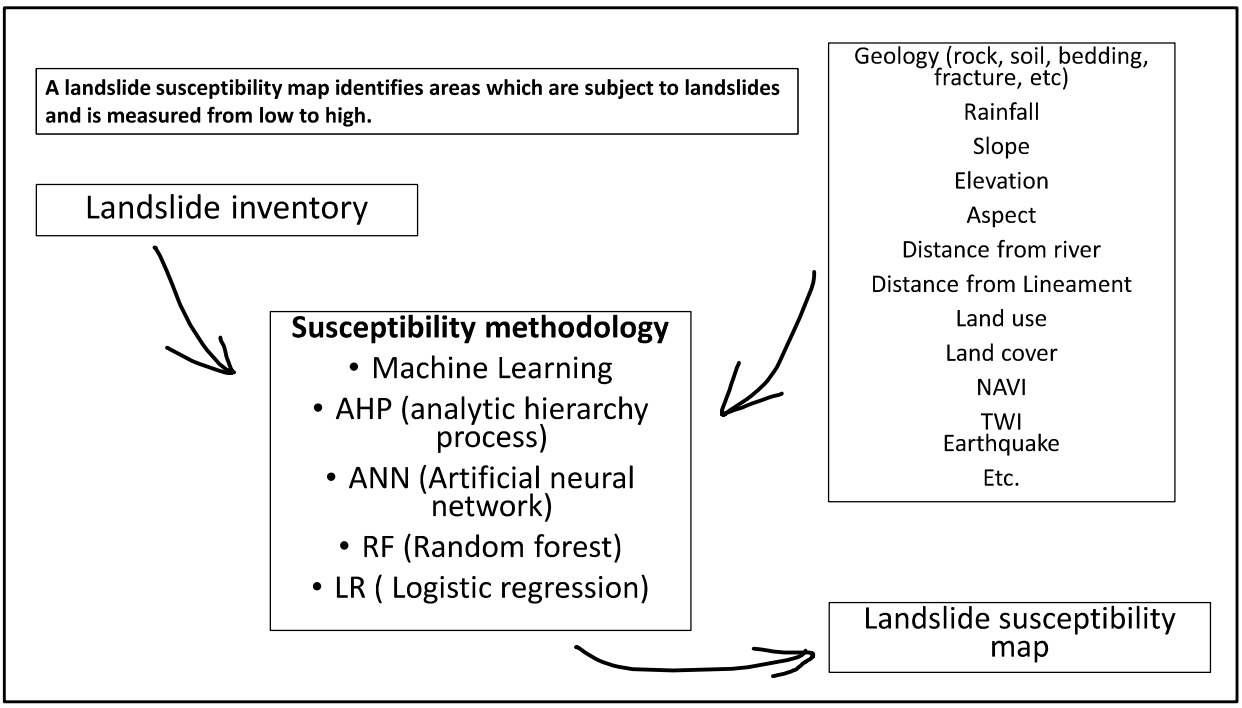
Planning and infrastructure development
The mapping method is based on the relationship between the landslide distribution and the controlling factor in each parameter class.

