Picture Source: https://www.cleard.life/

SUSTAIN

(tSUnami reSilient criTicAl INfrastructure)

Harkunti Pertiwi Rahayu

Chair of Inter ICG TOWS WG Task Team on Disaster Management And Preparedness
Vice Chair of ICG IOTWMS
Prof in Sumatra Institute of Technology, Indonesia

First Ocean Decade Tsunami Programme (ODTP) Conference, 10–11 November 2025 | INCOIS, Hyderabad, India

Endorsed as Decade Action

About SUSTAIN Project

Rationale of the Project

- SUSTAIN aims to strengthen the resilience of coastal communities in the Indian Ocean region to the impact of tsunami, by developing guidelines and building capacities for assessing, planning, adapting, retrofitting and monitoring of critical infrastructure to address tsunami risk.
- It considers the specific challenges and requirements of different infrastructure sectors and national contexts (e.g., Least Developed Countries, Small Island Developing States, governance).
- It includes constructing scenarios to model interdependencies that can aid this process and support the development of training and exercises for disaster mitigation and response.
- This project is co-designed with stakeholders from end users / stakeholders in member states, as reflected by the partner countries and organisations.
- The project includes intensive field studies in four partner countries, who will directly benefit from the project: Indonesia, Seychelles, Sri Lanka, Timor Leste.
- Several of the proposed activities are aimed at upscaling the benefits to all 27 IOTWMS member states, with the potential to also reach members states in other ocean basins.

Goal

The high-level objective is to **develop and promote state of the art risk assessment guidelines** for existing and new **critical infrastructure** in IOTWMS member states to reduce their vulnerability to tsunami hazards and their cascading effects, and to strengthen community preparedness and resilience.

Project Activities

Year 1

a. Identify **Preliminary works**
b. Conduct a **state of the art, systematic review of risk assessment** approaches for critical infrastructures.
- Adopt **National Vertical Evacuation Design Guideline**
- Adopt **draft Guideline of Tsunami Ready For Critical Infrastructure (WG3)**
- Adopt **L1 and L2 Mitigation Principles**

c. Conduct a **series of scientific missions** in target IOTWMS member states as scoping exercises, carried out with **multi-sectoral national and local stakeholders**

Year 2

a. Develop **draft risk assessment framework** and associated instruments
b. Construct **scenarios to model interdependencies in critical infrastructure** that can support the development of training and exercises for disaster mitigation and response
c. Conduct **scientific missions** in target IOTWMS member states to **carry out risk assessments of critical infrastructure** in different contexts

Year 3-4

a. Development and **piloting of risk assessment guidelines for critical infrastructure**
b. Organise **regional and national-local training-of-trainer workshop**(s) on tsunami risk assessment for critical infrastructure and to share knowledge across countries
c. Develop **recommendations to strengthen and support Tsunami Ready programme**
d. Develop and disseminate **outreach materials for critical infrastructure stakeholders**

Target

1. **Increased resilience of critical infrastructure** in IOTWMS member states
2. **Improved risk information**, through understanding and knowledge of the relationships between tsunami characteristics and the impact on physical property and infrastructure, and how the damage to one type of critical infrastructure can trigger failures of other facilities
3. **Enhanced tsunami risk assessment guidance and tools for critical infrastructure** in tsunami prone areas
4. **Improved capacities** among IOTWMS members states and critical infrastructure stakeholders for assessing and managing tsunami risk, including cascading events and impacts
5. **Improved intersectoral coordination and partnerships**, especially across various sectors involved for shared management and decision making relating to critical infrastructure
6. **Strengthened Tsunami Ready recognition programme**, with countries better prepared to respond to tsunami related hazards and their cascading impacts.

Adapt and Modified Existing Standards

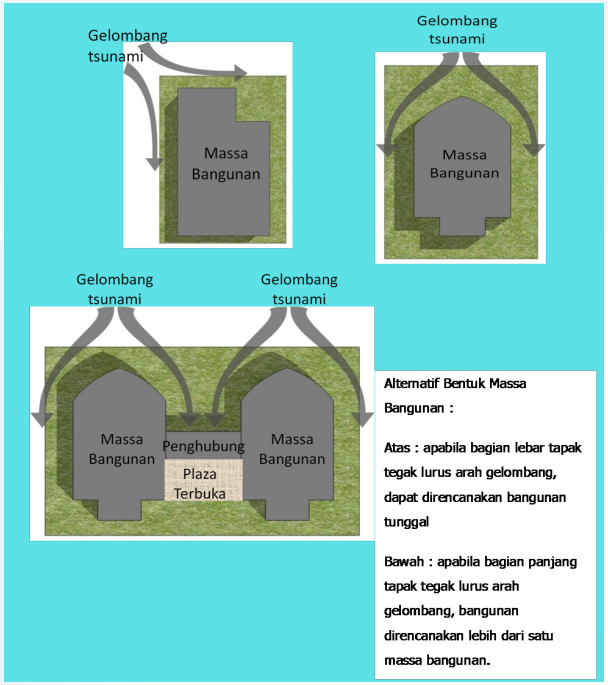
1 Engineering Design Criteria
(Earthquake and Tsunami Resistant)

Technical Guidelines for Vertical Tsunami Evacuation Shelter

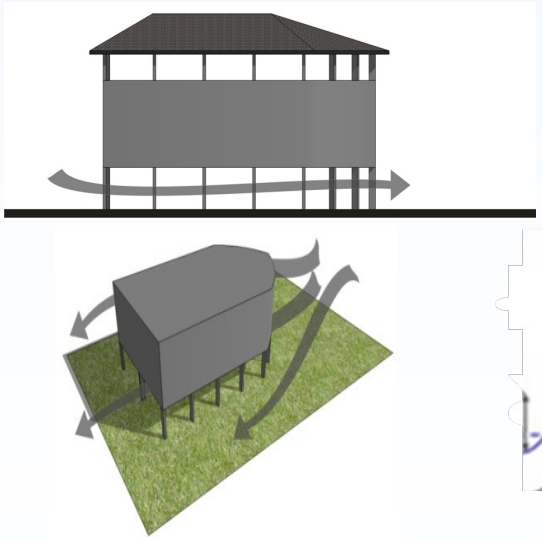
Source: Harkunti et al 2015

Aspects of Building Mass Composition

- Part of building facing to the direction of the waves must be aerodynamic shape.
- First floor of the building should be open → allows tsunami waves to flow and protects buildings from being hit by waves
- Another alternative is to raise the courtyard and terrace of the building → above tsunami inundation level



