Investigating Conservation Area Based on Tsunami Hazard Mapping in Sand Dune Parangtritis Area

By:

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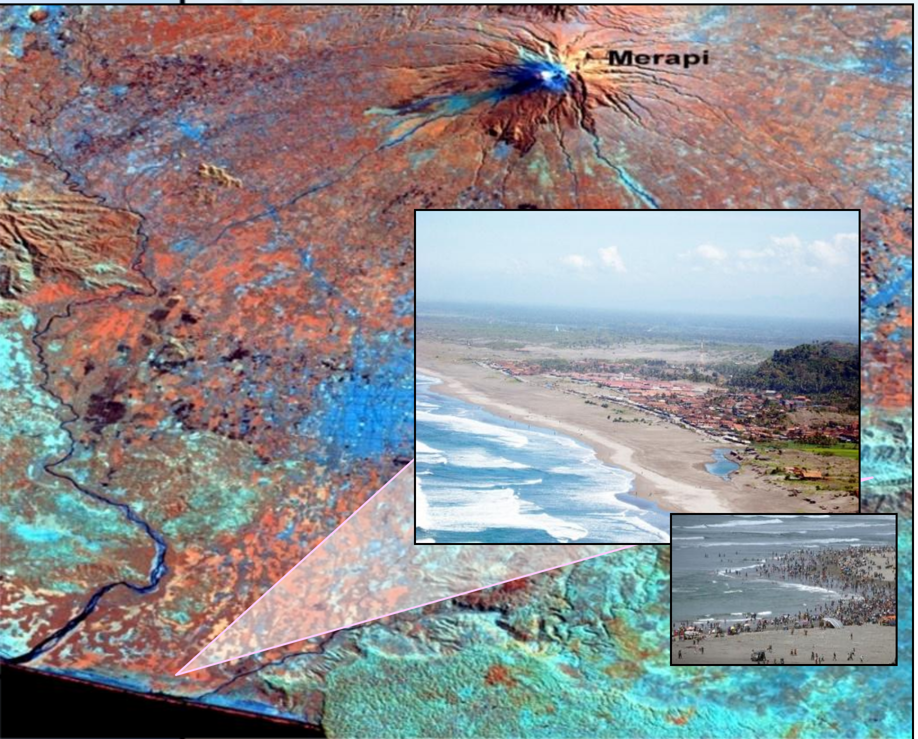
BACKGROUND

Indonesia is one of the most vulnerable areas due to natural disaster. This area is closed to the three main tectonic plates in the world. Java Island due to tectonic setting is very vulnerable occurred by Tsunami disaster.

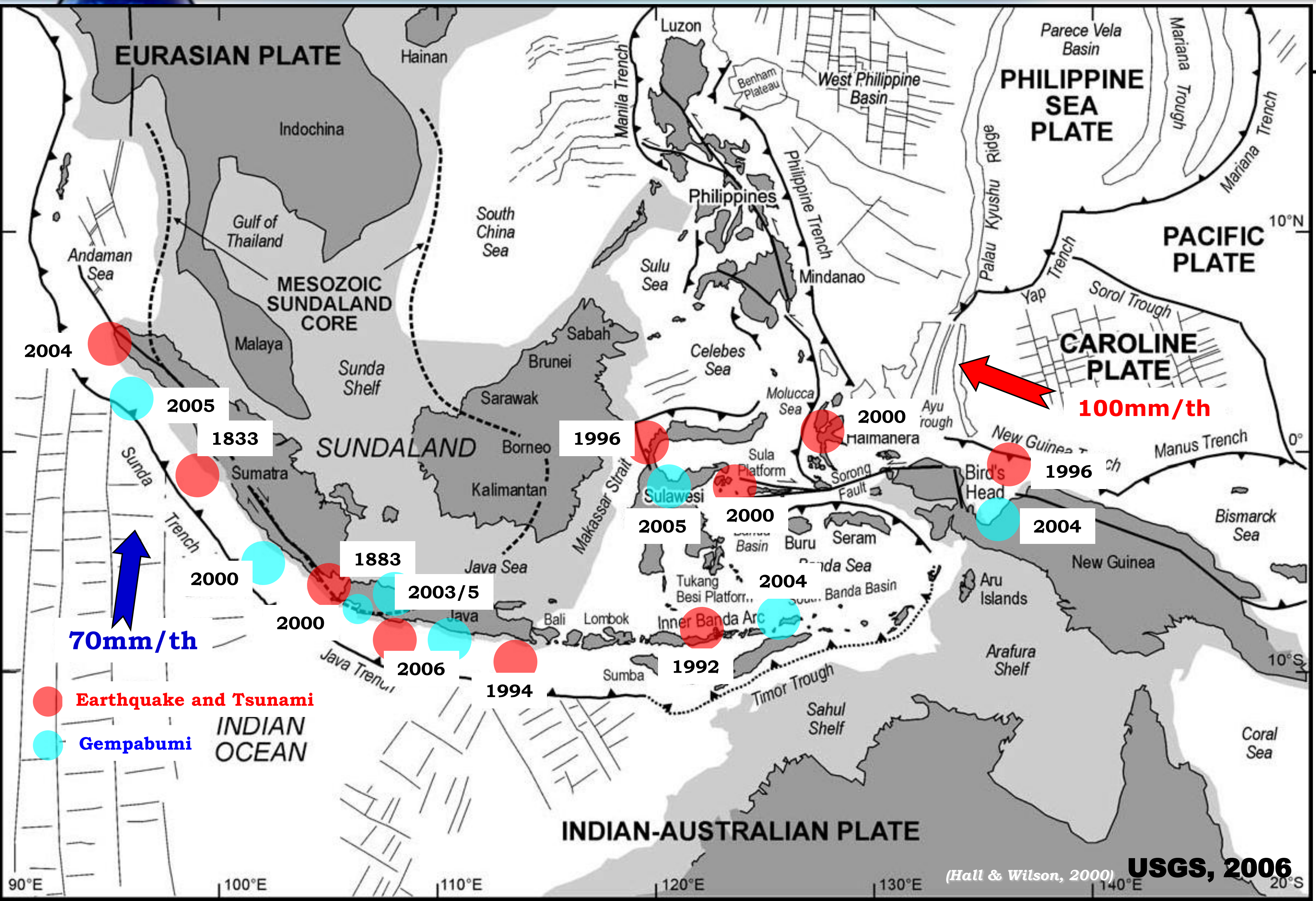


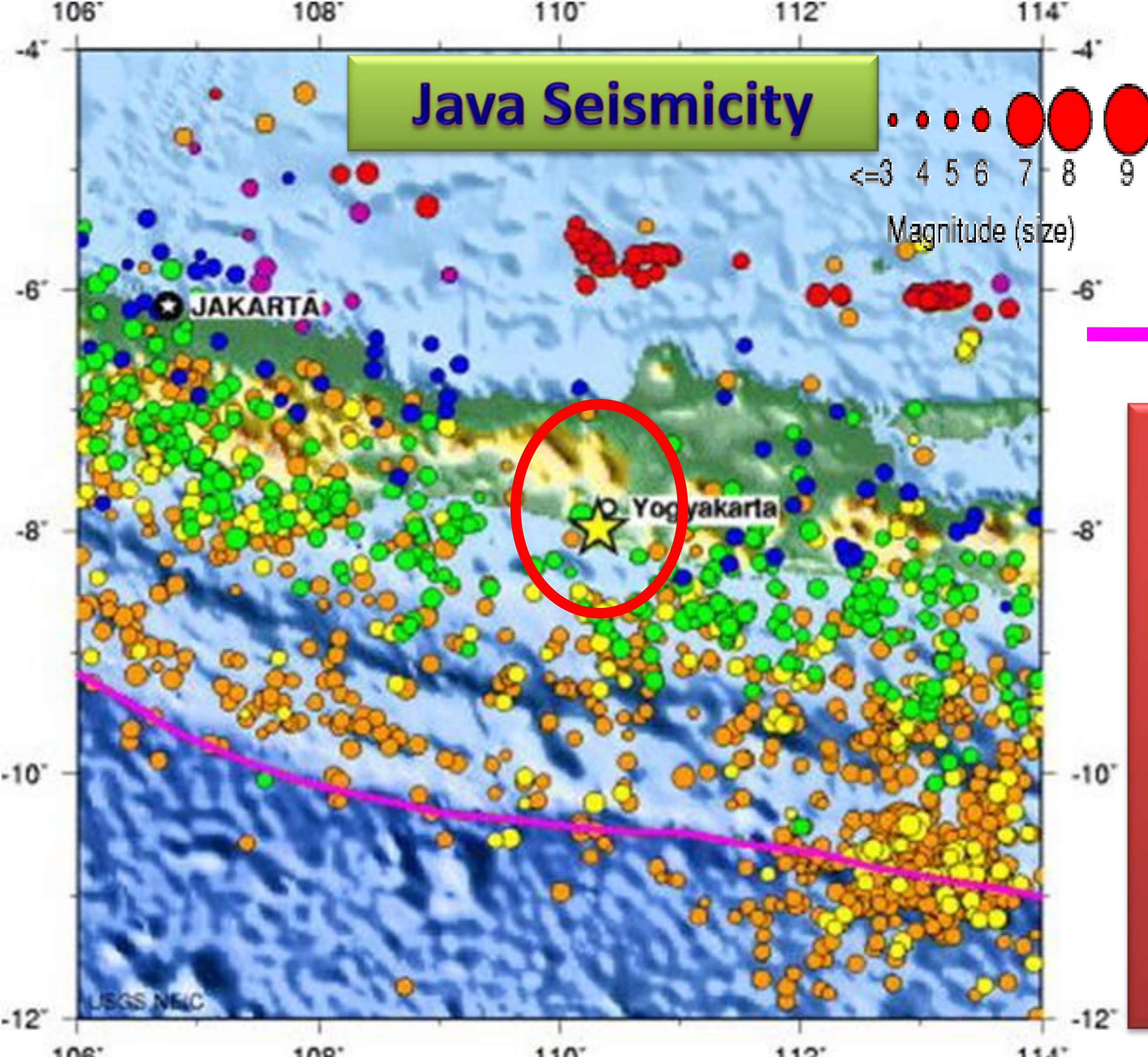
17th July 2006 Tsunami is generated by an earthquake in Southern part of Java with magnitude 7.7 in Richter Scale:

- 600 people died.

- 35,000 people lost their homes.

Earthquake & Tsunami in Indonesia





The coast of Jogjakarta was one of impacted areas by tsunami wave and the maximum tsunami height was measured of about 3.4 meters around this area. This Mw 7.7 earthquake (USGS, 2006) has a depth of about 10 km under the seafloor.

JAVA, INDONESIA

2006 05 26 22:54:02 UTC 7.98S 110.32E Depth: 35.0 km, Magnitude: 6.3

Seismicity 1990 to Present

USGS, 2006

STUDY AREA

THAILAND
SOUTH CHINA ASIA
Banda Aceh
Medan
MALAYSIA
Kuala Lumpur
SINGAPORE
MALAYSIA BORNEO
Padang
SUMATRA
KALIMANTAN
Balikpapan
Manado
Palu
SULAWESI
Raja Ampat
Sorong
BANDA ISLANDS
BANDA SEA
Krakatoa
Jakarta
JAVA
Jogyakarta
Surabaya
Makassar
BALI
KOMODO
FLORES
ALOR
EAST TIMOR
Kupang
N
W
E
Sand Dune
Bandung
Semarang
Surabaja
Java
Parangtritis
Image © 2007 DigitalGlobe
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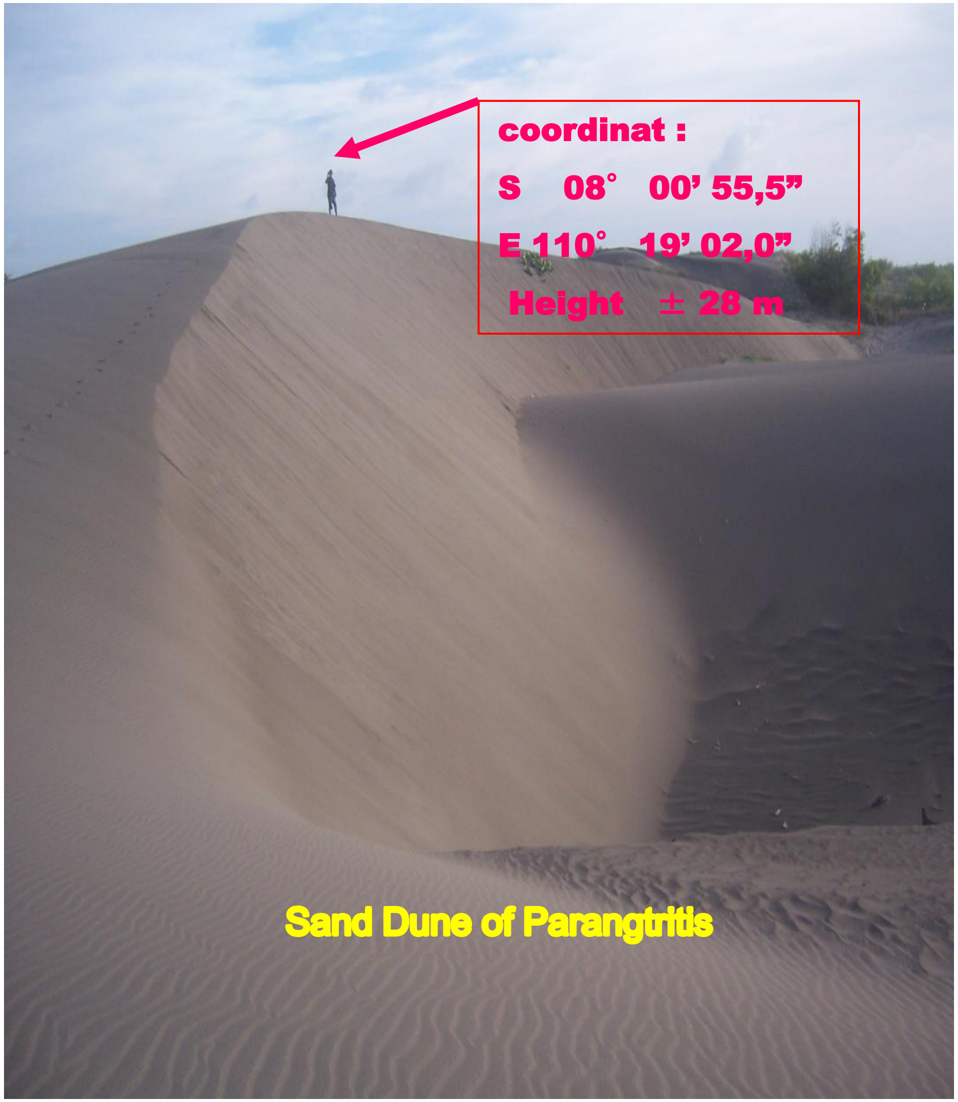
Google

TARGET AREA

•Parangtritis is located in Bantul Regency, Yogyakarta Special Region, Indonesia. Bantul regency is one of five regencies in Yogyakarta Special Province.

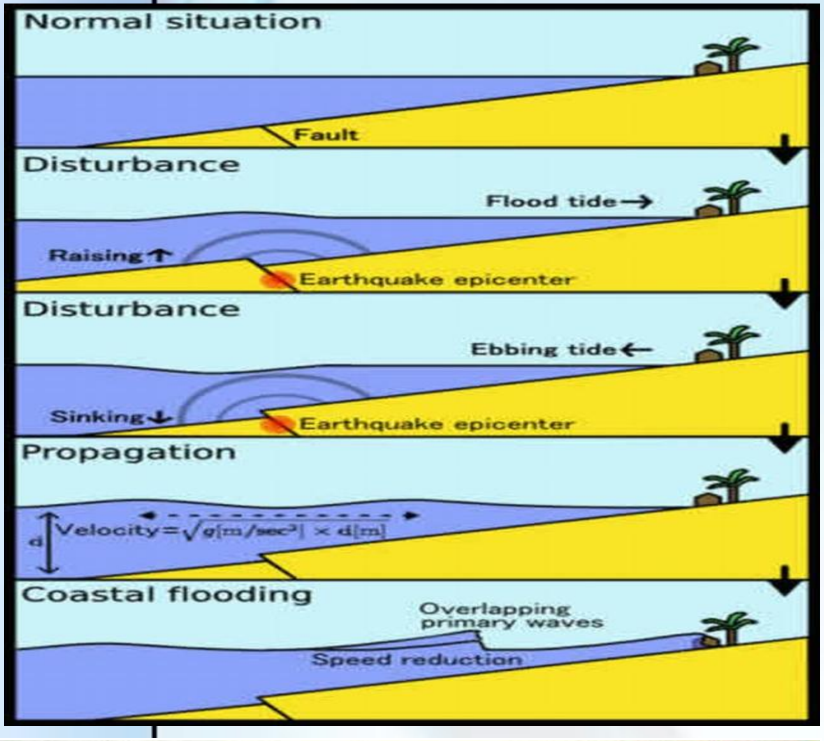
•Sand dune in Parangtritis as the unique phenomena of Coastal area in the World. Sand dune conservation as a barrier tsunami hazard using combination of Remote sensing and Field measurement is important.