Deterministic

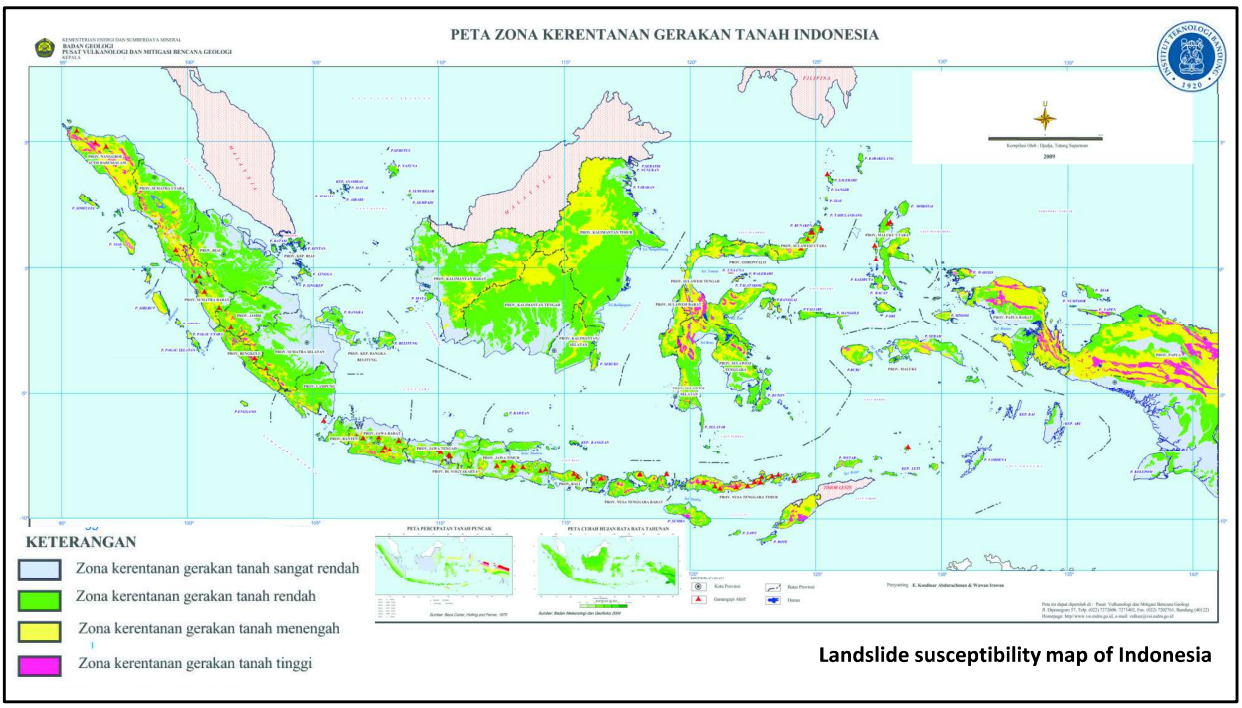
Desain and infrastructure build
Analysis based on slope stability safety factor.

Indonesian Standard (SNI) 8291:2016

Type of landslide, based on material, speed, and geometry
Methods in mapping landslide susceptibility according to scale and level of detail

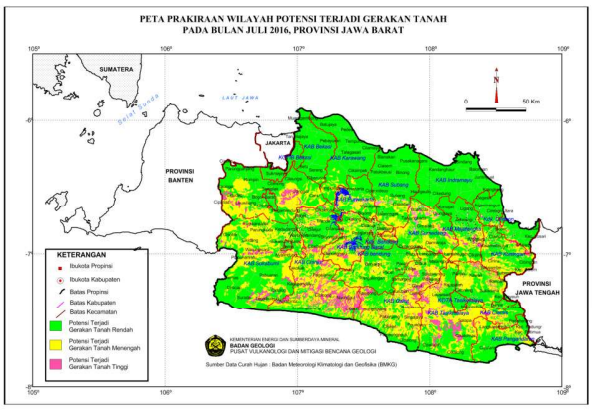


Methods in mapping landslide susceptibility according to scale and level of detail