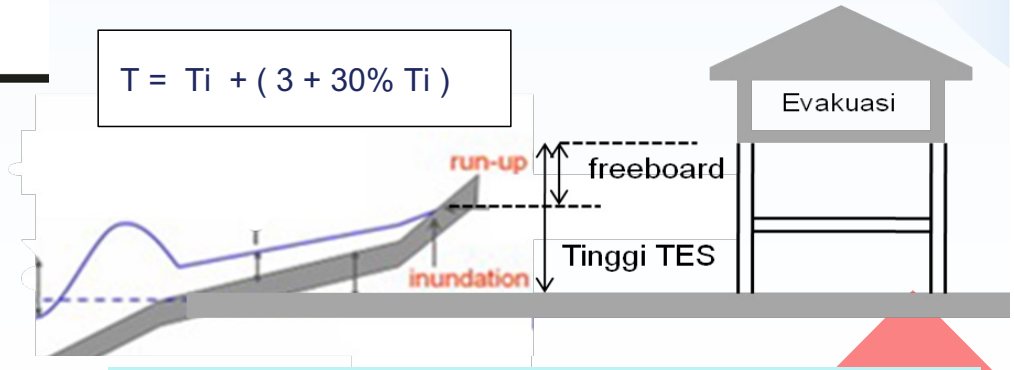
Type of Building Mass



Estimated Minimum Height for TVES from earth surface

$T = Ti + Freeboard$

$T = Ti + (3 + 30\% Ti)$

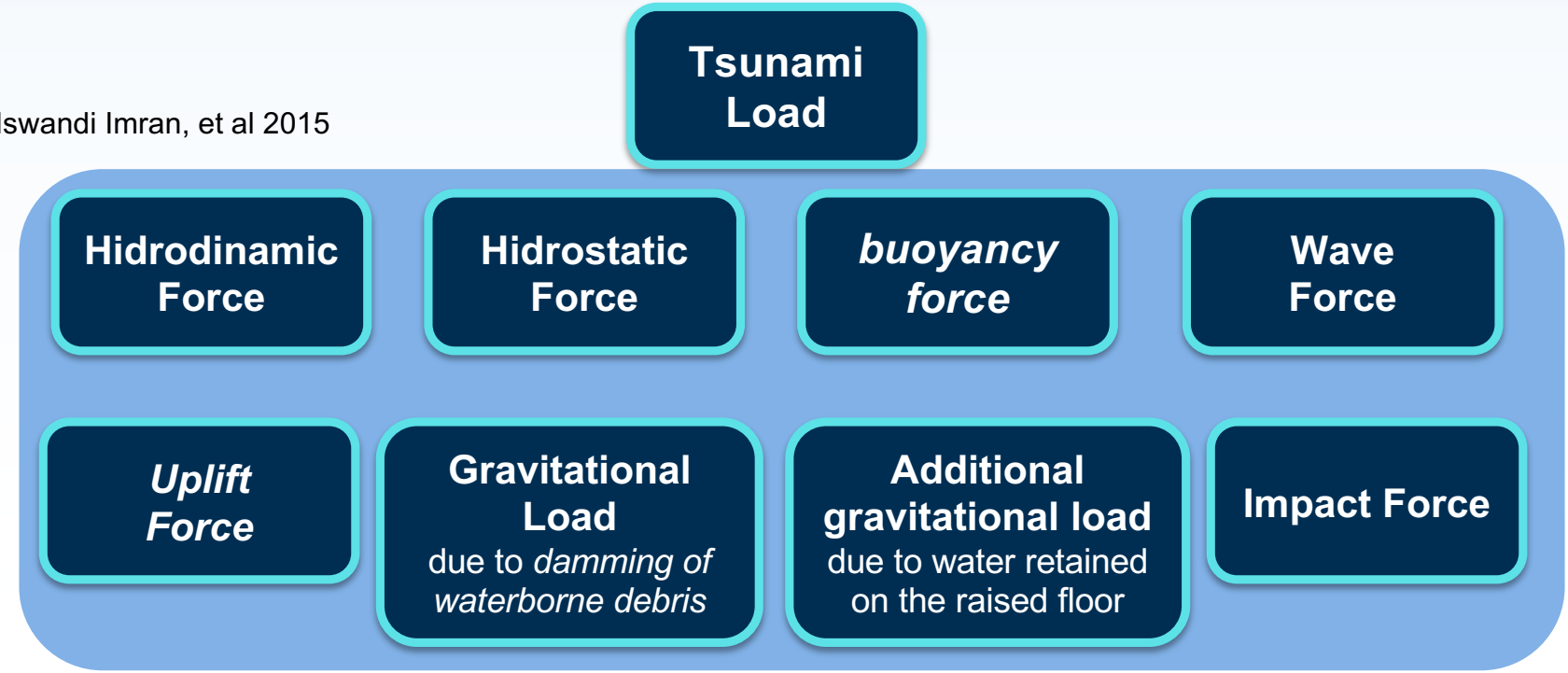


T = TVES height from earth surface (m)
Ti = *inundation height* (m)
Freeboard = 3 m + 30%Ti