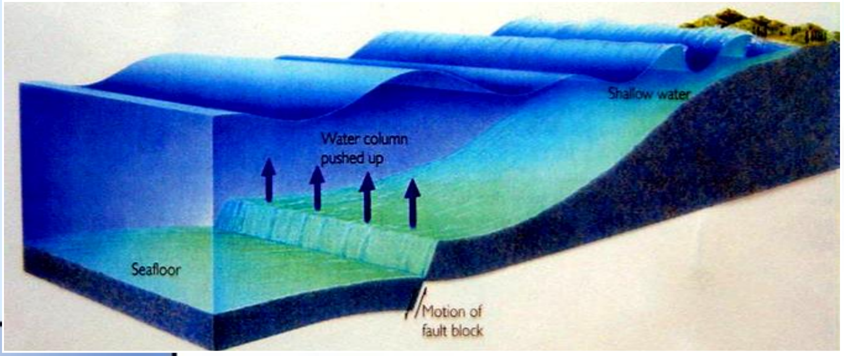


Parangtritis Coastal Area




TSUNAMI HAZARD OF PARANGTRITIS COASTAL AREA





Coastal characterization along southern coast of Yogyakarta can be divided into two zones of tsunami risk;

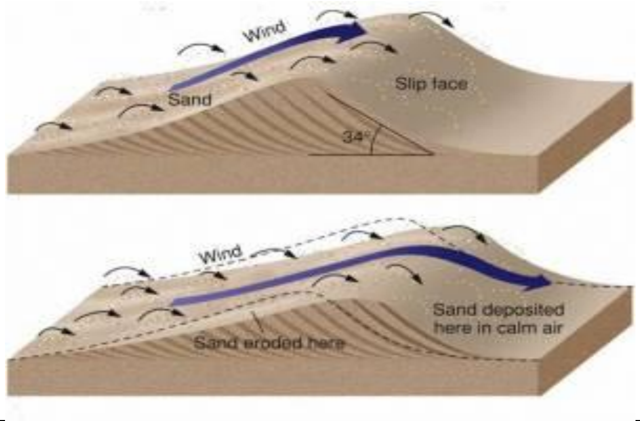
1. **First zone is high tsunami risk.**
   It can be represented by coastal area along Parangendog to Sadeng. This area has a bay-shape, settlement area is generally very close to the shoreline without sufficient protection;
2. **Second Zone is Medium tsunami risk. This area has sand dune morphology in Parangtritis coastal area and it dominated by straight shoreline, and settlement area behind the sand dune, makes this area did not protected by tsunami risk.**

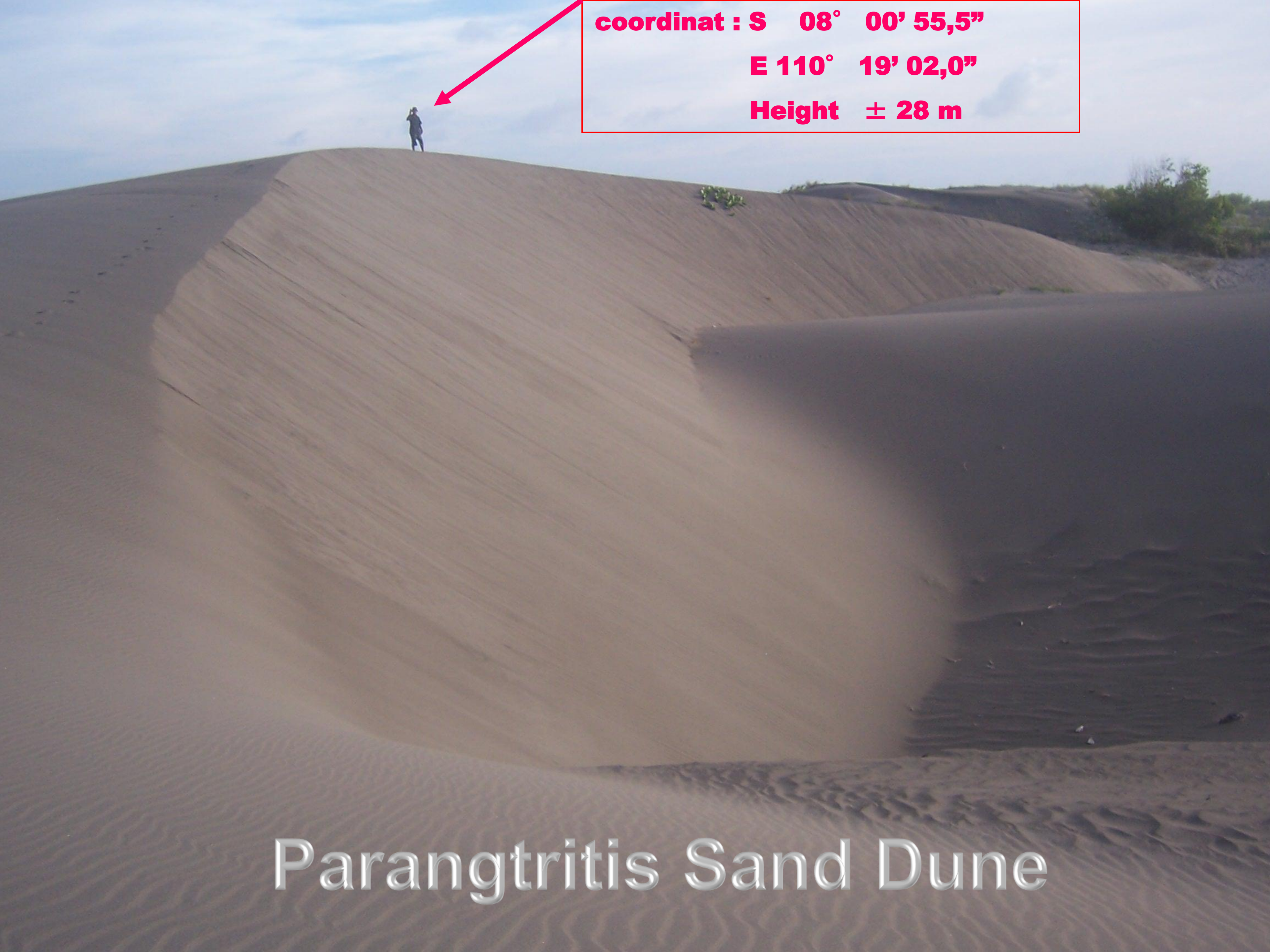
SAND DUNE AS A BARRIER FOR TSUNAMI HAZARD

- **Sand dune conservation have many functions as a barrier to minimize tsunami wave impact in coastal area.**

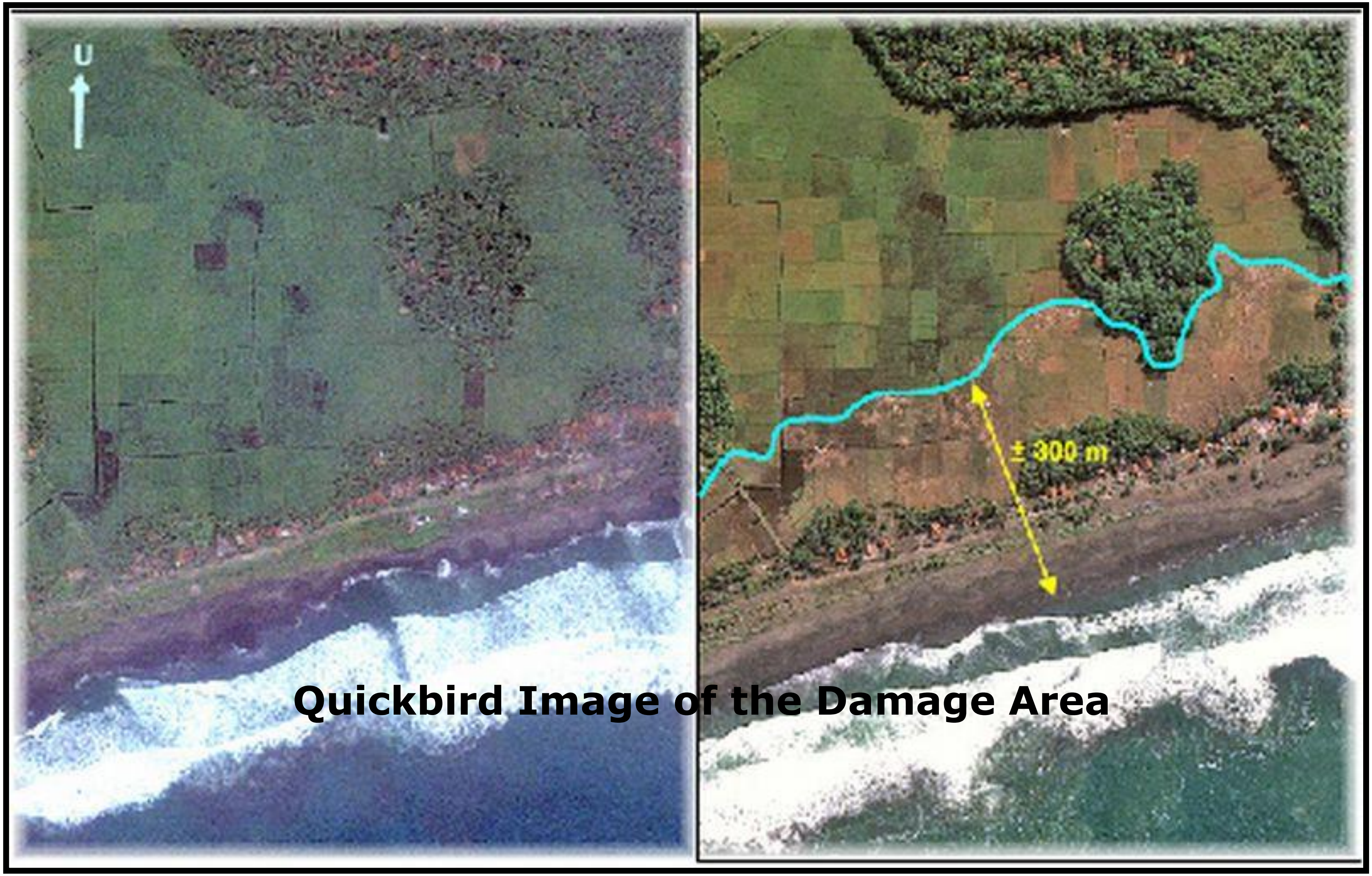
- **Foredunes act as barriers against the action of waves and tides, and are a source of sand for the beach during periods of erosion. They protect areas behind them from wave damage and tsunami hazard during hazard event.**

- **The problem of this research, it is caused Parangtritis Beach have sand dune but some stakeholders did not give aware to sand dune conservation.**

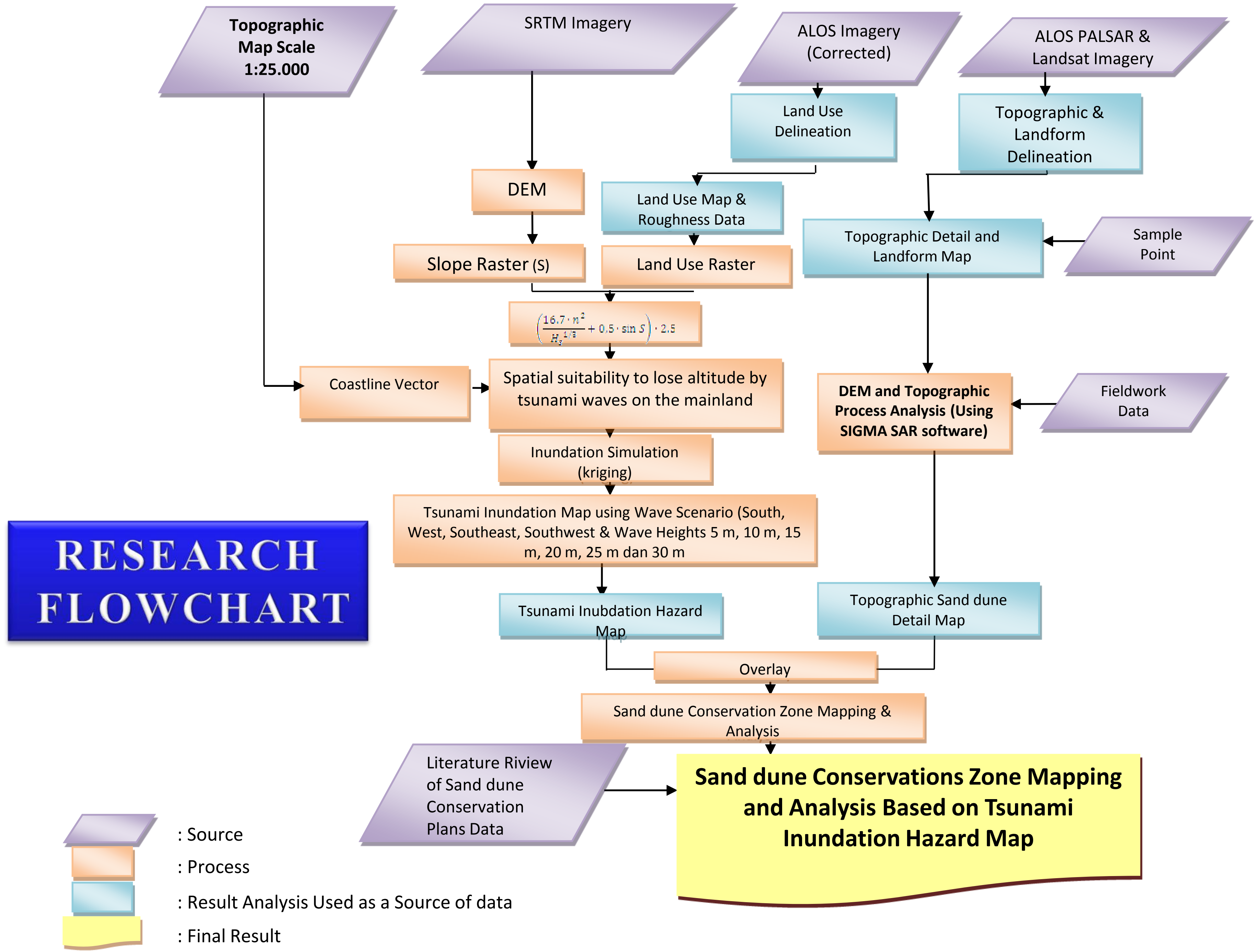



coordinat : S 08° 00’ 55,5”
E 110° 19’ 02,0”
Height ± 28 m
Parangtritis Sand Dune

QUICKBIRD image in Yogyakarta Special Province
Before and After the 17th July 2006 Tsunami events



METHODOLOGY



RESEARCH FLOWCHART
Topographic Map Scale 1:25.000
SRTM Imagery
ALOS Imagery (Corrected)
ALOS PALSAR & Landsat Imagery
Land Use Delineation
Topographic & Landform Delineation
DEM
Land Use Map & Roughness Data
Topographic Detail and Landform Map
Sample Point
Slope Raster (S)
Land Use Raster
$\left(\frac{16.7 \cdot n^2}{H_s^{1/3}} + 0.5 \cdot \sin S\right) \cdot 2.5$
Coastline Vector
Spatial suitability to lose altitude by tsunami waves on the mainland
DEM and Topographic Process Analysis (Using SIGMA SAR software)
Fieldwork Data
Inundation Simulation (kriging)
Tsunami Inundation Map using Wave Scenario (South, West, Southeast, Southwest & Wave Heights 5 m, 10 m, 15 m, 20 m, 25 m dan 30 m
Tsunami Inubdation Hazard Map
Topographic Sand dune Detail Map
Overlay
Sand dune Conservation Zone Mapping & Analysis
Literature Riview of Sand dune Conservation Plans Data
Sand dune Conservations Zone Mapping and Analysis Based on Tsunami Inundation Hazard Map
: Source
: Process
: Result Analysis Used as a Source of data
: Final Result

METHODOLOGY

Tsunami Inundation Elevation Scenarios

Maximum distance of tsunami on landfrom the shoreline

$$X_{maks} = \frac{0.06\, Ho^{4/3}}{n^2}$$

Where :

X_{maks}= Maximum distance of tsunami on land from the shoreline;

H_0= Height of waves at the shoreline;

n= roughness coefficient (0.015 to 0.07)

Losing altitude to 1 m of the run-ins

$$\frac{dH}{dX} = \frac{12Sn^2}{H_0^{2/3}}$$

Losing altitude for the m distance tsunami propagation

$$H_{loss} = \left(\frac{16.7 \cdot n^2}{H_0^{\frac{1}{3}}}\right) + 0,5 \cdot \sin S$$

Where :

n = Roughness coefficient n

H_0 = Initial height of the tsunami on the coastline.

S = Surface of slope

The correlation between the speed of the tsunami on mainland

$$u = \sqrt{2g \cdot h}$$

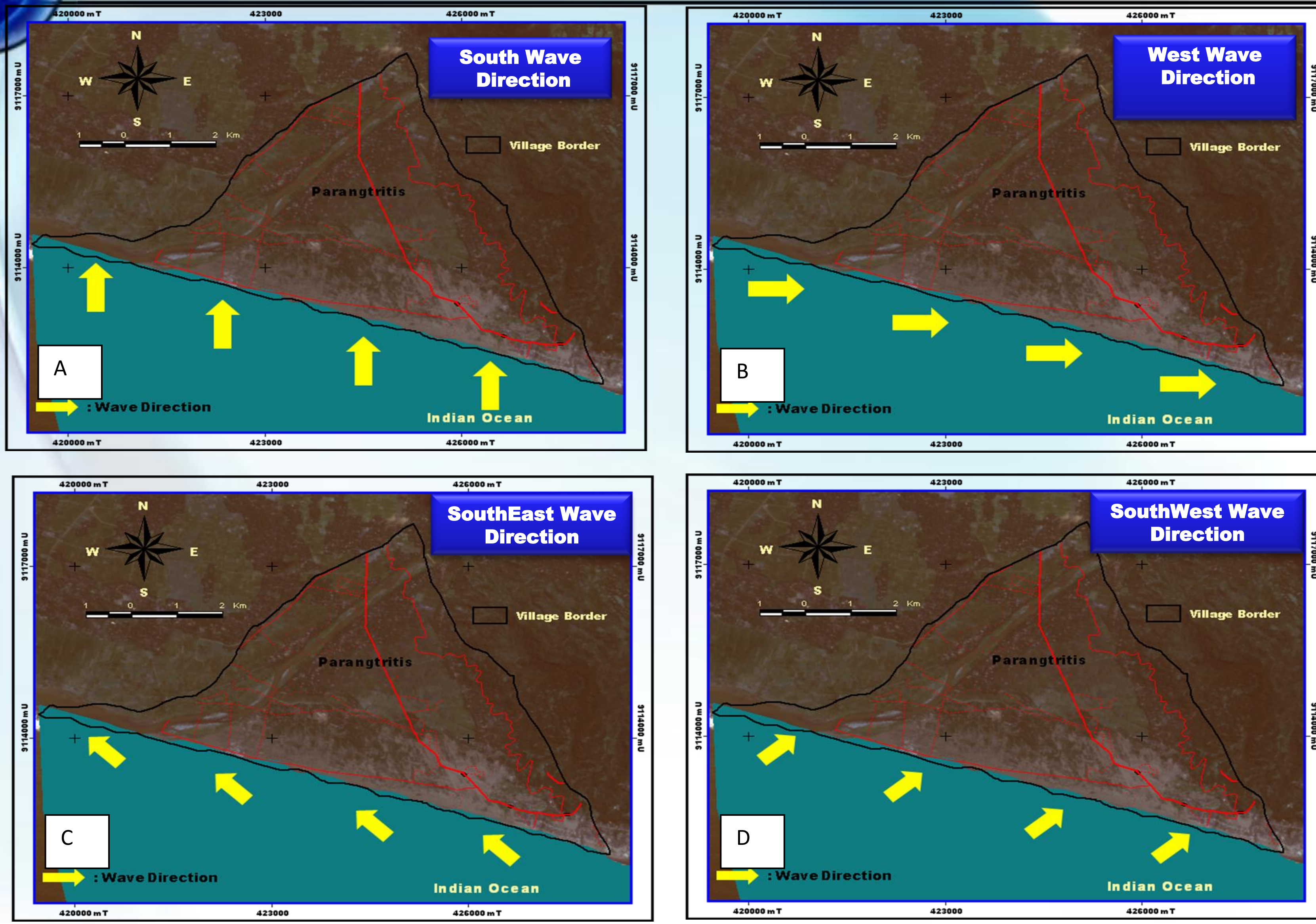
Where :

u= Wave Velocity

g= Gravitation Velocity

h= Depth

Tsunami Wave Simulation Scenario



UGM

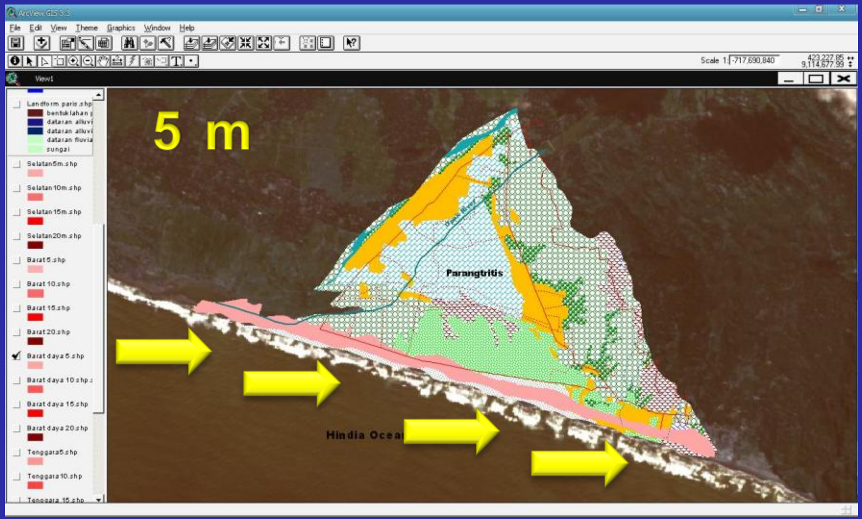
Tsunami Wave Simulation Scenario

$$H_{loss} = \left(\frac{16.7 \cdot n^2}{H_0^{\frac{1}{3}}} \right) + 0,5 \cdot \sin S$$