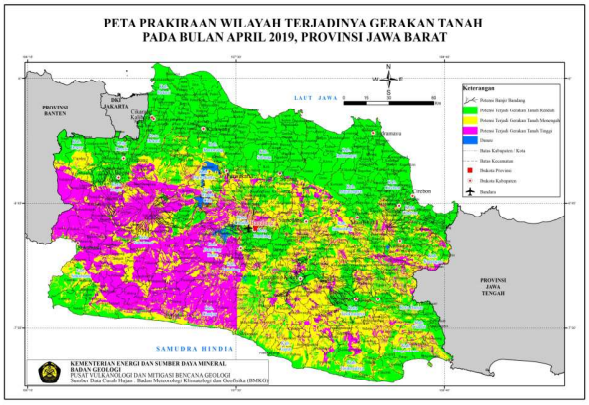


Landslide susceptibility map of Indonesia

Landslide susceptibility map of West Java



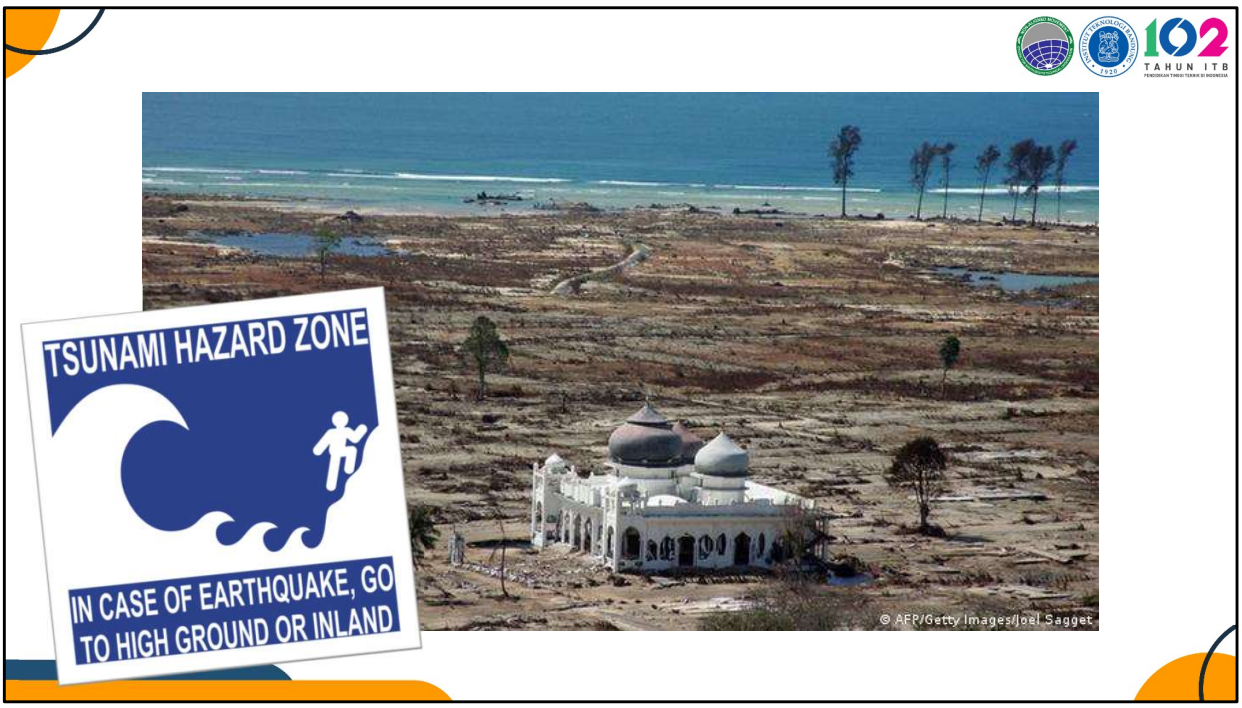
July 2016



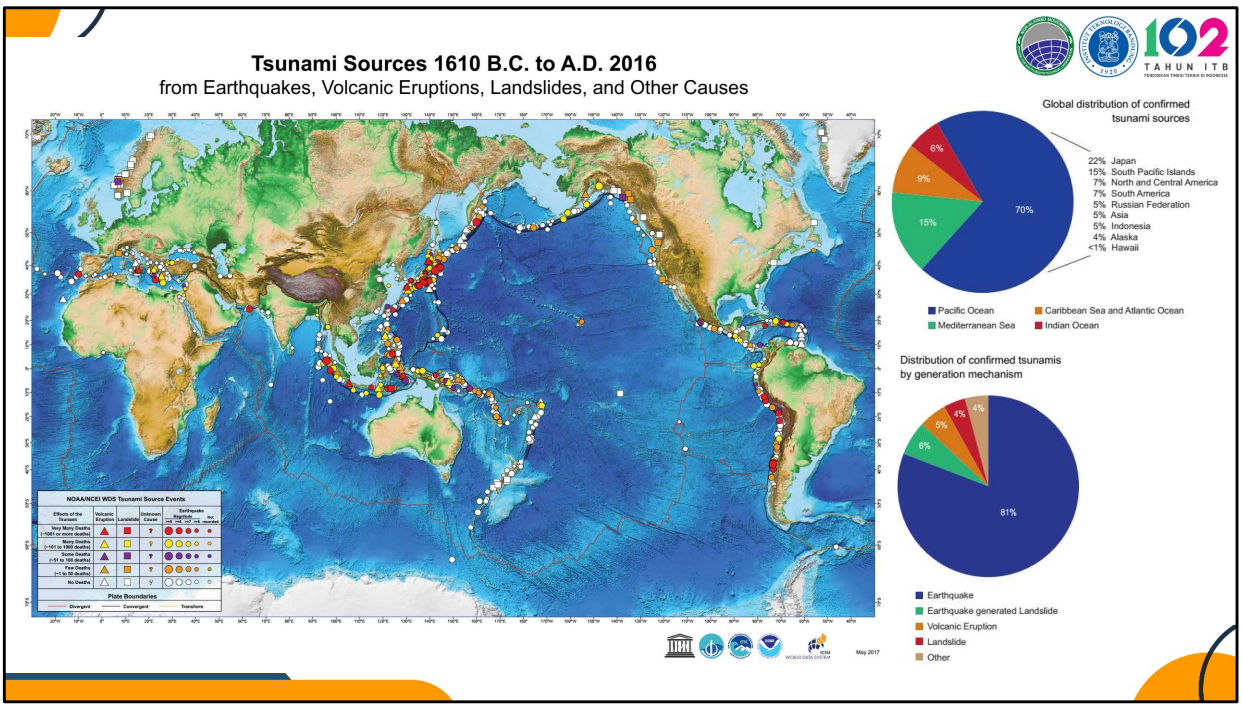
April 2019

Temporal Landslide susceptibility map of West Java

Landslide hazard

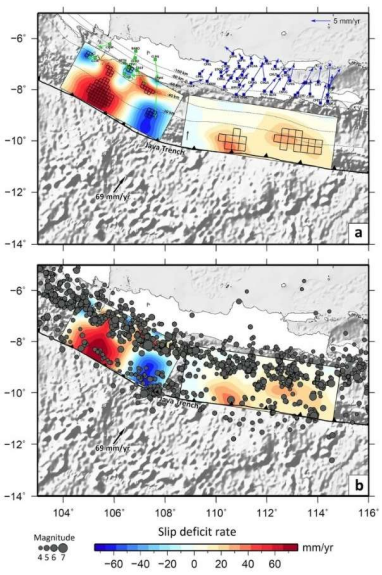