Structural Design Criteria: Design Load

1. Gravitation Load
2. Seismic Load
3. Wind Load
4. Tsunami Load

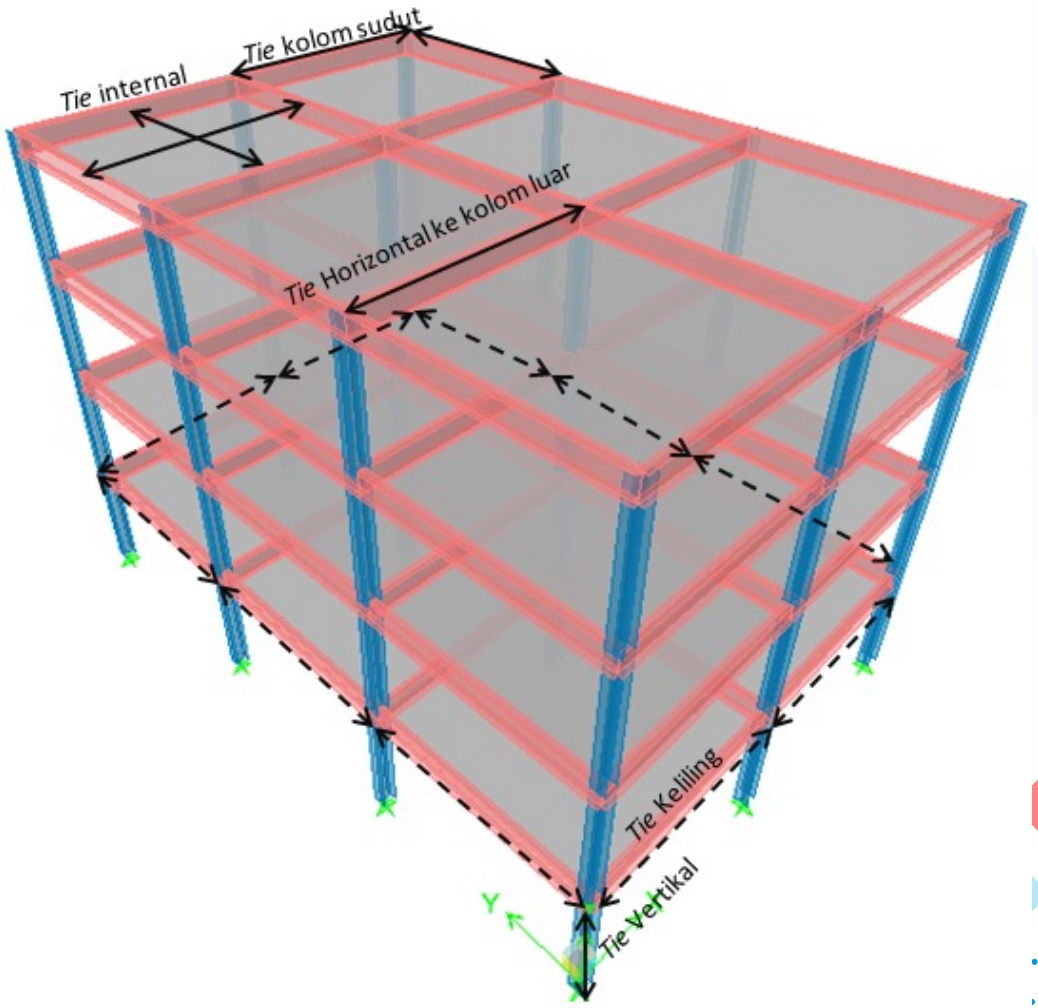
Source: Iswandi Imran, et al 2015



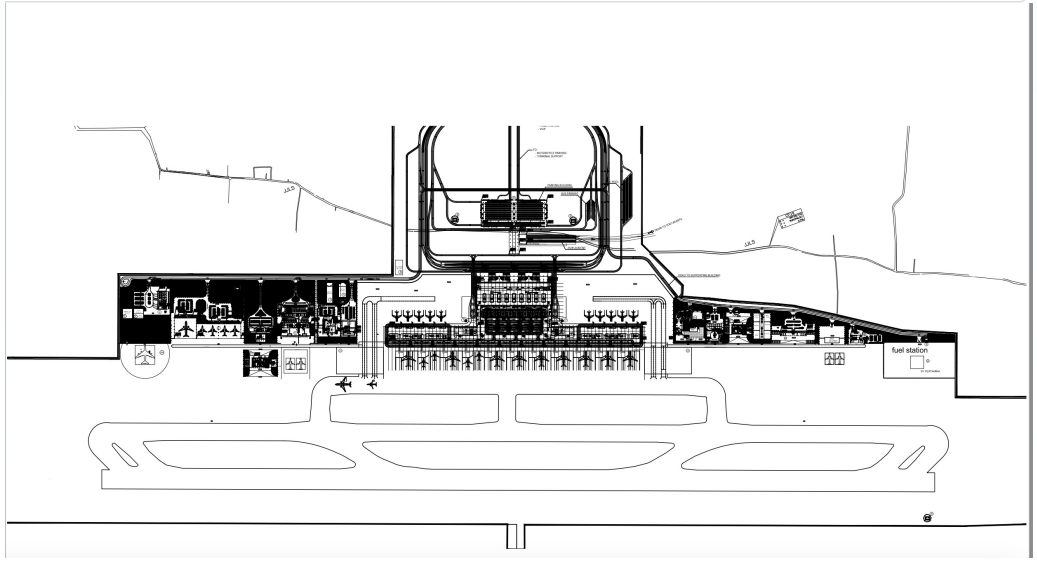
Structural and Ductility Aspect

STRUCTURE

- Must meet the minimum requirements of SNI-0301726-2002 – Concrete Structure design for building
- Must meet other structural design regulations.
  - Earthquake and tsunami resistant structural design criteria
  - strong enough to withstand the pounding of tsunami waves, buoyancy, hydrostatic forces, hydrodynamic forces, the effects of erosion, and the effects of impacts
- Circular columns can produce smaller drag forces than square or rectangular columns



Engineering Design using L 1 and L2 Mitigation for Tsunami: Yogyakarta International Airport



Engineering Design using L 1 and L2 Mitigation for Tsunami approaches:

L1 – Level 1 countermeasures refer to Prevention → an area that is likely to be affected by a high-frequency, but low-impact tsunami is designated Level 1 → AOC → to function the airport swift recovery

L2 – Level 2 countermeasures refer to Mitigation → and low-frequency, high-impact being designated as Level 2 for Saving people

2 Draft Guideline of Tsunami Ready For Critical Infrastructure

(12 Tsunami Ready Indicators for Critical Infrastructure)