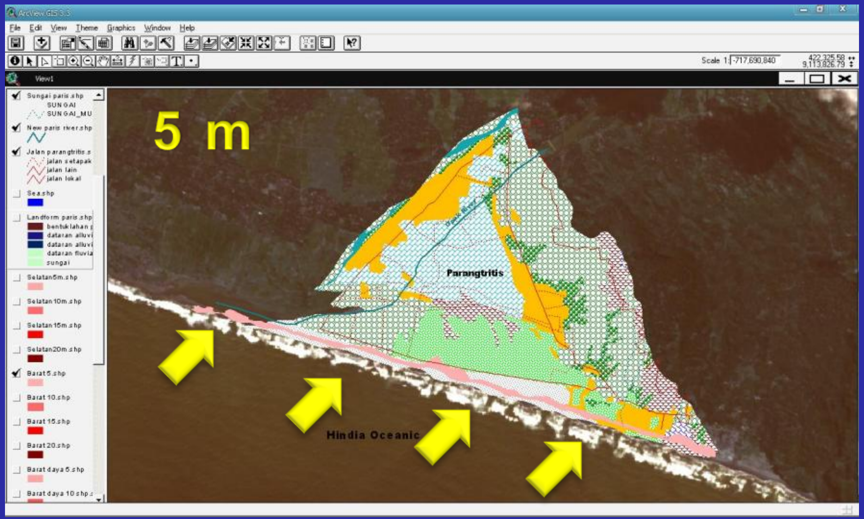
RESULTS

Tsunami Run-Up Map

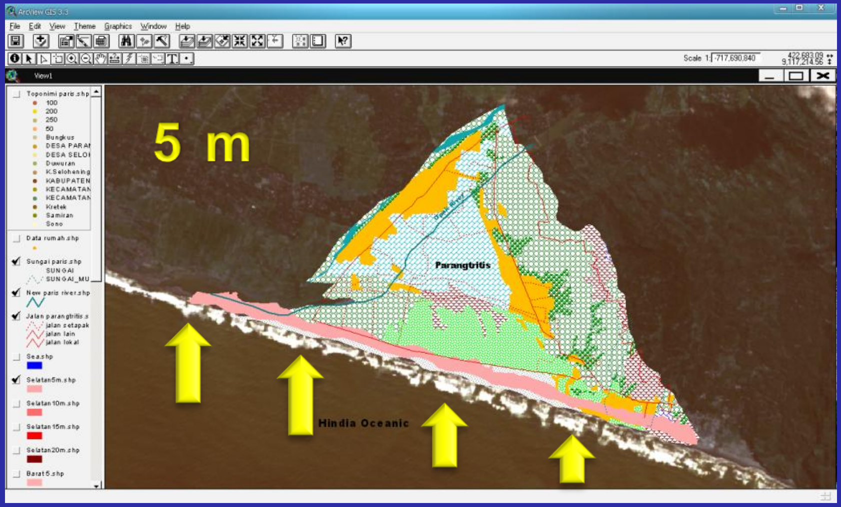
TSUNAMI RUN-UP & DIRECTION SCENARIO



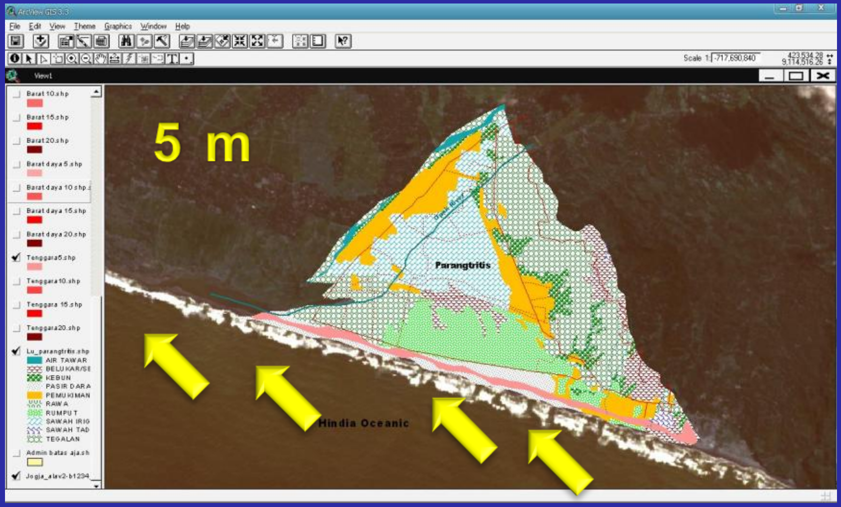
WEST WAVE DIRECTION



SOUTH WEST WAVE DIRECTION

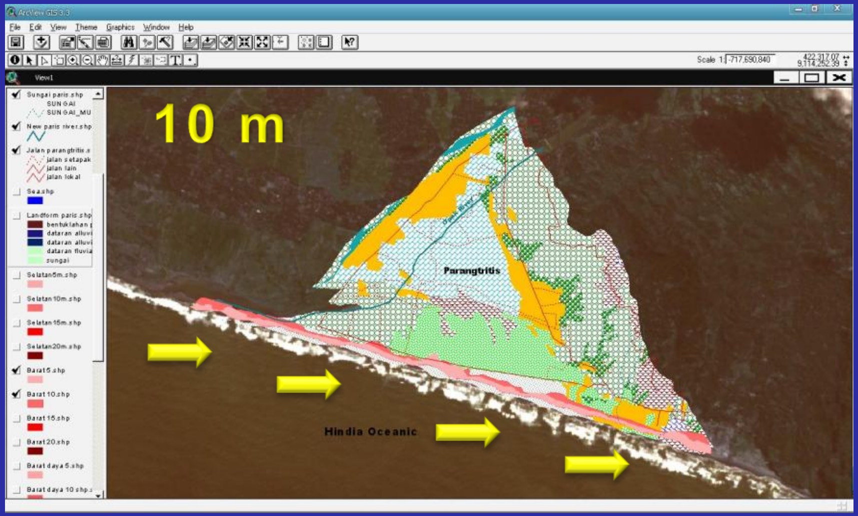


SOUTH WAVE DIRECTION

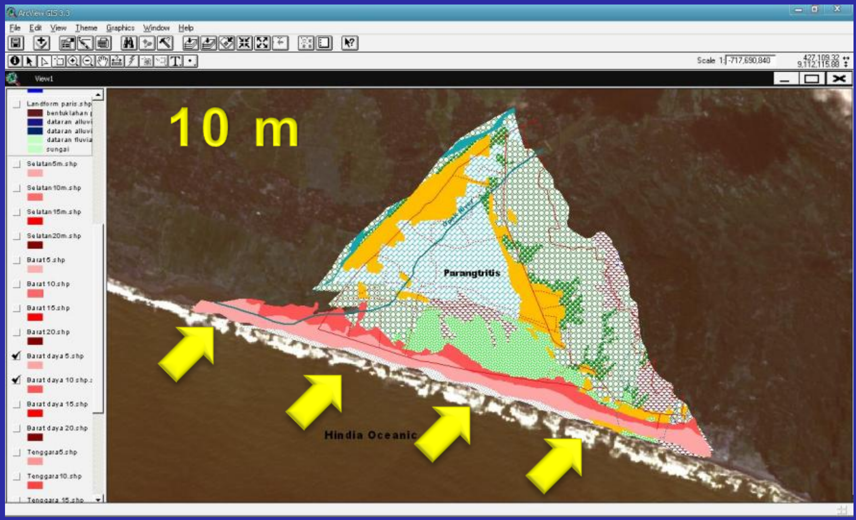


SOUTH EAST DIRECTION

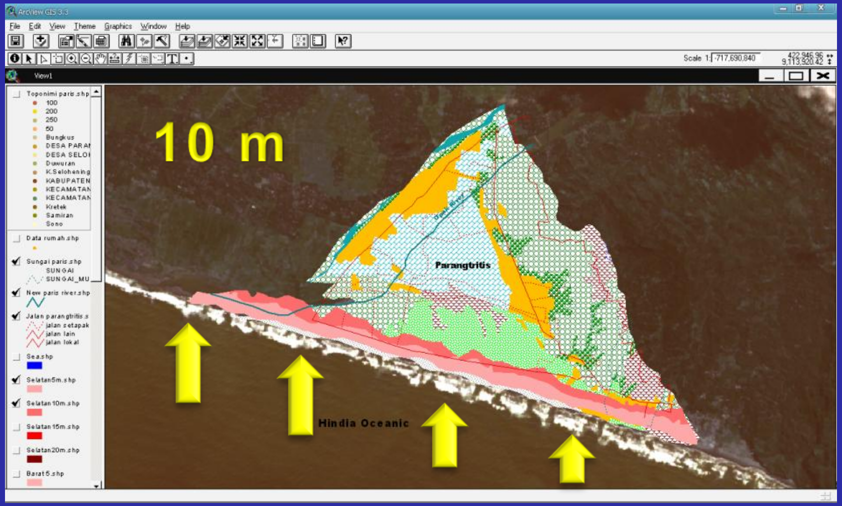
TSUNAMI RUN-UP & DIRECTION SCENARIO



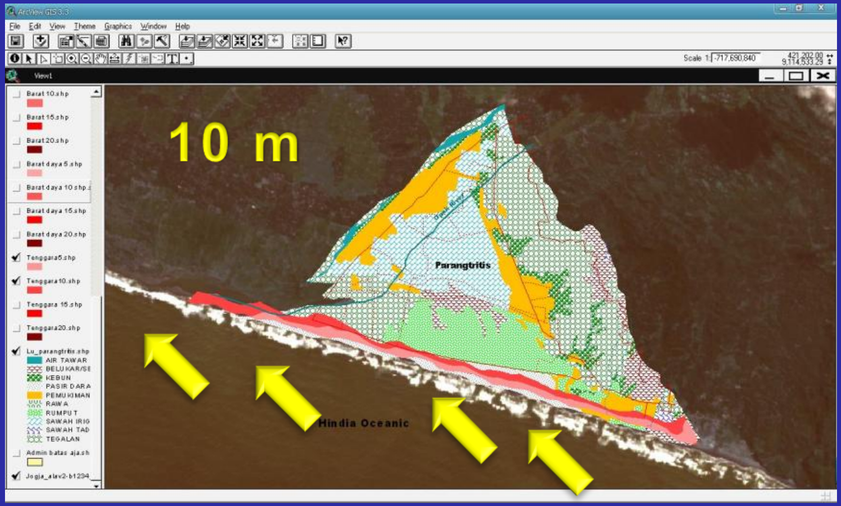
WEST WAVE DIRECTION



SOUTH WEST WAVE DIRECTION

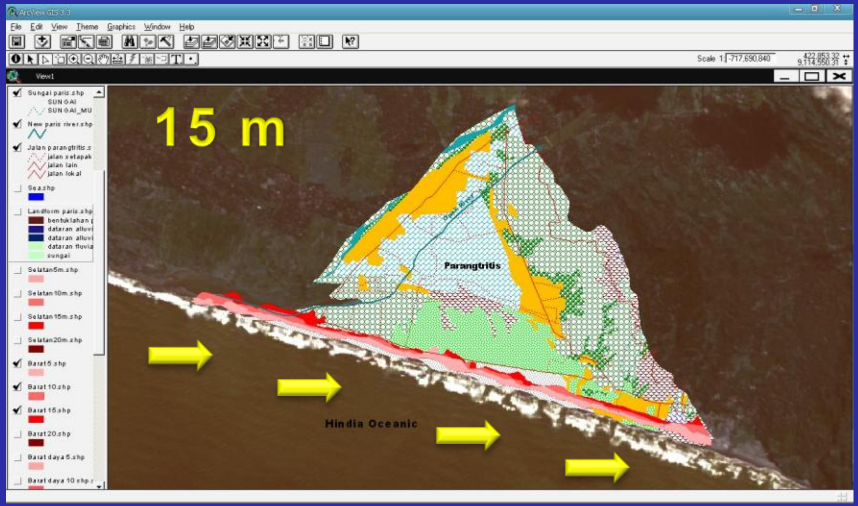


SOUTH WAVE DIRECTION

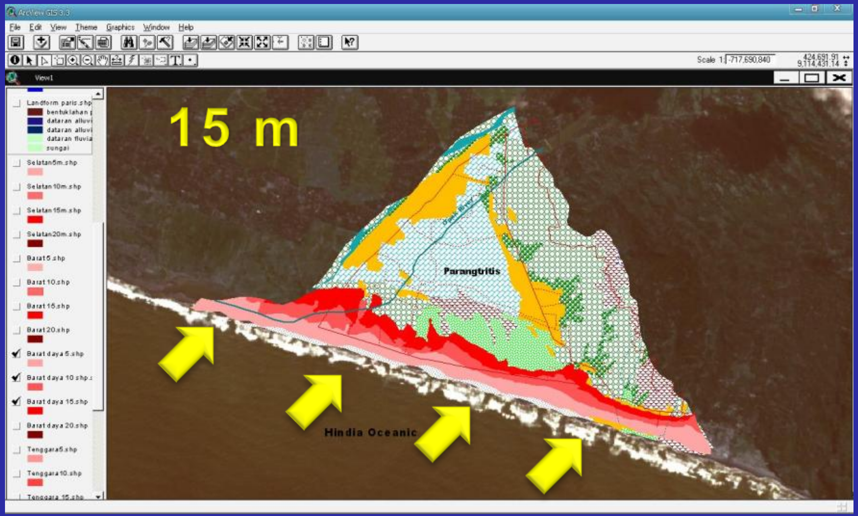


SOUTH EAST DIRECTION

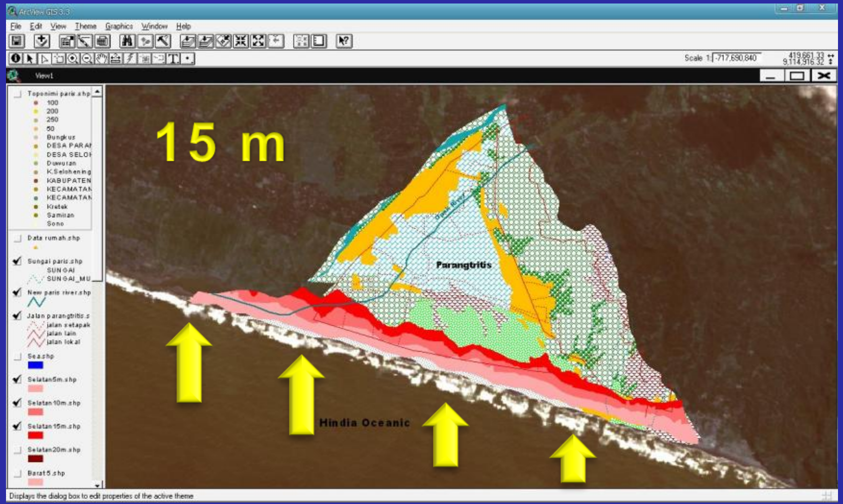
TSUNAMI RUN-UP & DIRECTION SCENARIO



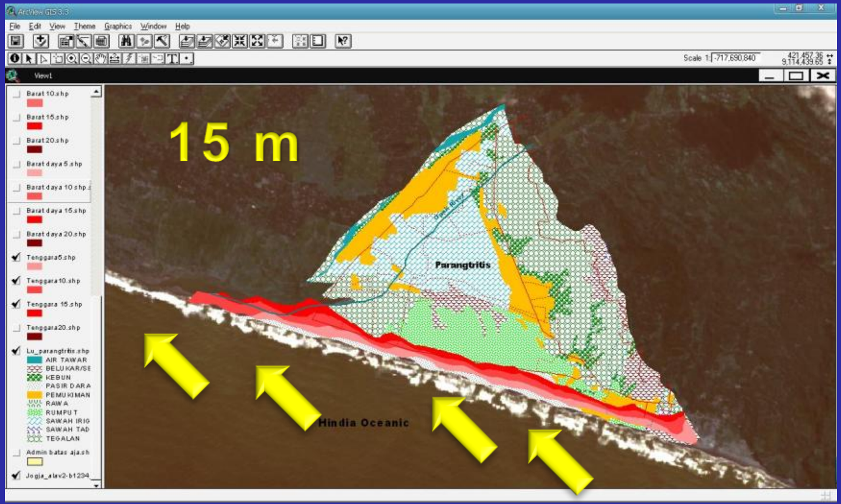
WEST WAVE DIRECTION



SOUTH WEST WAVE DIRECTION

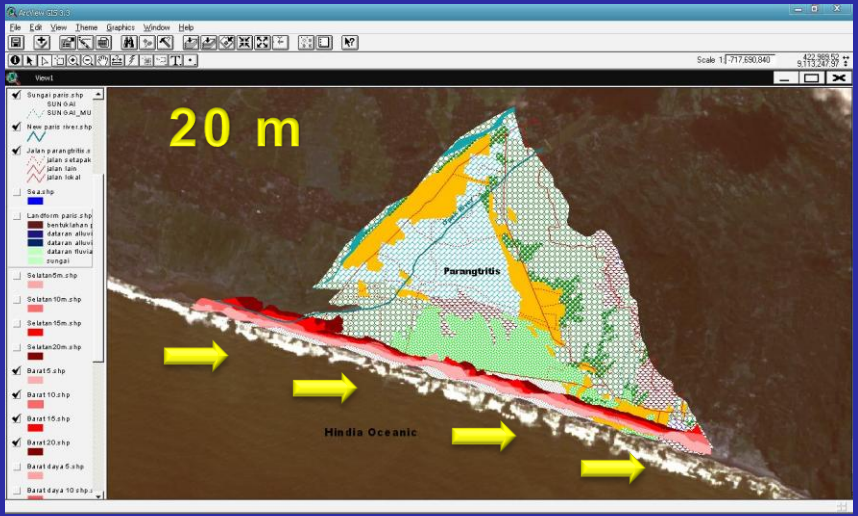


SOUTH WAVE DIRECTION



SOUTH EAST DIRECTION

TSUNAMI RUN-UP & DIRECTION SCENARIO



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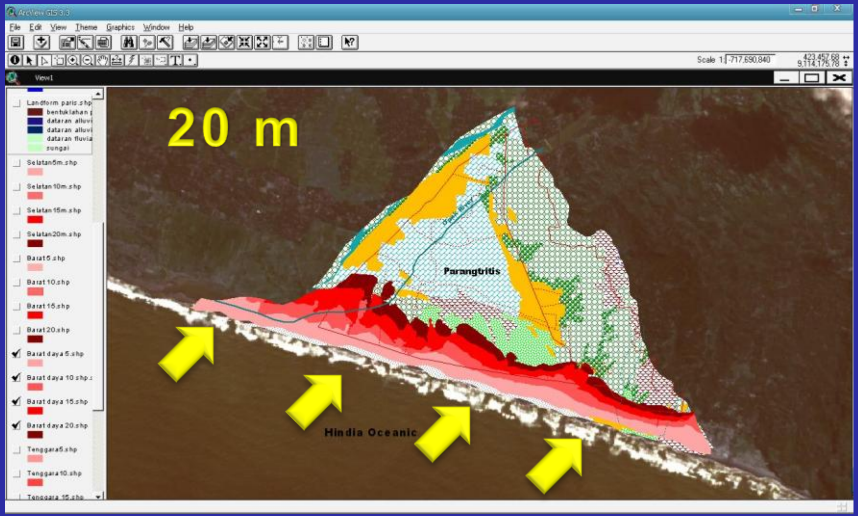
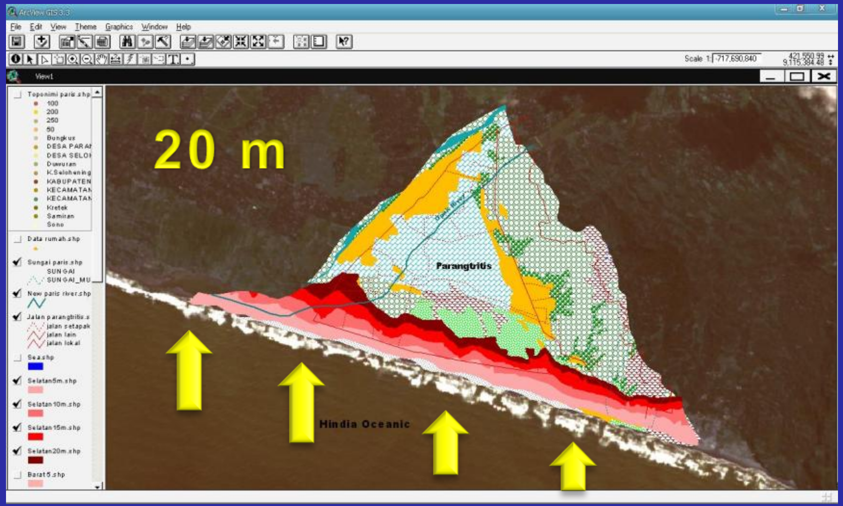
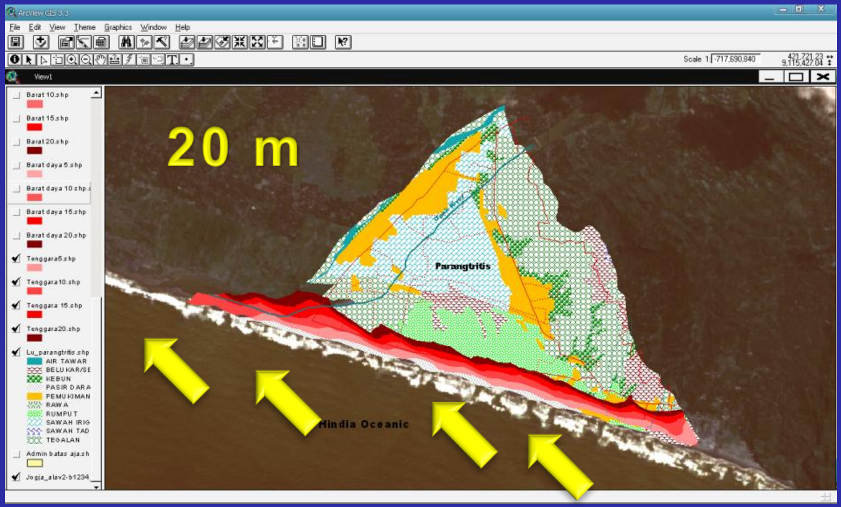