Tsunami hazard



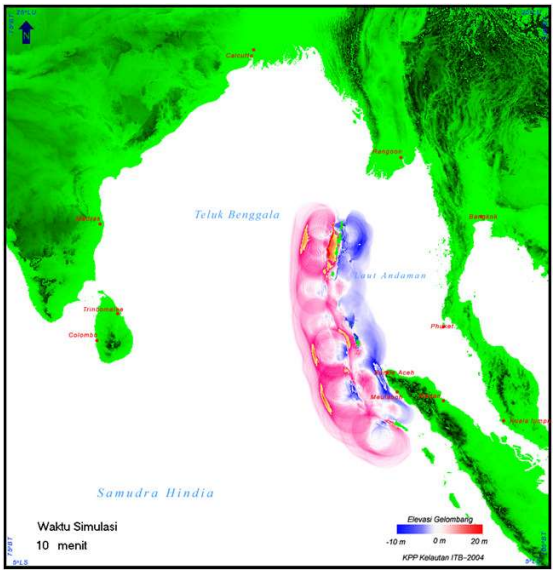
Source and location of historical tsunami from earthquake, volcano, landslide, and other causes. Most tsunami is generated by an earthquake. The Pacific Ocean is most experienced in tsunami events

Tsunami source identification and modeling



(Widiyantoro et al., 2020)