Courtessy to Suci Anugerah (WG3)

TSUNAMI READY INDICATORS FOR CRITICAL INFRASTRUCTURE

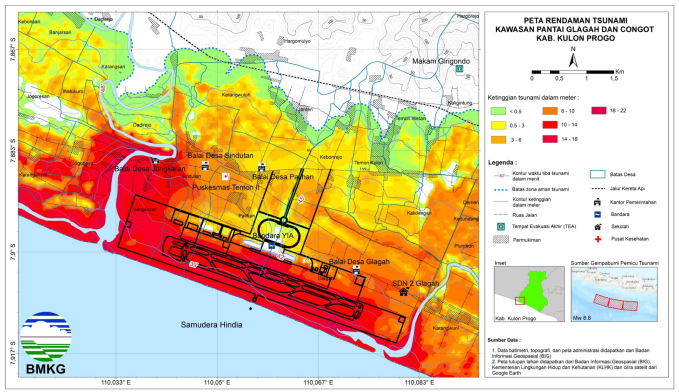
Same Foundation, The approach **adopts the 12 UNESCO-IOC Tsunami Ready indicators,** adjusts them based on **the type and function of each critical infrastructure** (e.g., airport, port, industrial zone).

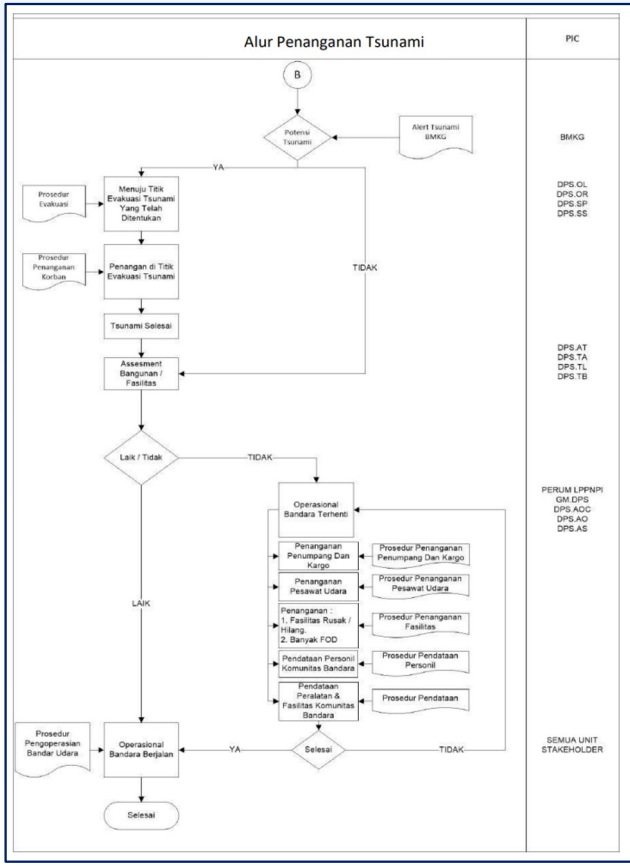
Breakdown Each indicator is **interpreted in context**:

- **Assessment,**
- **Preparedness,**
- **Response**

	TSUNAMI READY INDICATORS FOR CRITICAL INFRASTRUCTURE COMMUNITIES
I	**ASSESSMENT (ASSESS)**
1	**ASSESS-1**. Tsunami hazard zones within and surrounding the critical infrastructure area are mapped and formally designated, taking into account site-specific vulnerabilities such as access routes, power systems, and key operational facilities.
2	**ASSESS-2**. The number of personnel, service users, and operational assets at risk within the tsunami hazard zone is identified and quantified.
3	**ASSESS-3**. Essential economic, infrastructural, technical, and organizational resources available for tsunami preparedness, response, and recovery are identified and documented.
II	**PREPAREDNESS (PREP)**
4	**PREP-1**. Clear and easily understandable tsunami evacuation maps specific to the critical infrastructure area are developed, approved, and integrated into facility emergency plans.
5	**PREP-2**. Tsunami information, including evacuation routes and safe zones, is clearly displayed through standardized signage and information boards accessible to employees, visitors, and stakeholders.
6	**PREP-3**. Educational, communication, and training materials on tsunami awareness and preparedness are made available and disseminated among all personnel and relevant contractors.
7	**PREP-4**. Regular outreach or internal capacity-building activities on tsunami preparedness are conducted at least three times a year, ensuring participation of both management and operational staff.
8	**PREP-5**. A full-scale or tabletop tsunami drill involving internal emergency teams and external response agencies is conducted at least once every two years to evaluate coordination and readiness.
III	**RESPONSE (RESP)**
9	**RESP-1**. A tsunami emergency response plan specific to the critical infrastructure facility is developed, approved, and aligned with local and national disaster management frameworks.
10	**RESP-2**. Adequate capacity, personnel, and resources are established to manage emergency operations and maintain critical functions during a tsunami event.
11	**RESP-3**. Reliable, redundant communication systems are in place to ensure timely receipt of 24-hour official tsunami alerts from authorized agencies.
12	**RESP-4**. Reliable, redundant communication and dissemination systems are in place to promptly deliver official tsunami alerts and safety instructions to all staff, contractors, and facility users.