SOUTH WEST WAVE DIRECTION

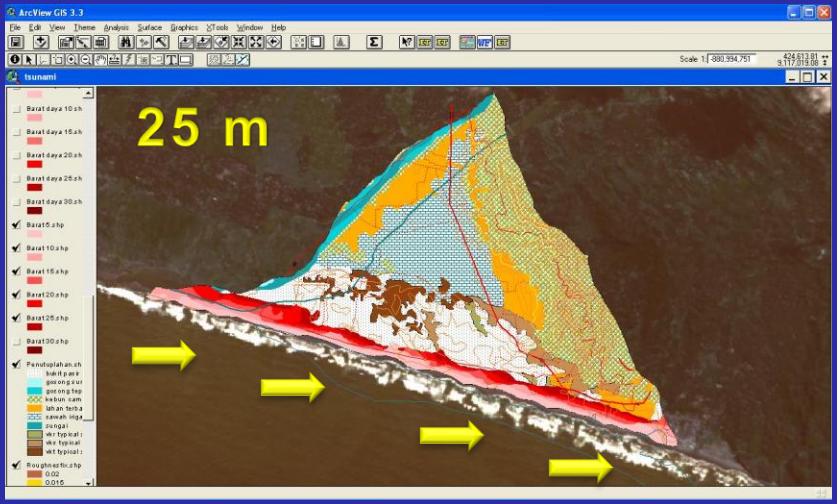


SOUTH WAVE DIRECTION

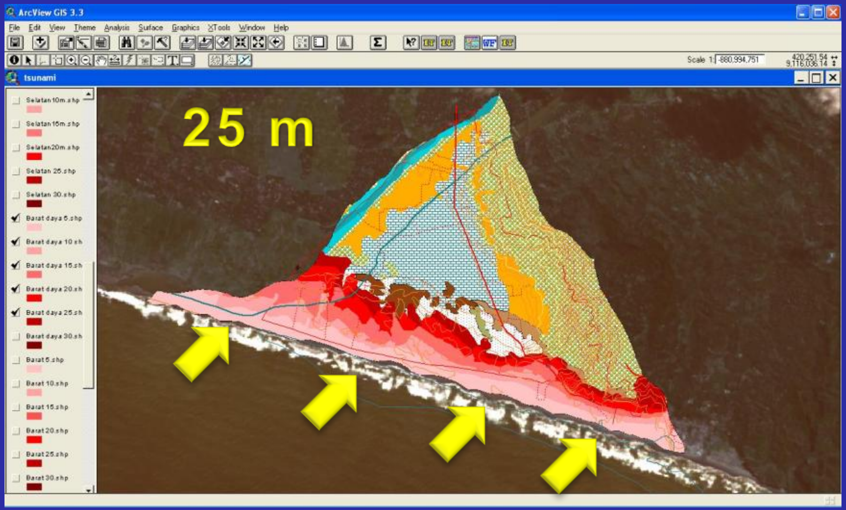


SOUTH EAST DIRECTION

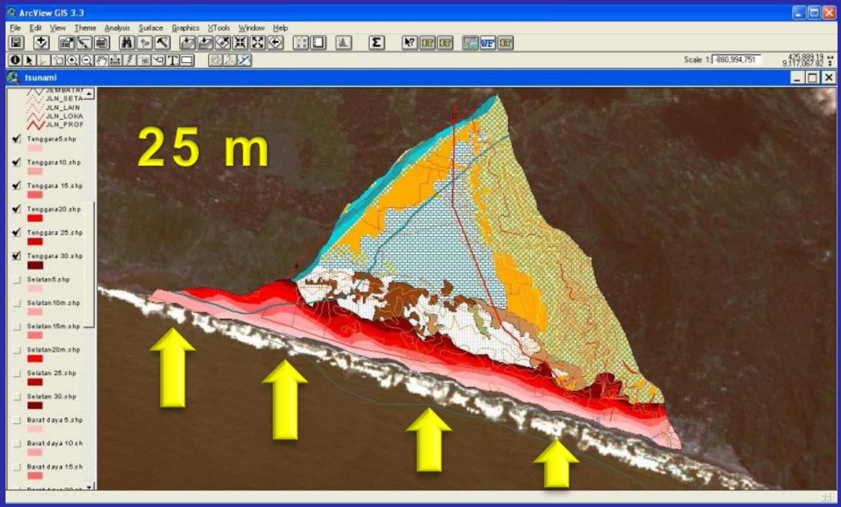
TSUNAMI RUN-UP & DIRECTION SCENARIO



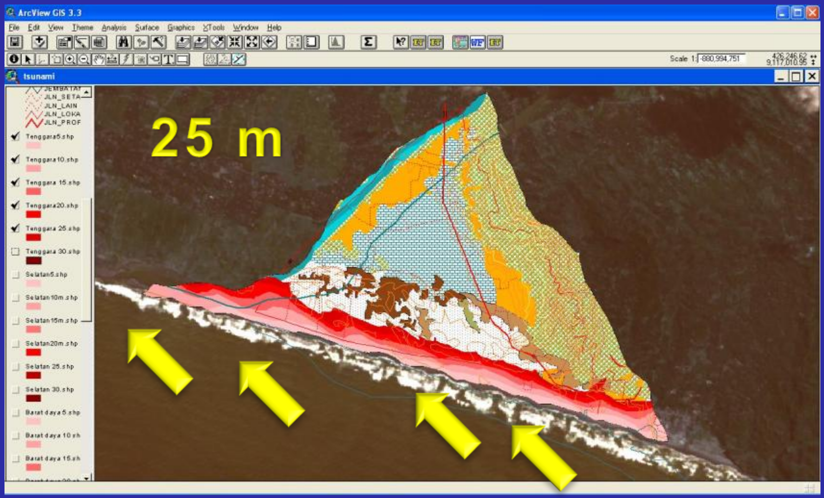
WEST WAVE DIRECTION



SOUTH WEST WAVE DIRECTION

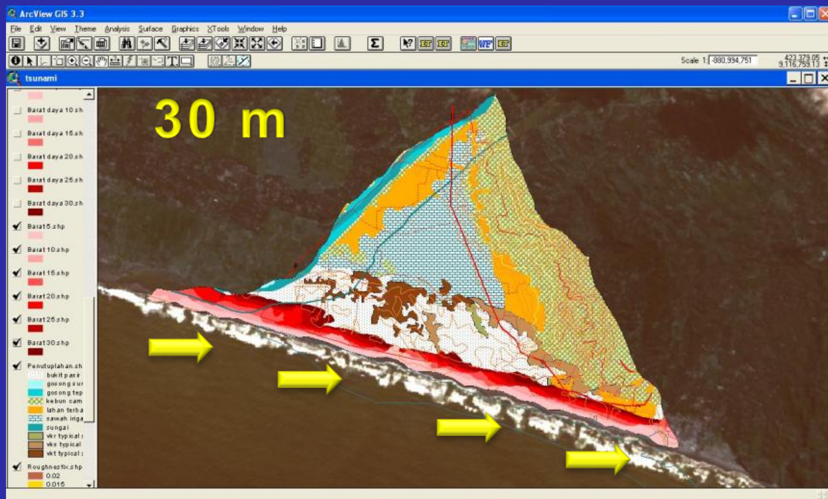


SOUTH WAVE DIRECTION

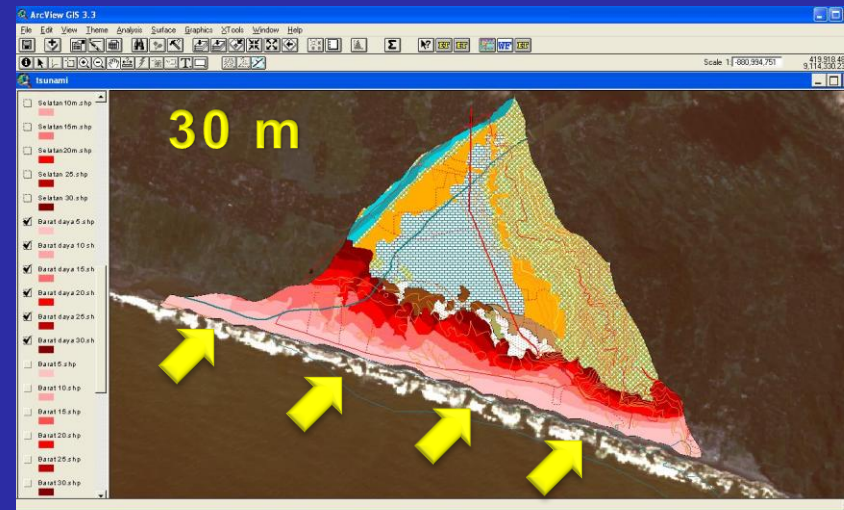


SOUTH EAST DIRECTION

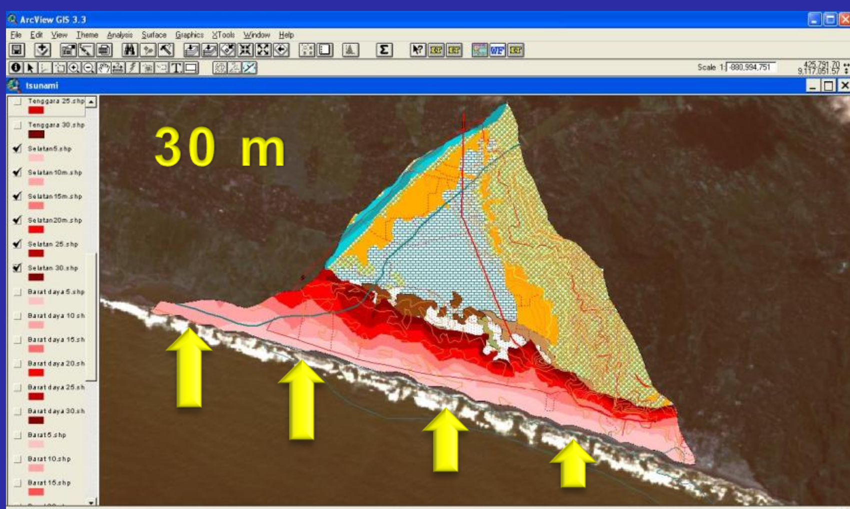
TSUNAMI RUN-UP & DIRECTION SCENARIO



WEST WAVE DIRECTION



SOUTH WEST WAVE DIRECTION



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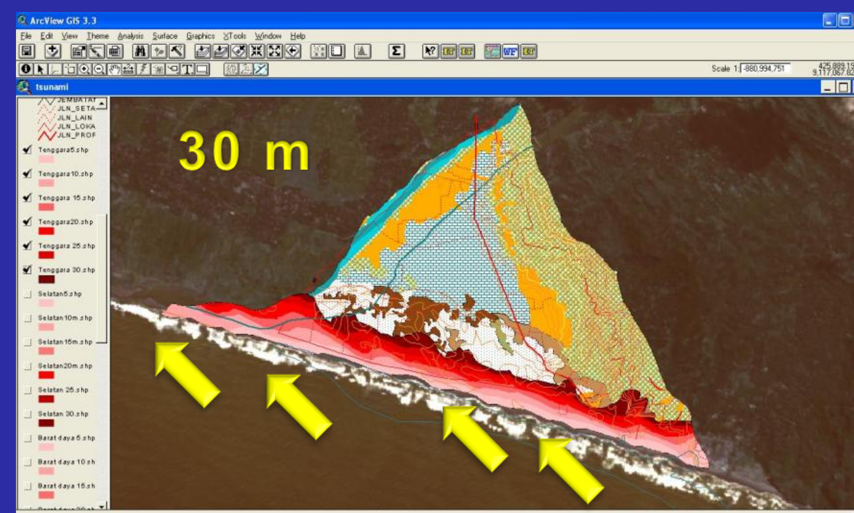
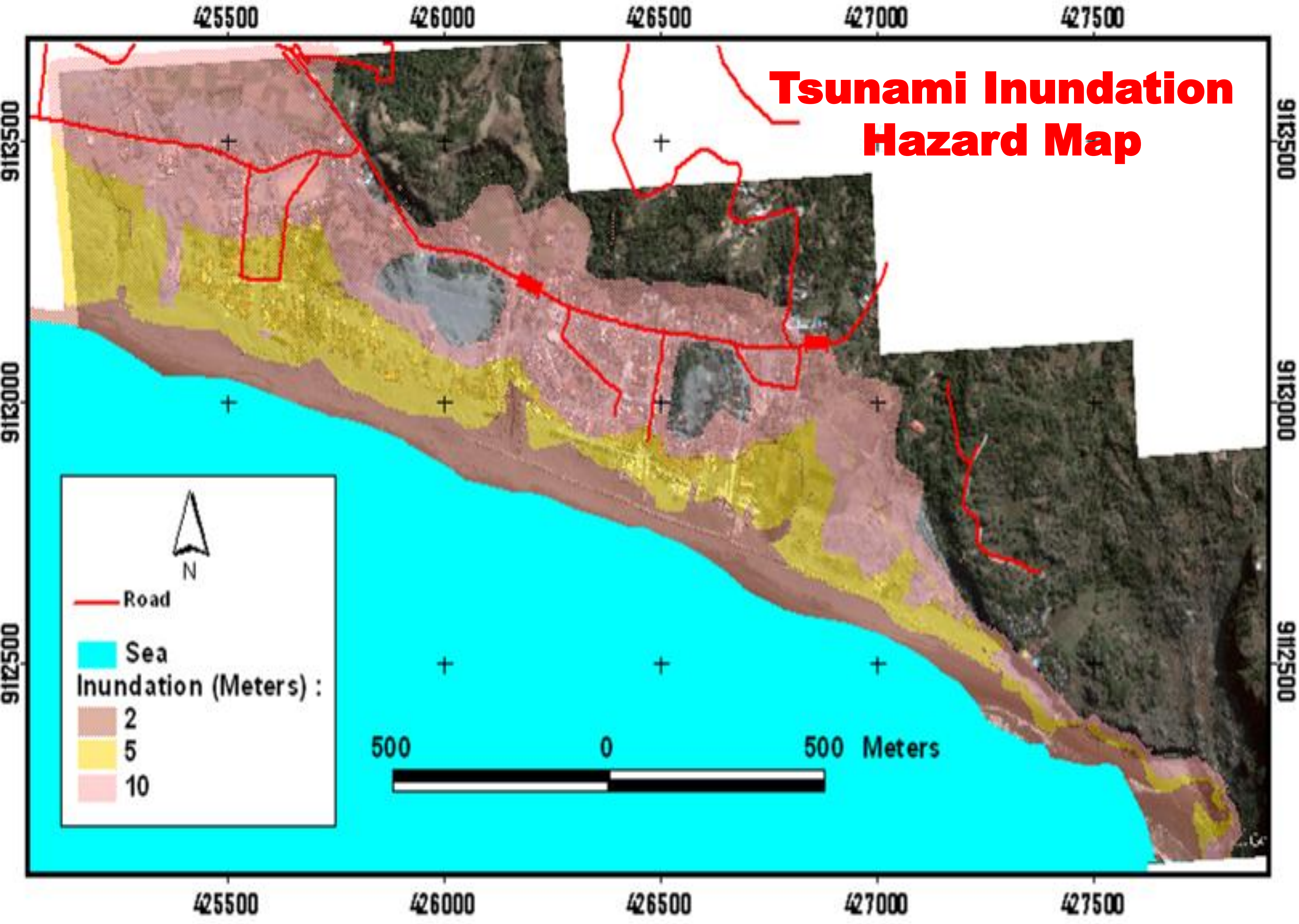
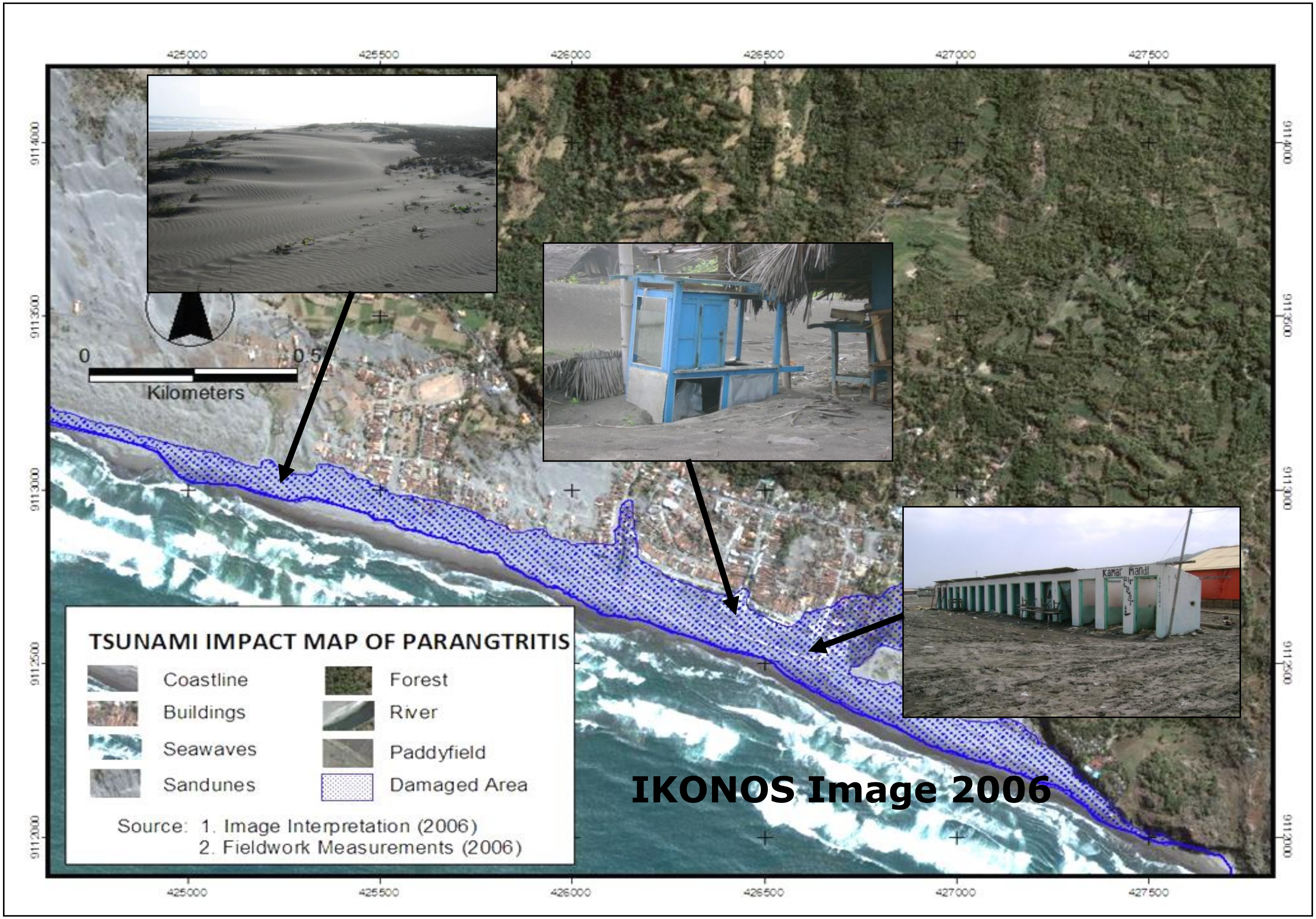
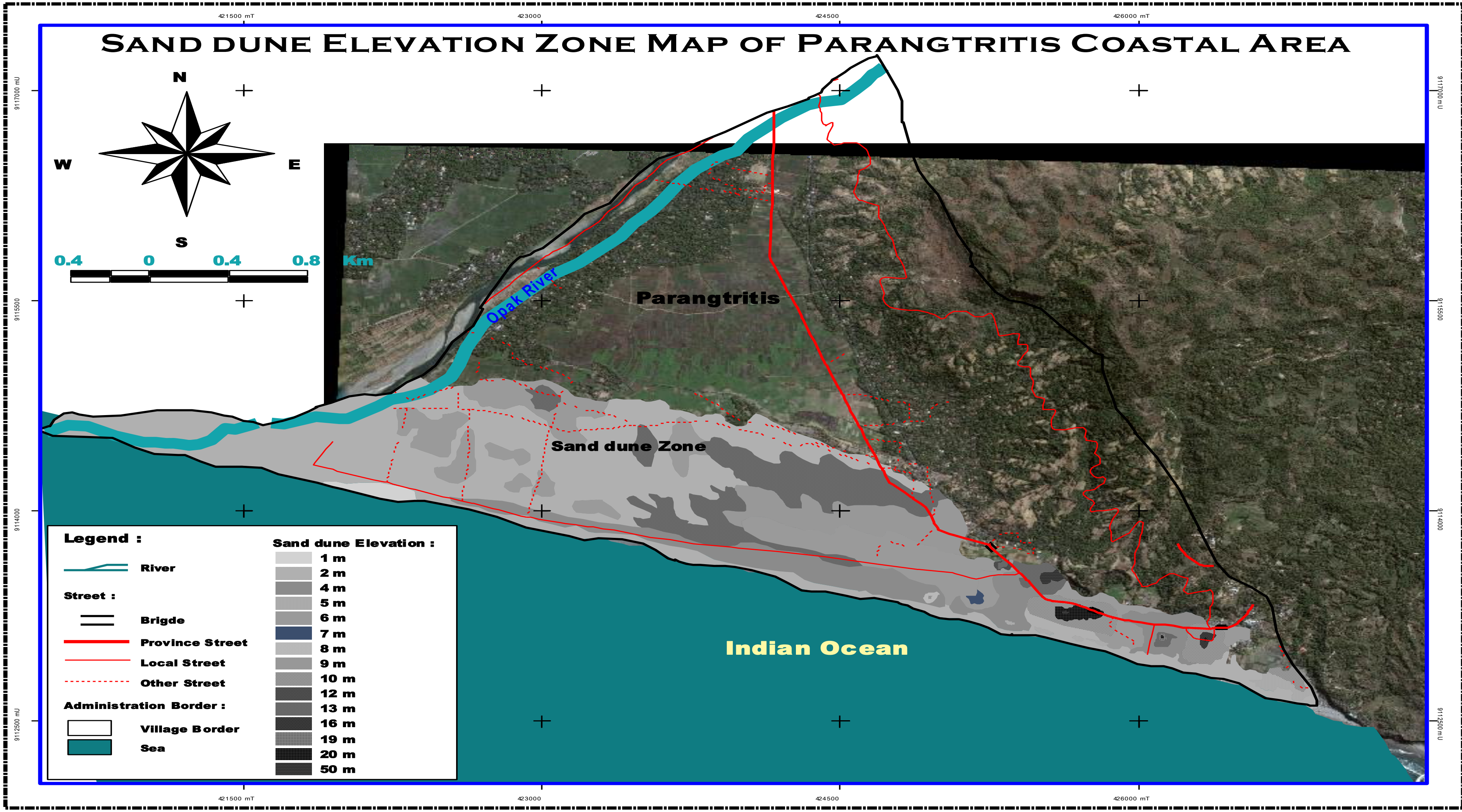


SOUTH EAST DIRECTION

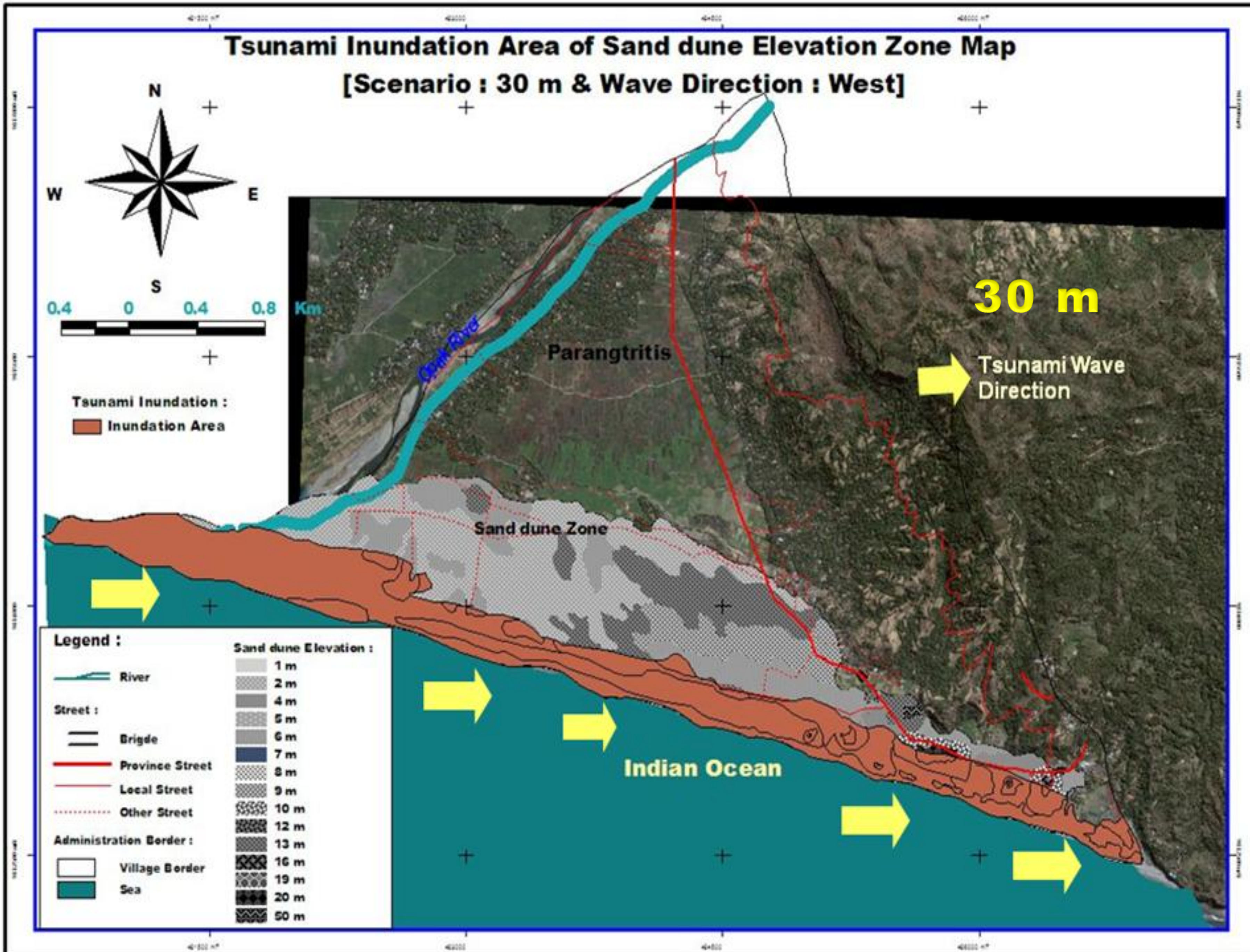

Tsunami Inundation
Hazard Map
425500
426000
426500
427000
427500
9113500
9113000
9112500
N
Road
Sea
Inundation (Meters) :
2
5
10
500
0
500 Meters