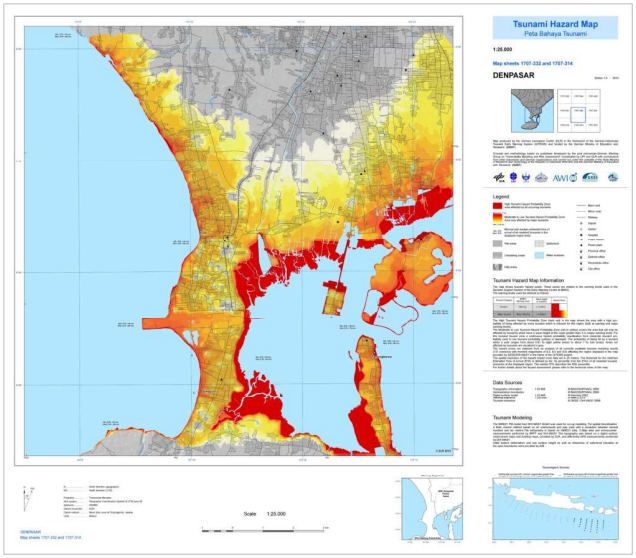
Tsunami source base on the Altimetry Data



(Tsunami Research Group Marine Research Center ITB)

Tsunami modeling is required in order to assess the hazard on land

Tsunami Hazard Map



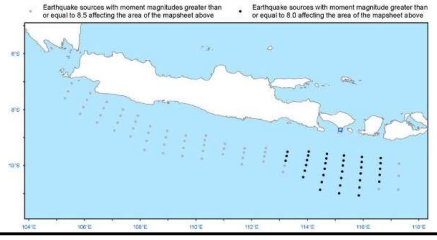
Tsunami Hazard Map Information

The map shows tsunami hazard zones. These zones are related to the warning levels used in the Decision Support System of the Early Warning Center at BMKG.
The warning levels used are defined as follows:

Tsunami Category	BMKG Warning Level	Wave height at coastline	Hazard Zone
Tsunami	Warning	≤ 3 meters	
Major Tsunami	Major Warning	> 3 meters	

The High Tsunami Hazard Probability Zone (dark red) in the map shows the area with a high probability of being affected by every tsunami which is relevant for this region (both at warning and major warning levels).
The Moderate to Low Tsunami Hazard Probability Zone (red to yellow) covers the area that will only be affected by tsunamis which have a wave height at the coast greater than 3 m (major warning level). For this tsunami hazard zone a continuous hazard probability visualization from moderate tsunami probability (red) to low tsunami probability (yellow) is displayed. The probability of being hit by a tsunami within a year ranges from about 0.01 ‰ (light yellow areas) to about 7 ‰ (red areas). Areas not affected by tsunamis are visualized in grey.
The hazard zones are obtained from an analysis of all currently available tsunami modeling results (137 scenarios with moment magnitudes of 8.0, 8.5 and 9.0) affecting the region displayed in the map provided by GKSS/DHI-WASY in the frame of the GITEWS project.
The spatial resolution of the hazard impact zone data set is 25 meters. The threshold for the minimum Estimated Time of Arrival (ETA) is defined by the 1st percentile from the ETA's of all modeled tsunami scenarios at the displayed region. The median ETA describes the 50th percentile.
For further details about the hazard assessment please refer to the technical notes of this map.

Tsunamigenic Sources



The tsunami hazard analysis result can be presented as a tsunami hazard map. Probabilistic approach often used in tsunami hazard analysis.

Living with natural hazard

House in Nias, North Sumatera, add cross bracing to withstand frequent earthquake shaking.

Houses in flood-prone areas are designed as stilt houses to accommodate regular floods.