Yogyakarta and Bali International Airport, Kulon Progo





AngkasaPura | AIRPORTS

BANDAR UDARA INTERNASIONAL

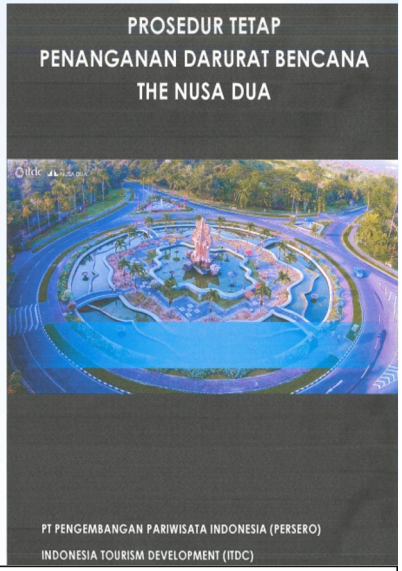
I GUSTI NGURAH RAI – BALI

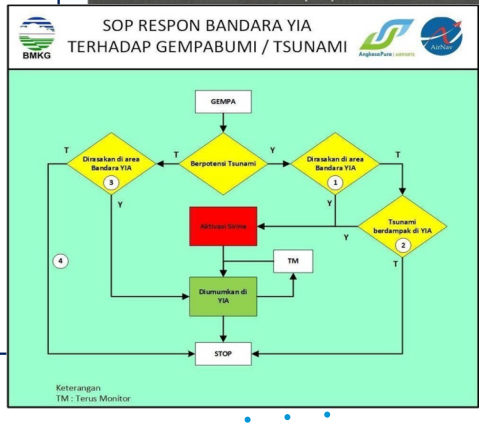
BUKU PEDOMAN BANDAR UDARA

SIAGA BENCANA

JUNI 2021

PT ANGKASA PURA I (PERSERO)

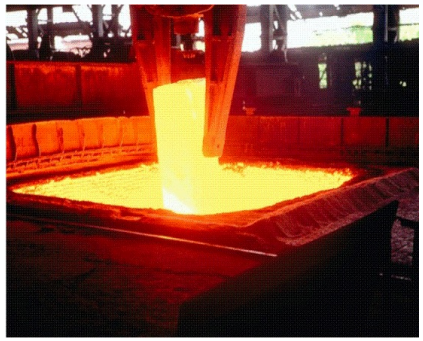




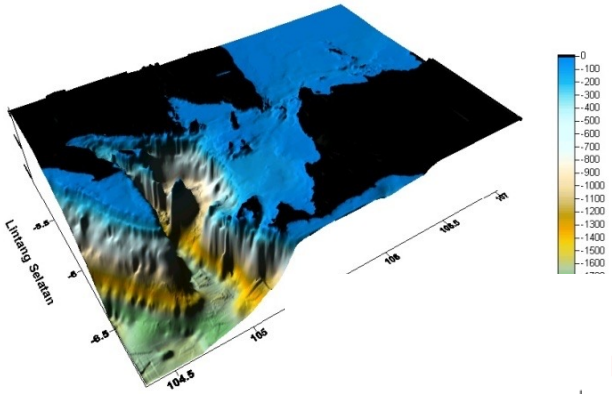
Identified Related Works Done

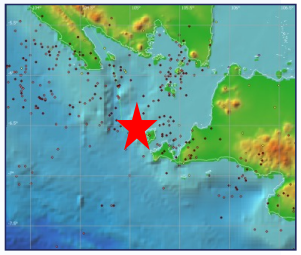
1 Cilegon Industrial Estate

Cascading Risk



Multi-Hazard Tsunami Risk Scenario …





Natural Hazard

Technological & Industrial Hazard

Hazard Scenario Analysis

Primary Hazard

Collateral Hazard

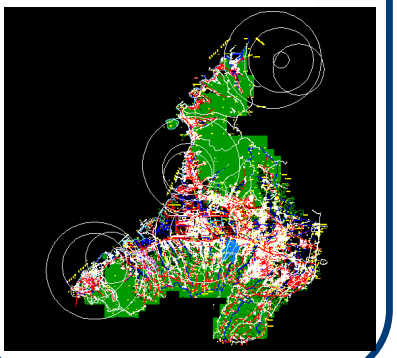
Tectonic Quake !!!