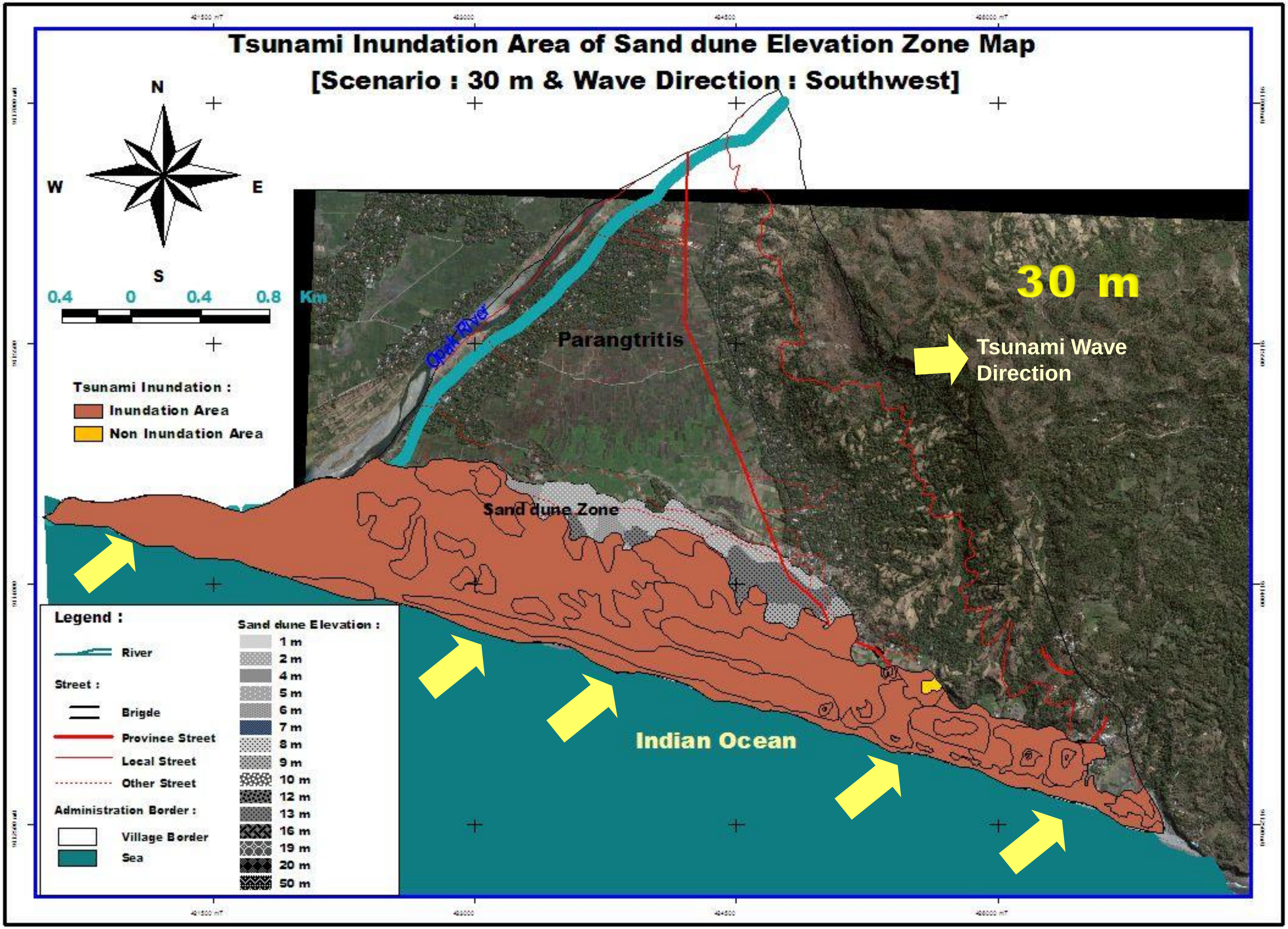
DAMAGE AREA OF TSUNAMI MAP

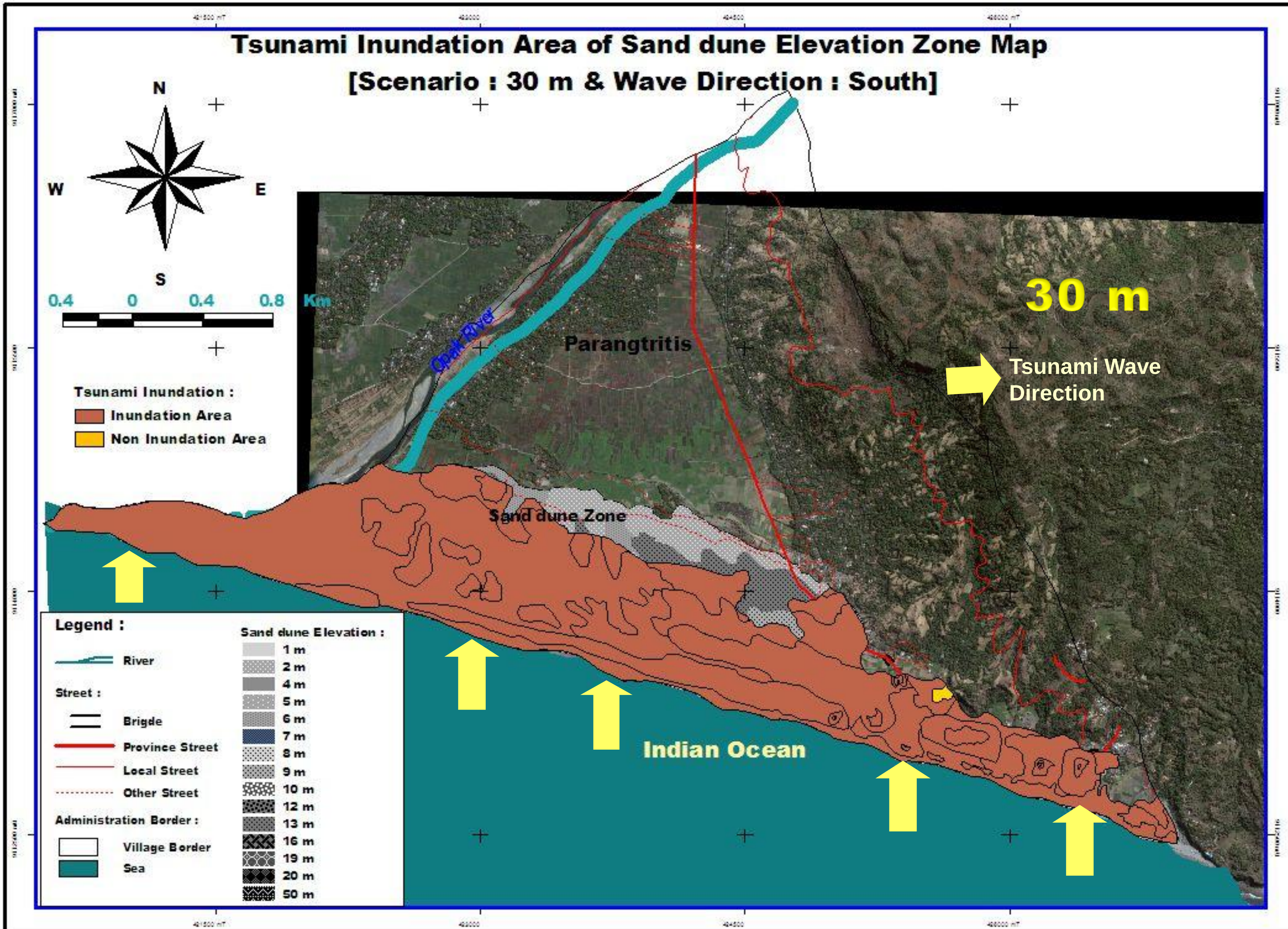




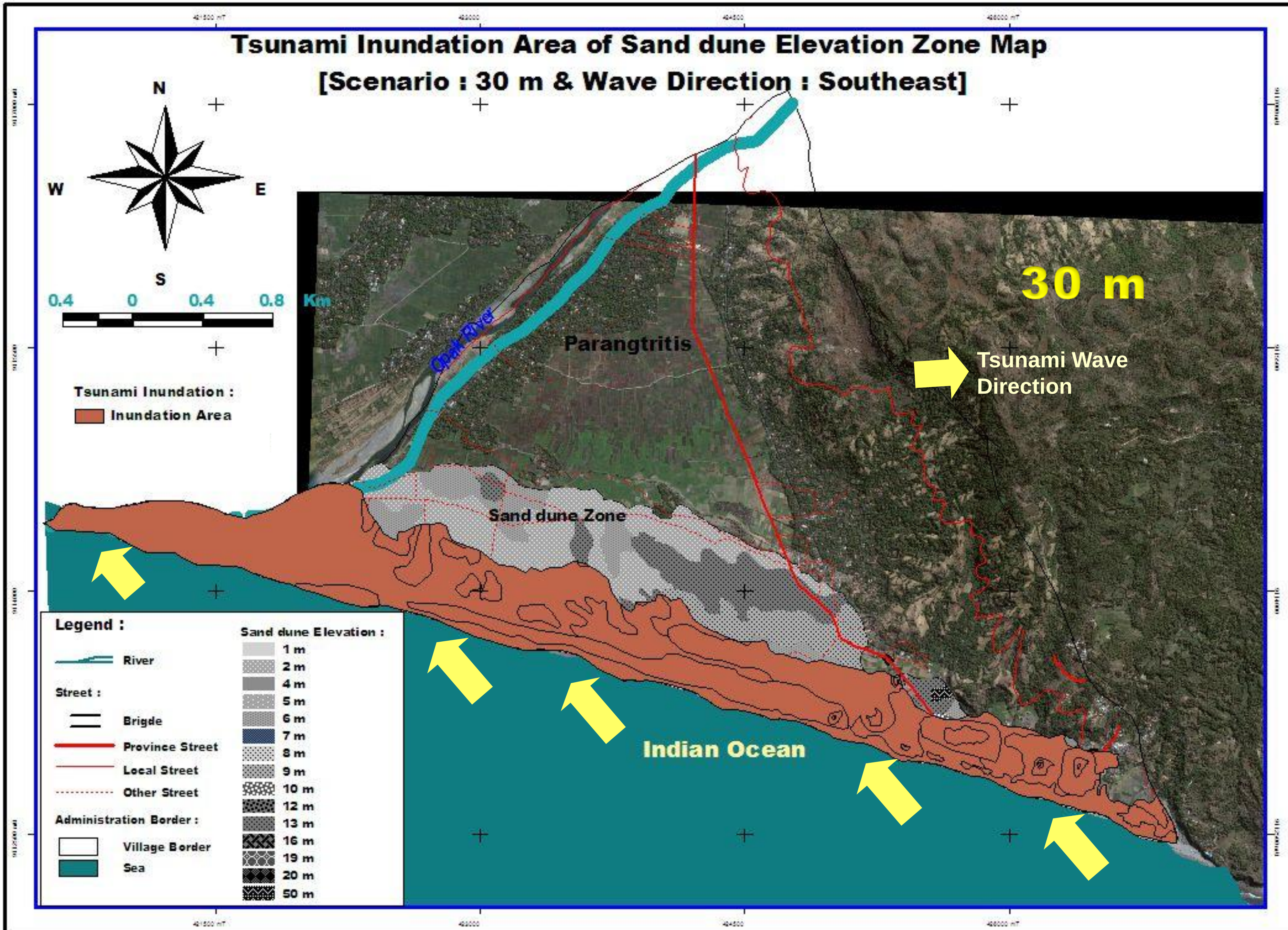
Sand Dune 2-Dimensional Elevation Map


Tsunami Inundation Area of Sand dune Elevation Zone Map
[Scenario : 30 m & Wave Direction : West]
N
S
W
E
0.4 0 0.4 0.8 Km
Tsunami Inundation :
Inundation Area
Opak River
Parangtritis
30 m
Tsunami Wave Direction
Sand dune Zone
Indian Ocean
Legend :
River
Street :
Brigde
Province Street
Local Street
Other Street
Administration Border :
Village Border
Sea
Sand dune Elevation :
1 m
2 m
4 m
5 m
6 m
7 m
8 m
9 m
10 m
12 m
13 m
16 m
19 m
20 m
50 m


Tsunami Inundation Area of Sand dune Elevation Zone Map
[Scenario : 30 m & Wave Direction : Southwest]
N
W
E
S
0.4 0 0.4 0.8 Km
Tsunami Inundation :
Inundation Area
Non Inundation Area
Opak River
Parangtritis
Sand dune Zone
30 m
Tsunami Wave Direction
Indian Ocean
Legend :
River
Street :
Brigde
Province Street
Local Street
Other Street
Administration Border :
Village Border
Sea
Sand dune Elevation :
1 m
2 m
4 m
5 m
6 m
7 m
8 m
9 m
10 m
12 m
13 m
16 m
19 m
20 m
50 m



Tsunami Inundation Area of Sand dune Elevation Zone Map
[Scenario : 30 m & Wave Direction : South]
N
W
E
S
0.4 0 0.4 0.8 Km
Tsunami Inundation :
Inundation Area
Non Inundation Area
Opak River
Parangtritis
30 m
Tsunami Wave Direction
Sand dune Zone
Indian Ocean
Legend :
River
Street :
Brigde
Province Street
Local Street
Other Street
Administration Border :
Village Border
Sea
Sand dune Elevation :
1 m
2 m
4 m
5 m
6 m
7 m
8 m
9 m
10 m
12 m
13 m
16 m
19 m
20 m
50 m



Tsunami Inundation Area of Sand dune Elevation Zone Map
[Scenario : 30 m & Wave Direction : Southeast]
N
W
E
S
0.4 0 0.4 0.8 Km
Tsunami Inundation :
Inundation Area
Opak River
Parangtritis
30 m
Tsunami Wave Direction
Sand dune Zone
Indian Ocean
Legend :
River
Street :
Brigde
Province Street
Local Street
Other Street
Administration Border :
Village Border
Sea
Sand dune Elevation :
1 m
2 m
4 m
5 m
6 m
7 m
8 m
9 m
10 m
12 m
13 m
16 m
19 m
20 m
50 m

3-Dimensional View of Parangtritis

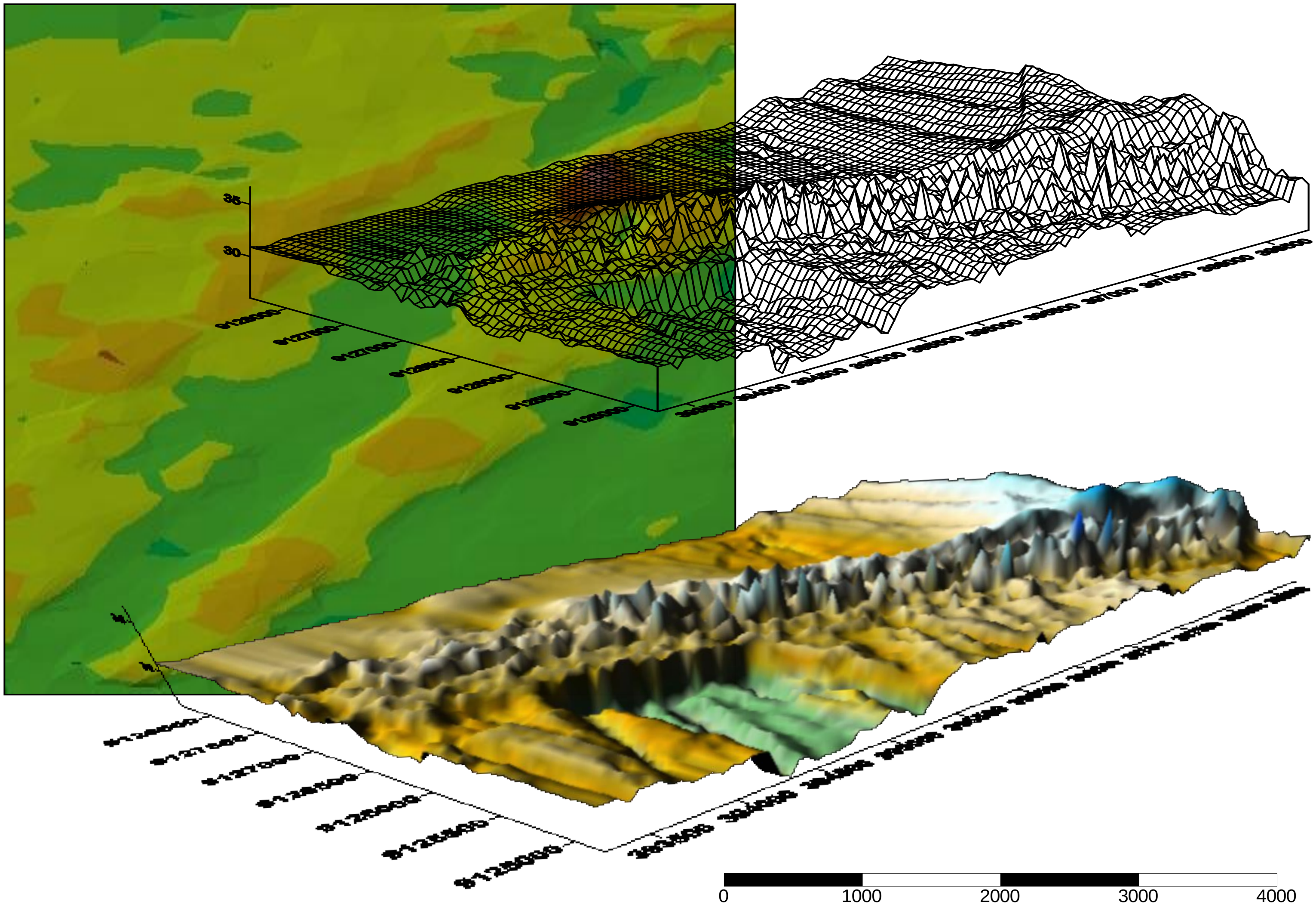
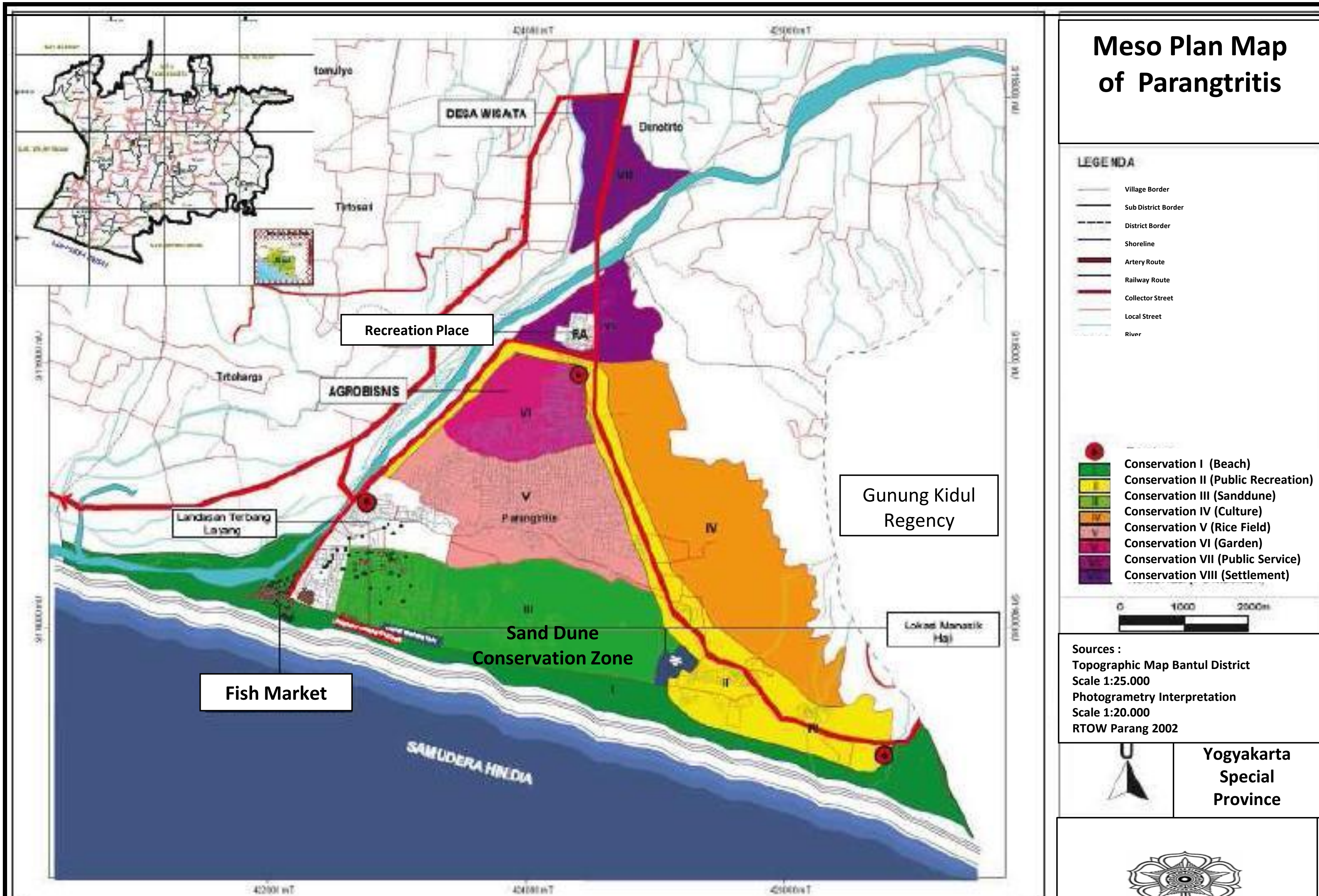


Table Tsunami Inundation Area of Sand dune Elevation Zone