Houses in flood-prone/earthquake-prone areas are designed as stilt houses to accommodate regular floods/shaking.


adidas
REPUBLIKA.co.id

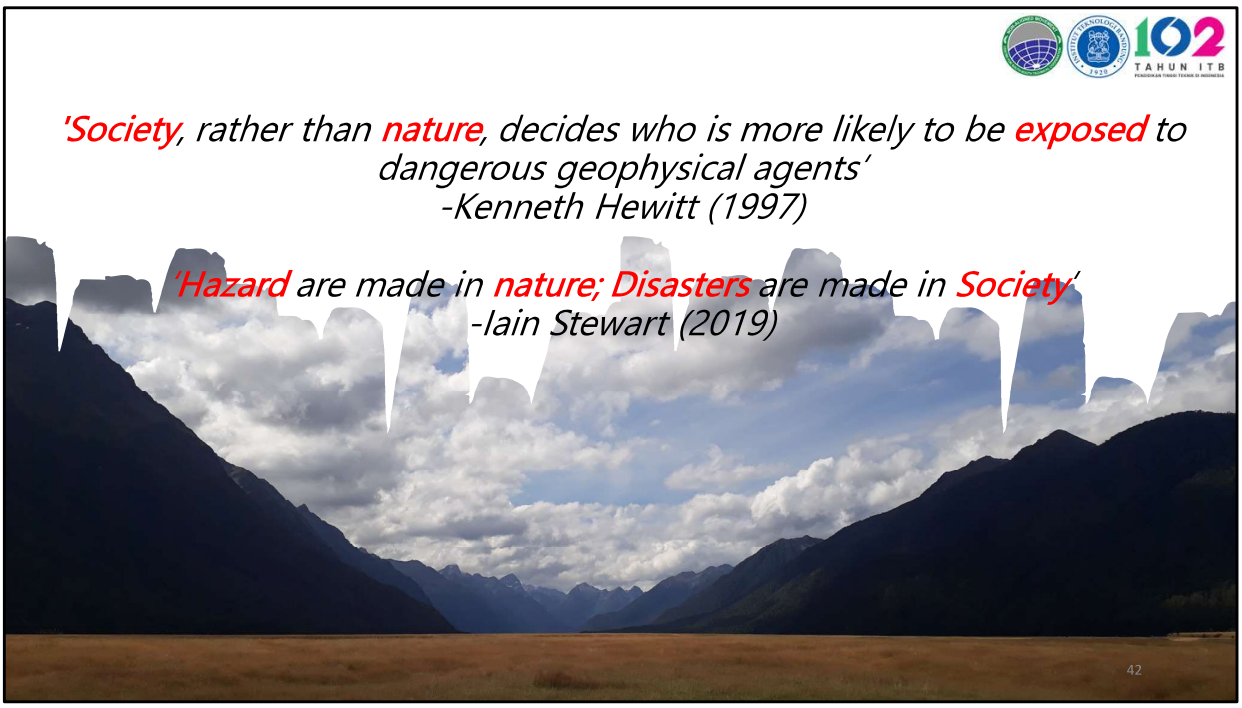

RISHA (Healthy Modest Instant House),
Modular structure house construction
adhi
8°17'14,717"S 123°26'17,413"E
Unnamed Road
Ile Ape
Altitude:79.0m
Speed:0.0km/h
Lokasi Waesesa, Lembata NTT
23 Jun 2021 16.51.43

Summary

- Hazards are natural processes that pose a threat to people or their property.
- An event becomes a disaster only when it affects people or their property.
- More common and less dramatic hazards, such as flooding, often have higher human affected than dramatic hazards, such as earthquakes and volcanoes.
- The cost of natural hazards is increasing worldwide as a result of growth in population and development.
- Climate change and global warming potentially increase the severity of weather-related hazards.

Summary

- Although the precise date and time for a disaster cannot be predicted, understanding the natural processes that control them allows scientists to forecast the probability of a disaster striking a particular area.
- Different types of natural hazards often interact with or influence one another.
- Natural processes can sometimes trigger other
- Mitigation involves efforts to avoid hazards to become disasters.
- People need to be educated about natural processes and how to learn to live with and avoid the hazards around them.
- Humans need to learn to live with some natural events rather than trying to control them.


'Society, rather than nature, decides who is more likely to be exposed to dangerous geophysical agents'
-Kenneth Hewitt (1997)
'Hazard are made in nature; Disasters are made in Society'
-Iain Stewart (2019)
42