- After Shock
- Tsunami
- Landslide
- Liquifaction
- Dam → Flood

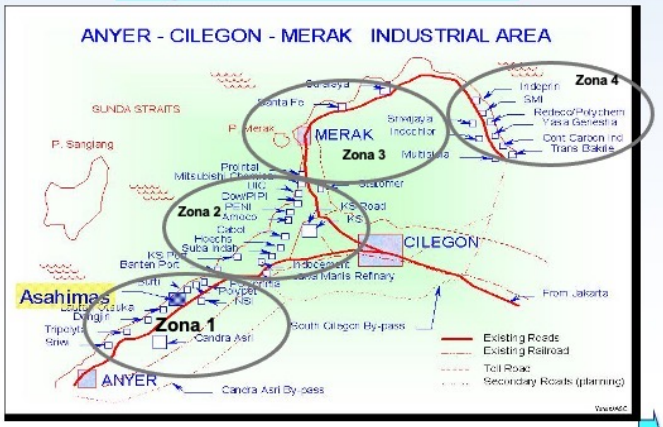
- 1. Gas
- 2. Liquid
- 3. Solid

Hazard Scenario & Disaster Scenario

1. Peta (Grafis)
2. Verbal



Cilegon-Merak Industrial area



SOP Company Wide
SOP Industrial Zone Wide

Emergency Preparedness & Response
Company Wide → Industrial Zone

Assembly Point & Evacuation Area

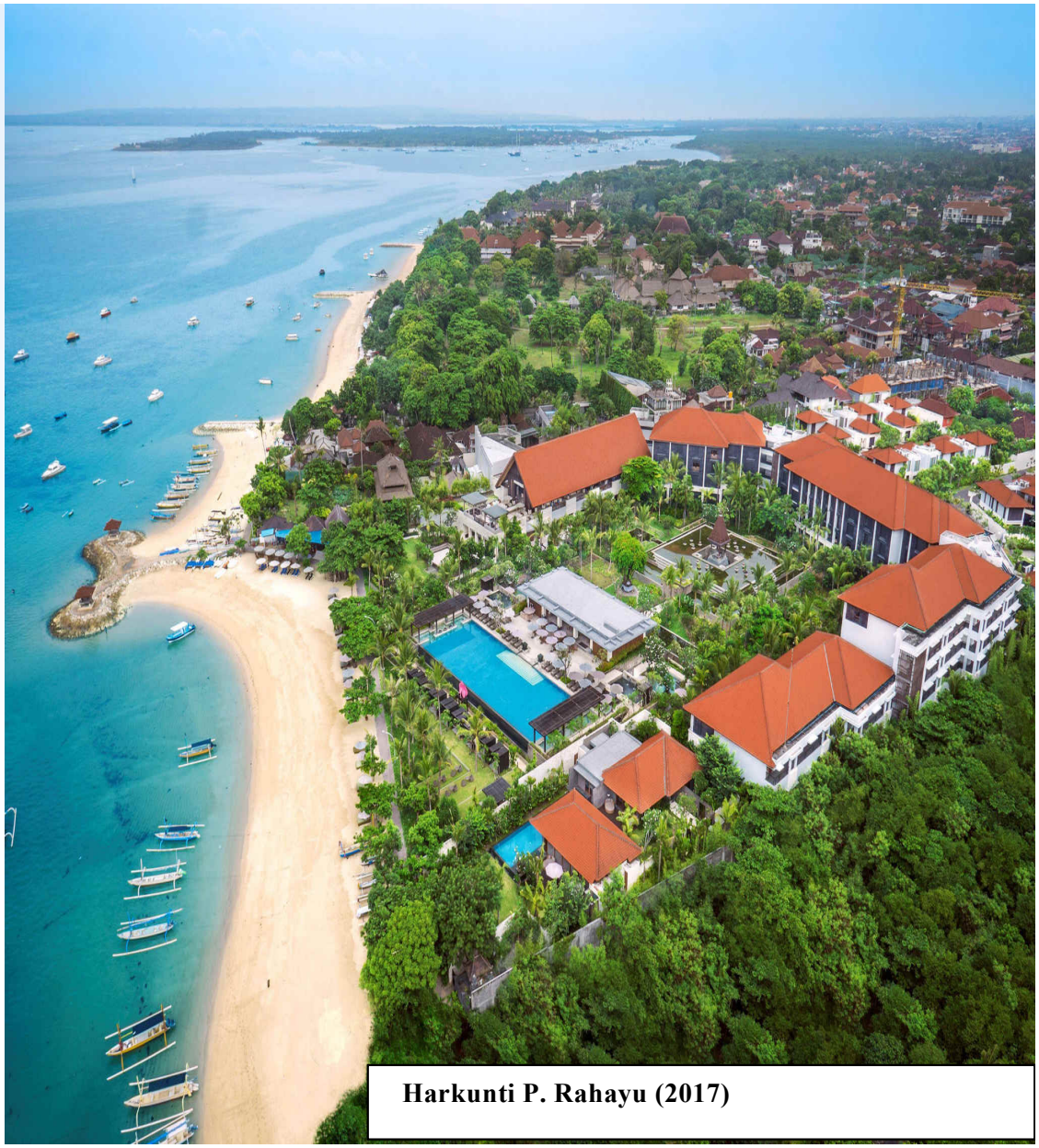
Tsunami Exercise → Building Partnership among Government, Private Sector and People

National Tsunami Drill Banten 2007

Documentations of H. Rahayu, 2007

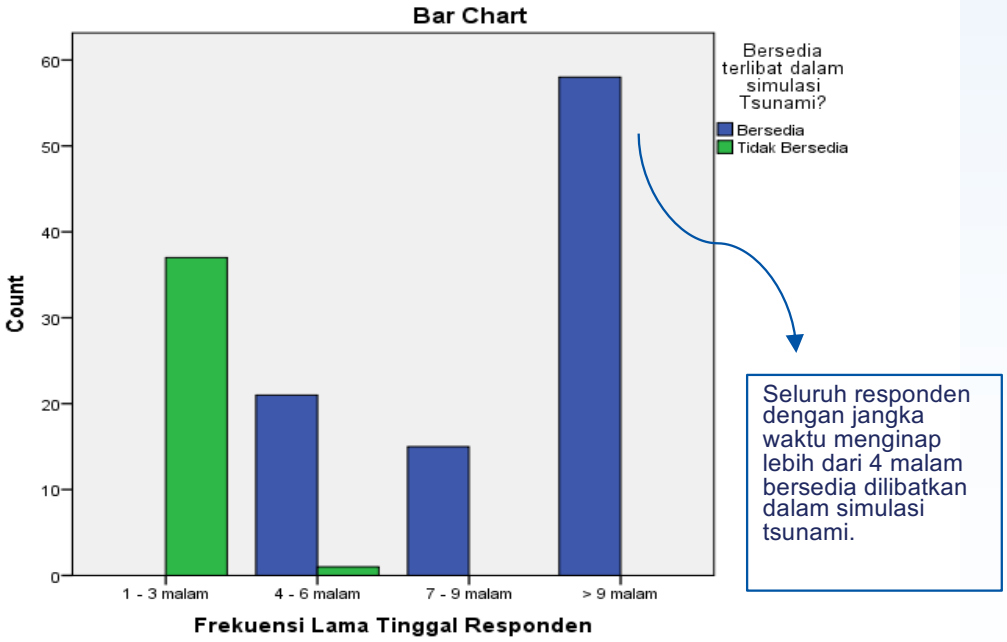
2

Tsunami Ready Hotel learning from Bali

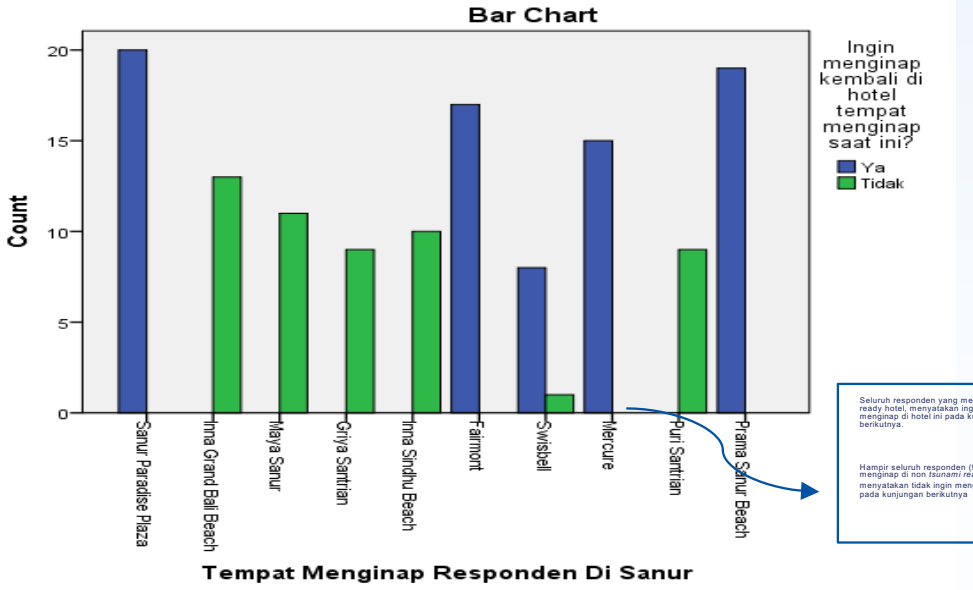


Harkunti P. Rahayu (2017)