Tsunami Inundation Scenarios (Height & Direction of Wave)		Inundation Area of Sand dune Zone (Ha)	Non Inundation Area of Sand dune Zone (Ha)
West	5 m	47,719	0,446
	10 m	70,232	0,030
	15 m	95,246	0,030
	20 m	126,921	0
	25 m	154,087	0
	30 m	178,280	0
South	5 m	83,911	8,327
	10 m	173,444	11,704
	15 m	247,954	2,859
	20 m	302,544	0,683
	25 m	341,43	0,809
	30 m	365,402	0,809
Southwest	5 m	111,310	9,512
	10 m	184,659	12,839
	15 m	276,742	2,739
	20 m	318,561	0,803
	25 m	346,437	0,809
	30 m	369,138	0,809
Southeast	5 m	85,654	8,327
	10 m	103,235	2,916
	15 m	153,249	6,265
	20 m	197,121	0
	25 m	227,272	0
	30 m	266,041	0



Meso Plan Map of Parangtritis

Conclusion

- Application simulation of tsunami inundation, sand dune actual condition and human activity (sand river minning) in arround research area can be used to determine sand dune conservation Simulation in this research area.

- To obtain the tsunami inundation maps, various approaches already has done, for example through a simple model based on contour lines or slope, based on the coefficient of surface roughness (roughness coefficient) and complex mathematical models.

- Sand dune conservation management needed coordination between stakeholder and local community. Many local communities are aware of the importance of the coastal sand dunes and have their traditional methods of dune conservation and restoration, as in the case of Southern part of Parangtritis Village.

Recomendations

1. Develop and promote planning policies and procedures which will aim to prevent or minimize further losses of sand dune habitat because of development.

2. Develop and promote coastal zone management policies which allow the maximum possible free movement of coastal sediment and pay full regard to the conservation of sand dunes. Include in Shoreline Management Plans where they have a role to play in flood defence.

3. Raise public awareness about the importance of sand dunes, and the essential mobility of coasts and the value of maintaining unrestricted coastal processes. Promote awareness of the implications of the policies outlined in this plan among decision-makers.

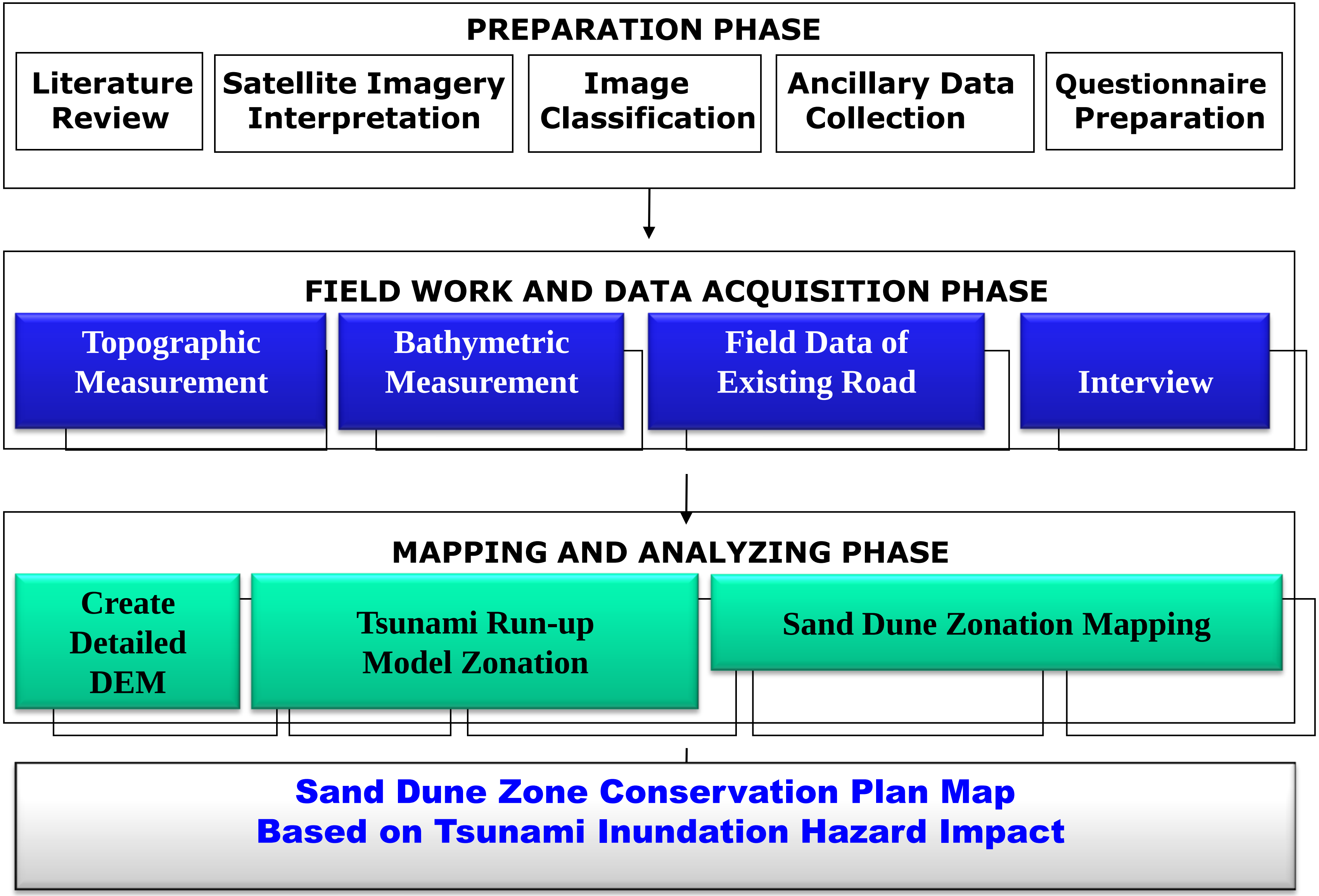

Thank You......