Tsunami Ready Hotel
Using Mitigation and Preparedness Parameter



Seluruh responden dengan jangka waktu menginap lebih dari 4 malam bersedia dilibatkan dalam simulasi tsunami.



Seluruh responden yang menginap tsunami ready hotel, menyatakan ingin kembali menginap di hotel ini pada kunjungan berikutnya.

Hampir seluruh responden (99%) yang menginap di non *tsunami ready hotel* menyatakan tidak ingin menginap di hotel ini pada kunjungan berikutnya

3 Nuclear Power Reactor (Puspitek Serpong Indonesia)

Experimental Nuclear Power Reactor

In the context of **constructing the Experimental Nuclear Power Reactor (3 M)**, it is necessary to i**dentify potential hazards caused by human activities** that may affect the Experimental Power Reactor Site in the Puspiptek Serpong Area.

Hazard Scenario

Material/ Substance	Scenario	Hazard Model	RED ZONE (m)	ORANGE ZONE (m)	YELLOW ZONE (m)
LPG Bulk Filling & Transportation (SPPBE/ LPG Depo) (butane)	Vapor Cloud Explosion (open space)	Explosion pressure (overpressure)	Does not occur	19 21	42 44
Jetfire	JET FIRE	Thermal Radiaton	11 12	26 26	45 45
Fireball	FIRE BALL	Thermal Radiaton	329 411	465 580	726 906
Gas Stations (SPBU) (Iso-oktane)	POOL FIRE	Thermal Radiaton	19	24	33
	FIRE BALL	Thermal Radiaton	300	423	659

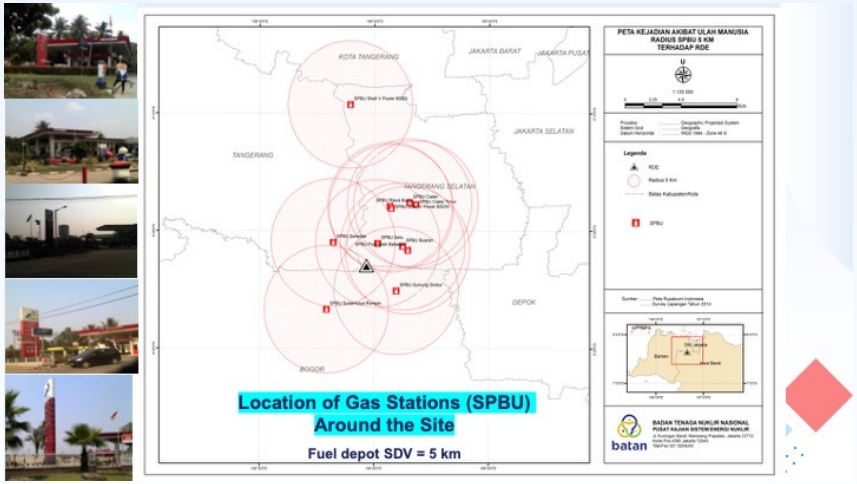
Stationary/ Non-Moving Sources

No.	Type of Sources	Identification Result (Name/Location)
1	Oil Refinery	-
2	Chemical Industry	PT Indah Kiat Pulp & Paper Tbk.
3	Fuel Storage Depot	Gas stations No. 34-15312 (Setu), No. 34-15304 (Suradita), No. 34-16317 (Gunung Sindur), No. 34-15308 (East Ciater), No. 34-15307 (Babakan Village), No. 34-15322 (Buaran), No. 34-15309 (Rawa Buntu), No. 34-16314 (Suka Mulya, Rumpin), and Gas Station No. 34-15317 (Ciater Village), as well as 2 Shell V-Power stations located in BSD II (Serpong Village) and BSD III (Buaran Rawa Buntu Village).
4	Gas Storage Depot (Compressed Natural Gas)	PT Bhakti Mingasutama and PT Indah Sri Rejeki, Ciater Village, South Tangerang
5	Telecommunication and Broadcasting Transmission Network	In 5 subdistricts of South Tangerang City
6	Mining or Excavation Operations	In Anamui Village, Suradita
7	Forest	In the Puspiptek Area
8	Other Nuclear Facilities	PTKRN, PRSG, PPIKSN, PTRR, PTBBN, PTLR, PSTBM, PRFN
9	Equipment Rotating with High Energy (e.g., Transformer)	Installation/Research Center in the Puspiptek Area
10	Military Facilities	KODIKLAT, Cavalry Battalion 9/Cobra, Headquarters of the Air Defense Artillery Battalion I (ARHANUDRI I) Rajawali, and Combat Engineer Company (Kompi Zeni Nubika Ditzi TNI-AD)