BATHYMETRIC MEASUREMENTS

UGM




METHODOLOGY



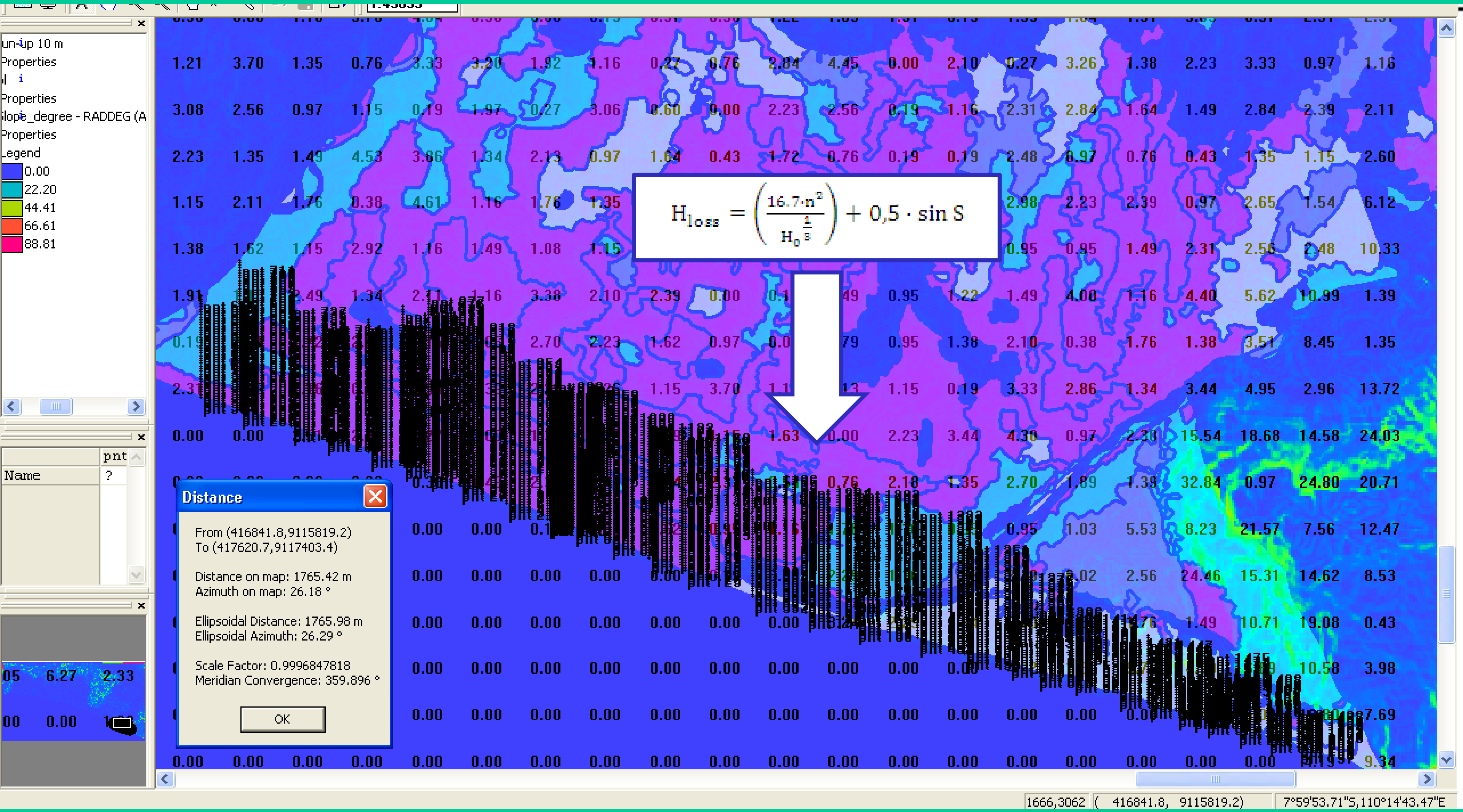
Bantul Disaster Mitigation

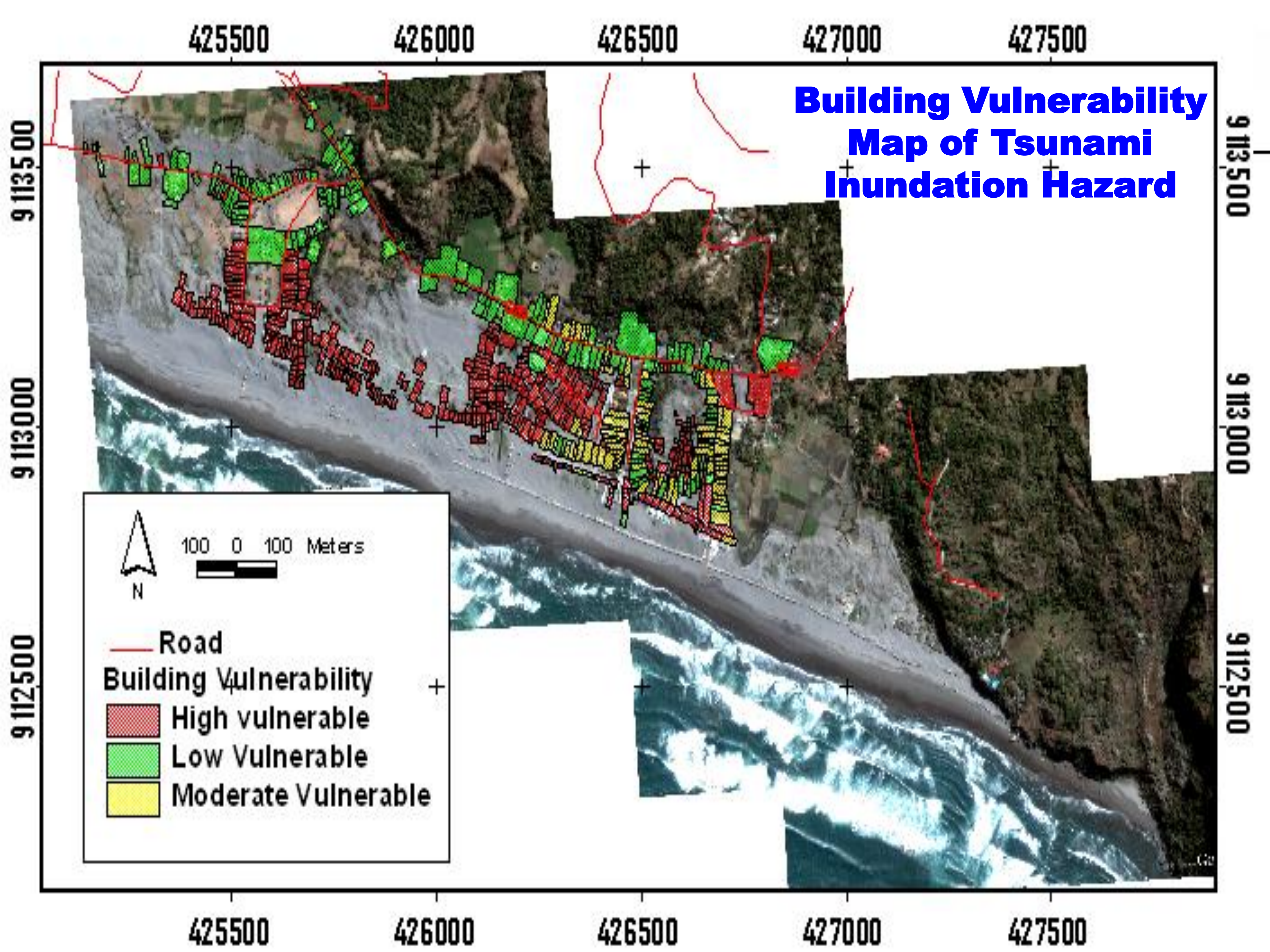
- **Tsunami Warning System means that a potentially destructive tsunami is imminent or expected.**

METHODOLOGY
Data Availability

Data type	Available	Source	Description	Processing Phase
Tsunami Events Data	√	NGDC, 2007	Historical Events Database	Frequency analysis
Tsunami 17th July 2006	√	Fieldwork, 2006	Evidence, validation aspects of the study result	Field database
Topoc Map -General -Detail	 √ -	 - BAKOSURTANAL, 2000 - Fieldwork	 - Use for generating DEM - Detailed DEM	 - DGPS Measurement
Landuse Map -General -Detail	 √ -	 - BAKOSURTANAL, 2005 - Fieldwork	 Use for calculating elements at risk	 Calculating area of elements at risk.
Geological Map -General	 √	 DGTL, 1994	 General description	 General description
Bathymetry Map -General -Detail	 √ -	 -Dishidros, 1998 -Fieldwork	 - General Bathymetry - Detailed Bathymetry	 - Interpolating contours point - Echo-Sounding
Satellite Images -Low-resolution -Medium-resolution -High-resolution	 √ √ √	-Landsat ETM,SRTM -Aster 2000-2006 -Ikonos,Quickbird -ALOS ALSAR, 2007 – 2008	- General description of Landcover -Detailed spatial distribution of inundation hazard -Using ArcView -Using SIGMA SAR [	Image Classification, image interpretation and modeling
Demography Data	√	Central Statistics Agency, 2008	Demographic condition (nr. people, density, age, etc)	Demographic Analysis

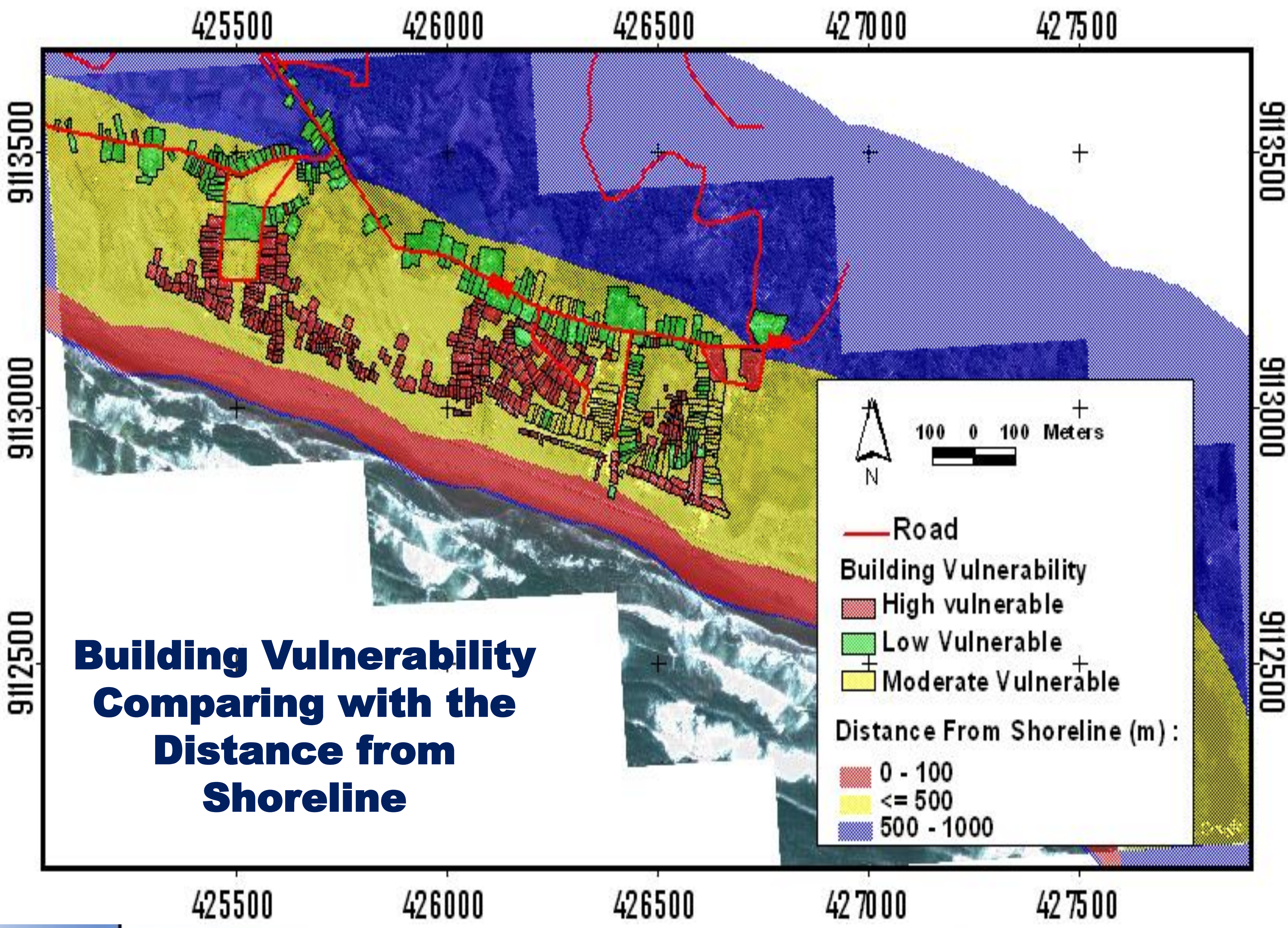
Iteration with Roughness Coeficient



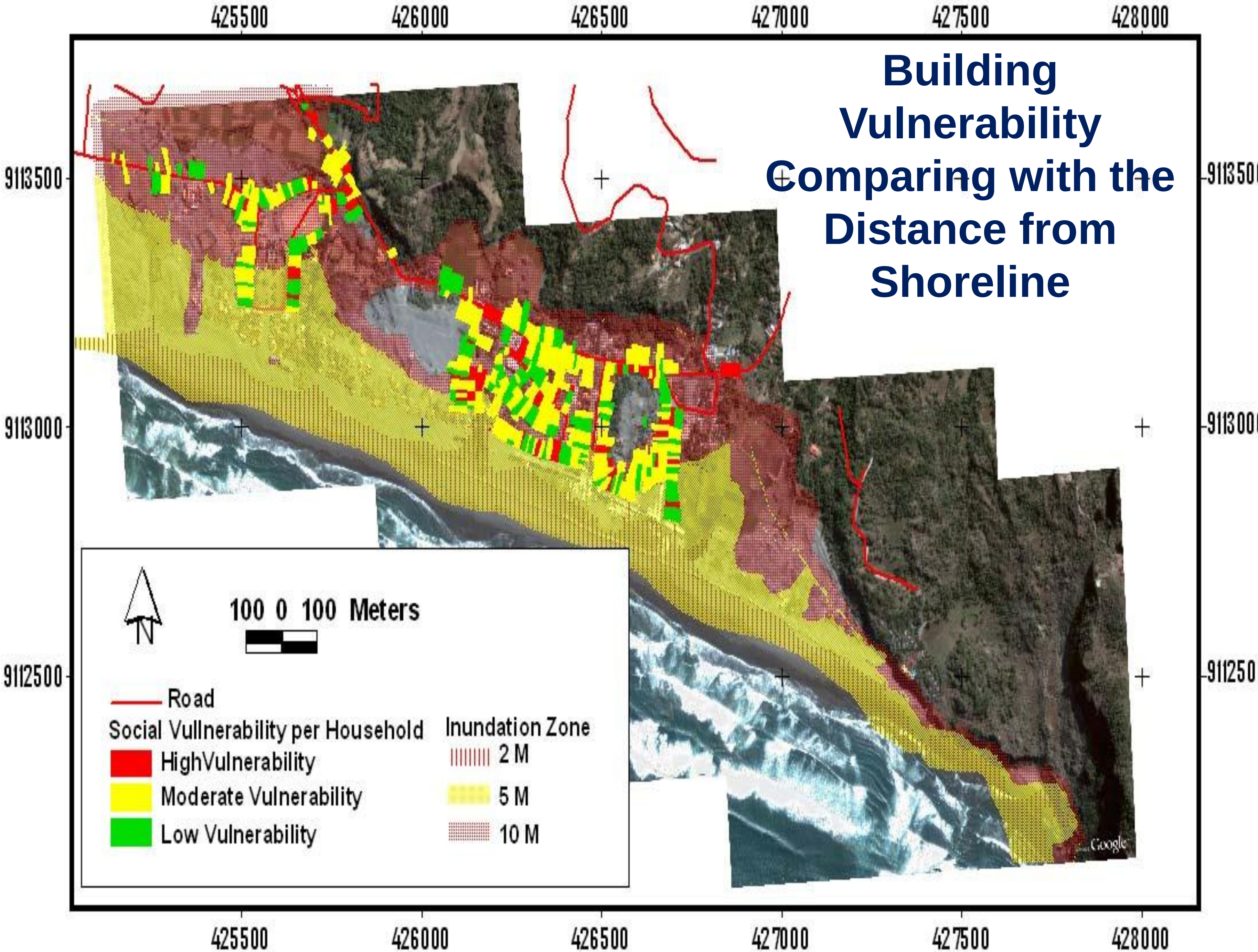


Building Vulnerability
Map of Tsunami
Inundation Hazard
425500
426000
426500
427000
427500
9113500
9113000
9112500
N
100 0 100 Meters
Road
Building Vulnerability
High vulnerable
Low Vulnerable
Moderate Vulnerable

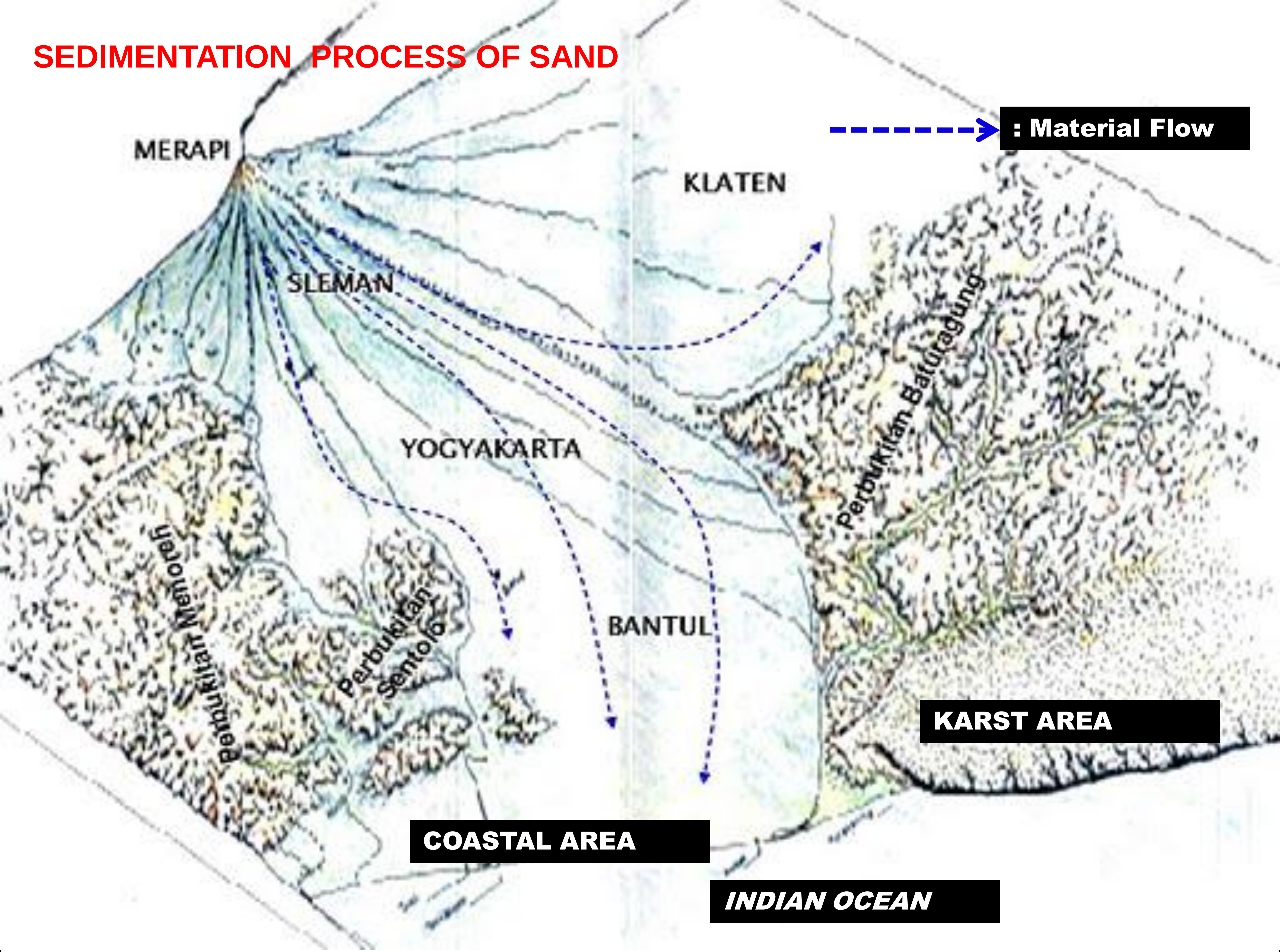
Building Vulnerability Comparing with the Distance from Shoreline