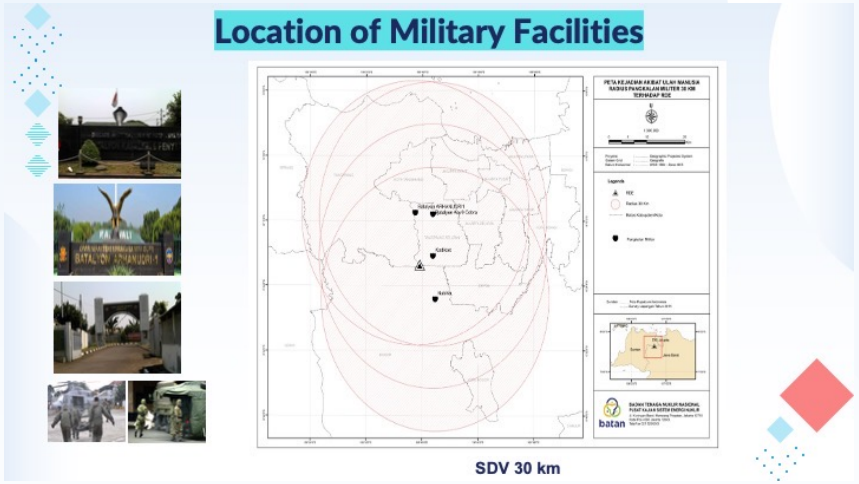
Mobile Sources

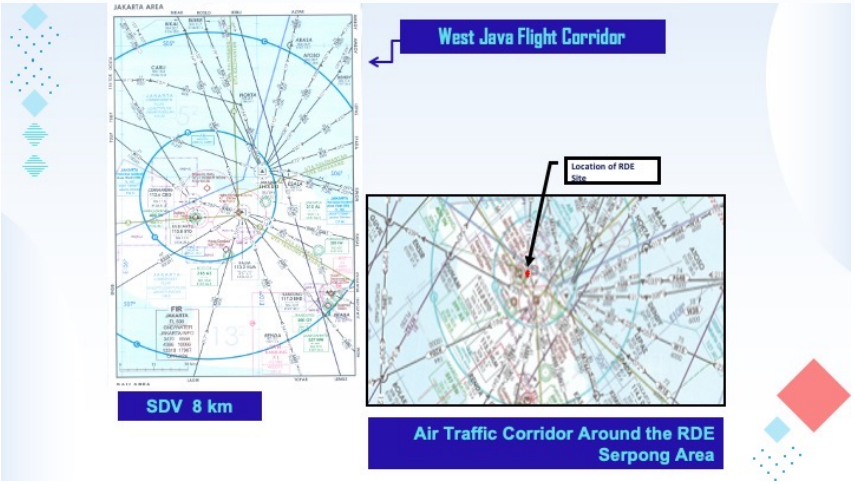
No.	Type of Sources	Identification Result (Name/Location)
1	Passenger and Freight Trains	Passenger and freight trains passing through 4 stations, namely: Cisauk Station, Serpong Station, Rawabuntu Station, and Sudimara Station
2	Land Trasnportation	Vehicles passing through Bogor–South Tangerang Regency Road (Prumpung–Gunung Sindur–Cisauk–Serpong), Bogor–Puspiptek Area–Tiga Raksa
3	Ships	Gas stations No. 34-15312 (Setu), No. 34-15304 (Suradita), No. 34-16317 (Gunung Sindur), No. 34-15308 (East Ciater), No. 34-15307 (Babakan Village), No. 34-15322 (Buaran), No. 34-15309 (Rawa Buntu), No. 34-16314 (Suka Mulya, Rumpin), and Gas Station No. 34-15317 (Ciater Village), as well as 2 Shell V-Power stations located in BSD II (Serpong Village) and BSD III (Buaran Rawa Buntu Village).
4	Barges	PT Bhakti Mingasutama and PT Indah Sri Rejeki, Ciater Village, South Tangerang
5	Pipeline	**Existing: PGN:** near Multi Media University, Sumarecon, Serpong. **Existing Perta Gas:** gas pipelines of Lengkong Wetan–East Warehouse Line and Parigi Baru–Pondok Aren Line. **Development Plan (PGN):** Sampora Village, Cisauk Subdistrict, Tangerang Regency, located in the AEON Mall area.
6	Airport/ Airfield Zone	**7 airfields:** Soekarno–Hatta Airport (Tangerang), Halim Perdanakusuma (public/military) (Kramatjati District, East Jakarta), Pondok Cabe (Pondok Cabe Udik Village, Pamulang District, South Tangerang City), Atang Sendjaja Air Base (Parung, Bogor), Budiarto (Curug, Tangerang Regency), Rumpin Airfield (Cisauk), and Pulau Panjang (Pulau Kelapa Village, North Seribu Islands District, Jakarta).
7	Air Traffic Corridor & Flight Zones (Military and Civil)	Budiarto (flight school), Pondok Cabe (Air Base, Police, Pertamina/aircraft maintenance), and Rumpin (alternative air base).

Some Screening Distance Review

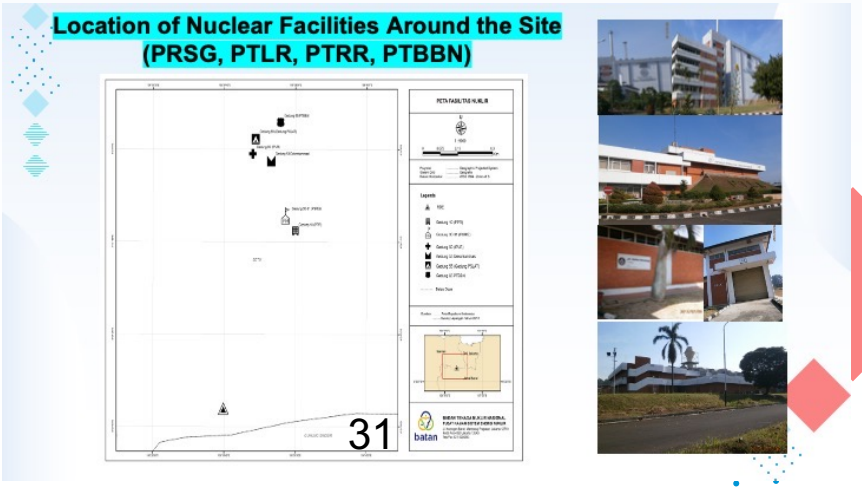


Location of Military Facilities





Location of Nuclear Facilities Around the Site (PRSG, PTLR, PTRR, PTBBN)



Next Target:
Port Ready for Disaster

Thank You