Building Vulnerability Comparing with the Distance from Shoreline



SEDIMENTATION PROCESS OF SAND



METHOD

Data type	Available	Source	Description	Processing Phase
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Satellite Images -Low-res -Medium-res -High-res	 √ √ √	-Landsat ETM,SRTM -Aster 2000-2006 -Ikonos,Quickbird -ALOS ALSAR, 2007 – 2008	- General description of Landcover -Detailed spatial distribution of inundation hazard	Image Classification, image interpretation and modeling
Demography Data	√	Central Statistics Agency, 2008	Demographic condition (nr. people, density, age, etc)	Demographic Analysis

FIELD WORK ACTIVITIES

TOPOGRAPHIC MEASUREMENTS

BATHYMETRIC MEASUREMENTS

FIELD DATA OF SAND DUNE

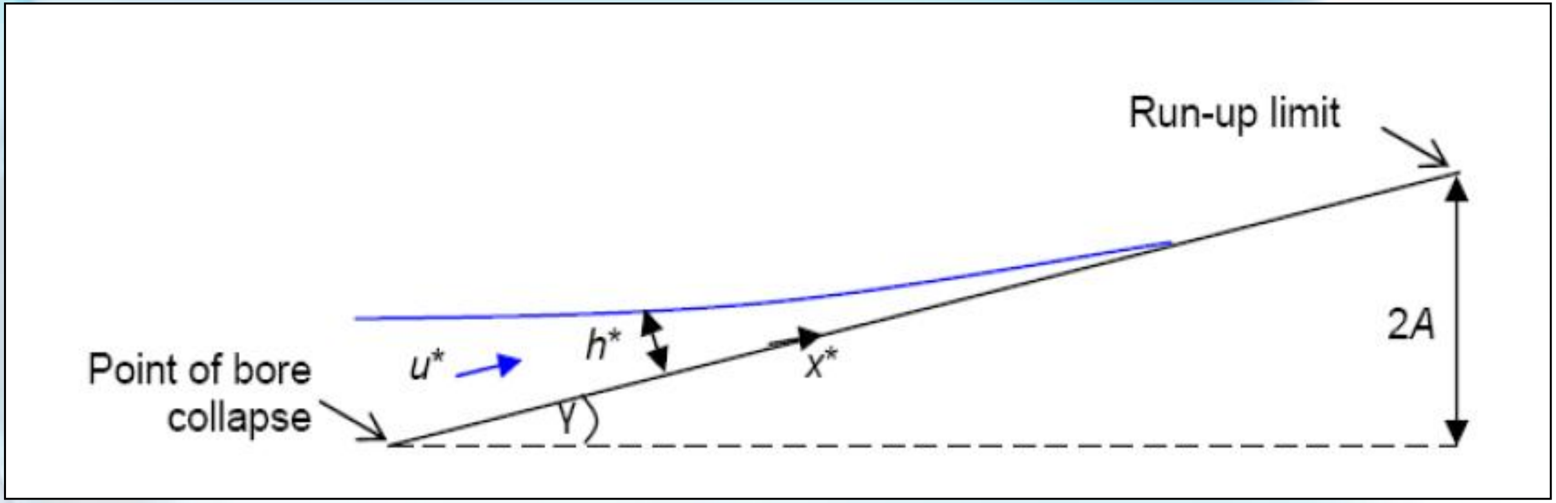
INTERVIEW

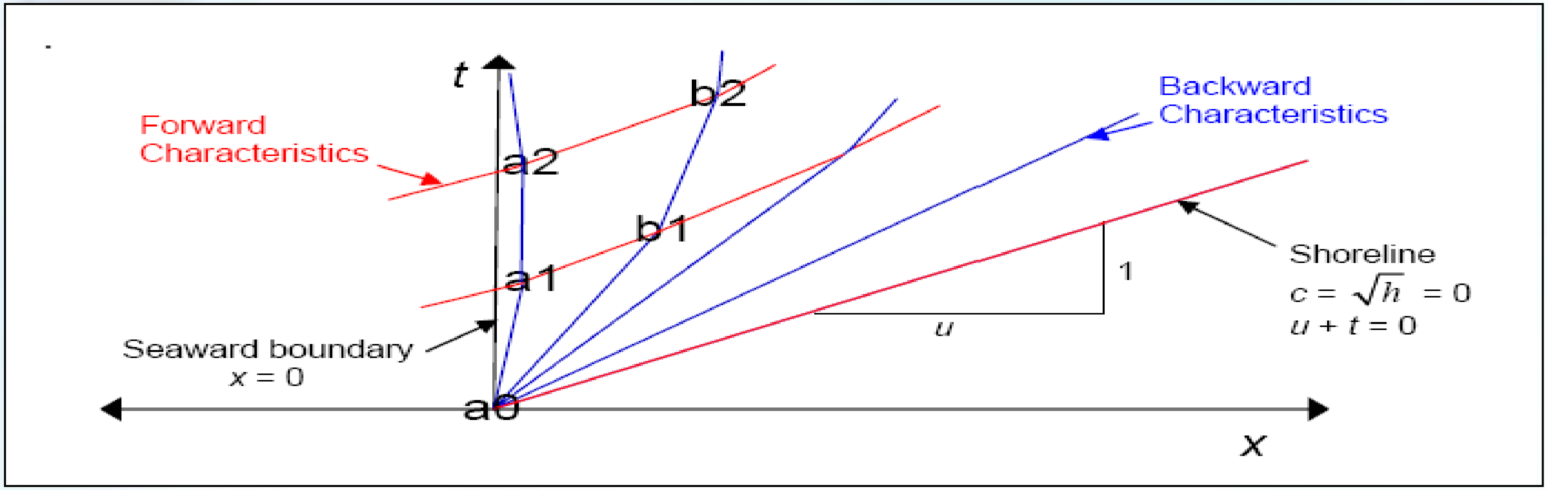
UGM

TOPOGRAPHIC MEASUREMENTS

Junun, Ratih, et.all. 2006

MODELS

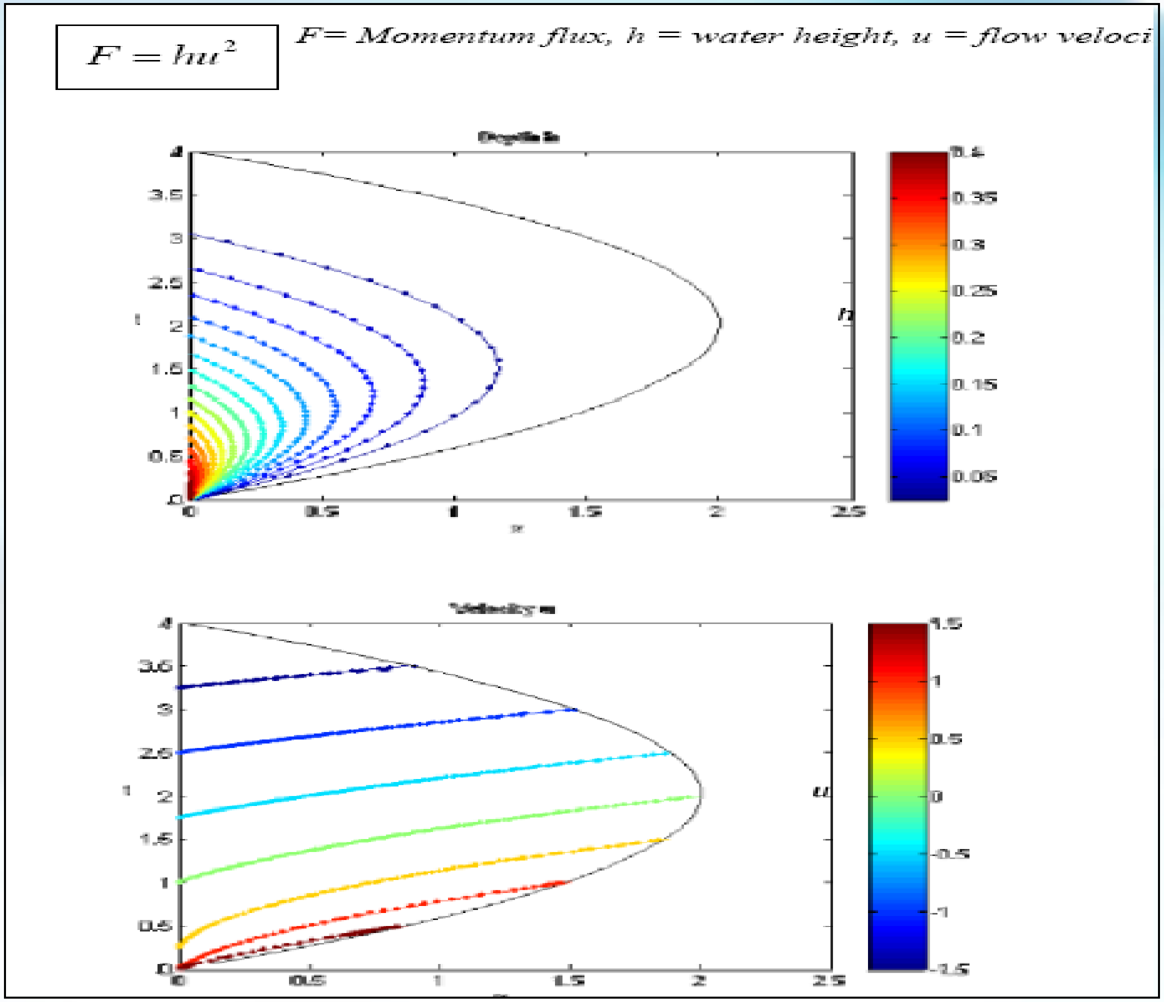




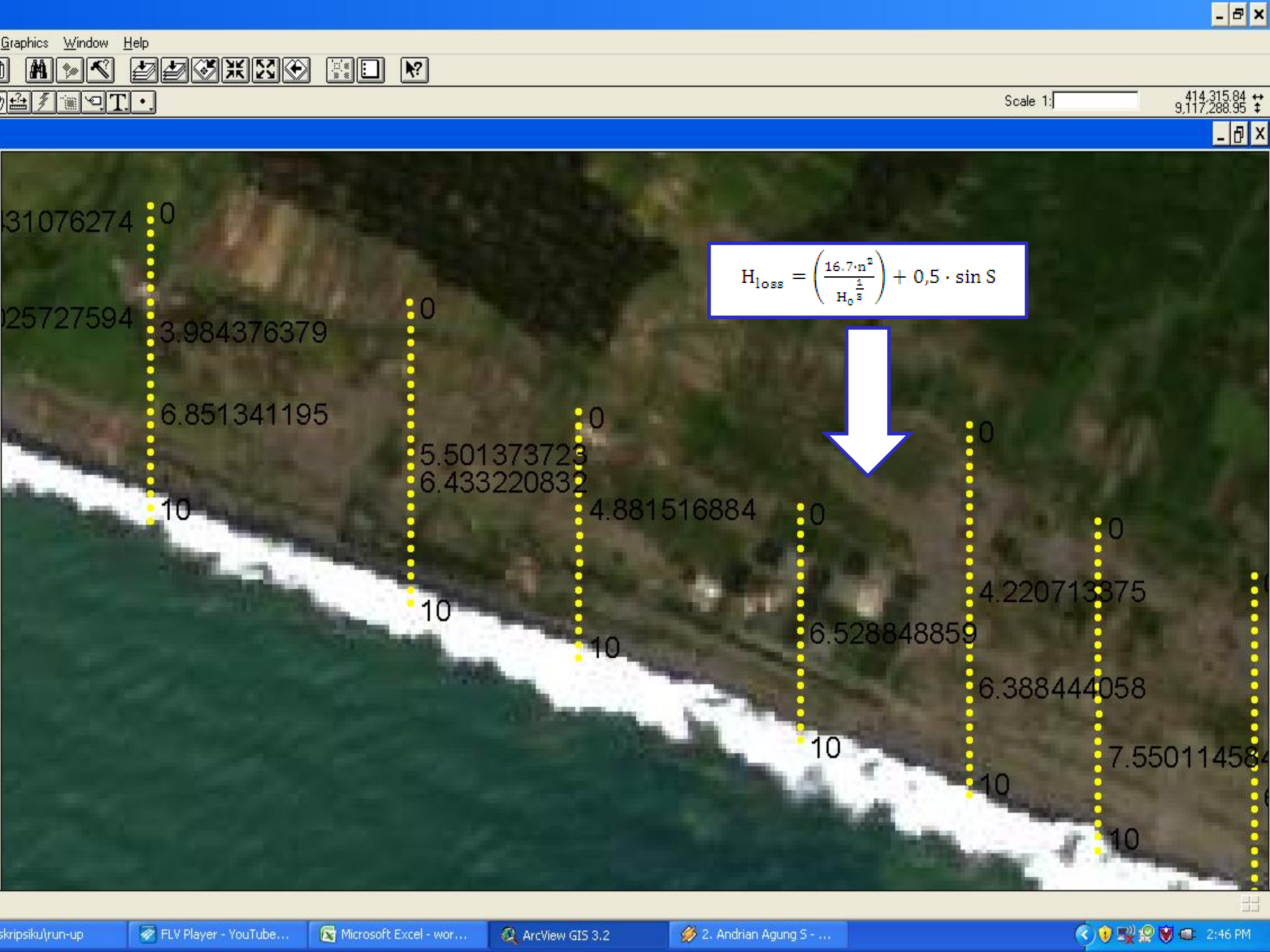
Numerical Model for Tsunami Run-Up (Guard, et.al., 2005)

BATHYMETRIC MEASUREMENTS

MODELS

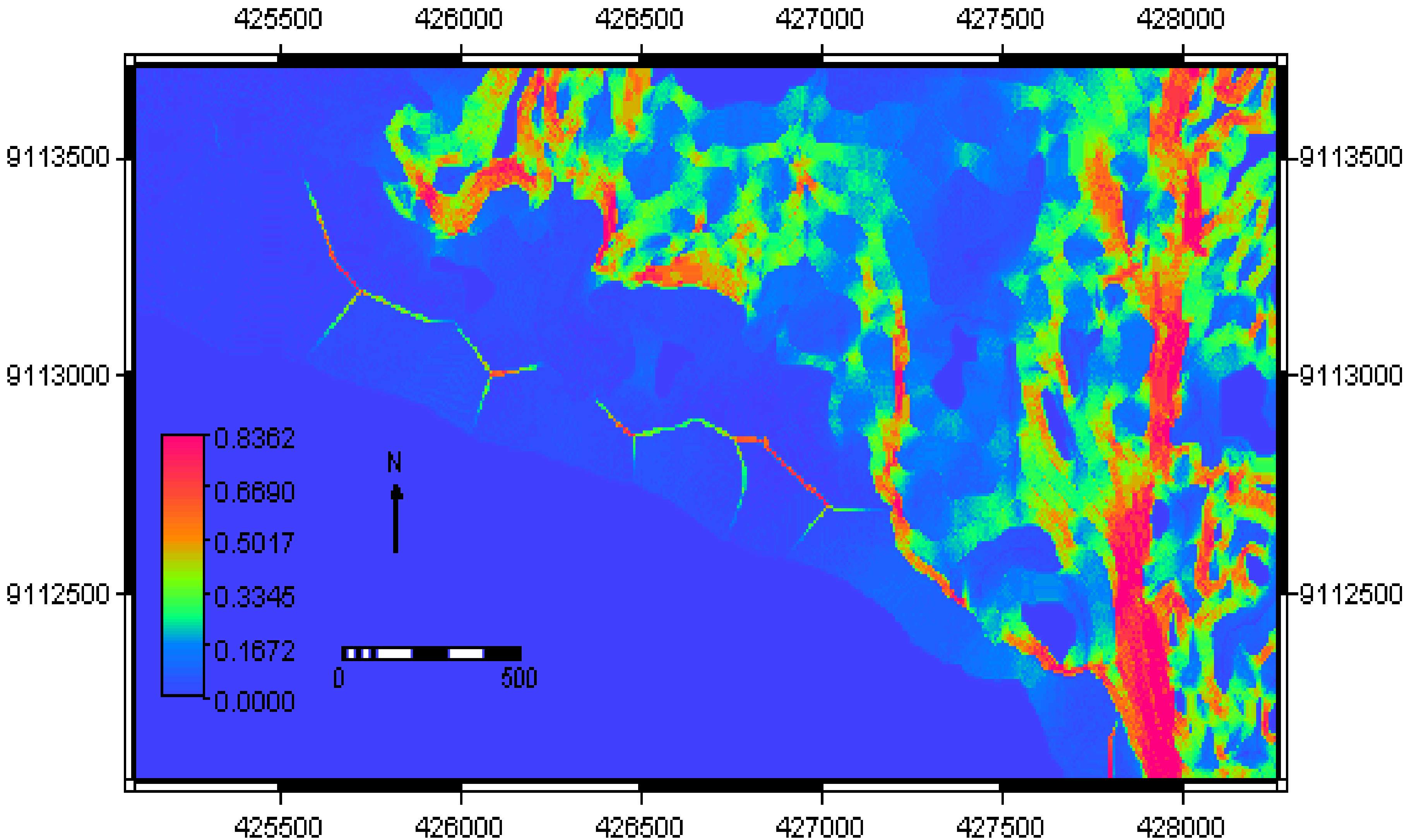


Momentum Flux (Guard, et.al., 2005)



$$H_{loss} = \left(\frac{16.7 \cdot n^2}{H_0^{\frac{1}{3}}}\right) + 0{,}5 \cdot \sin S$$

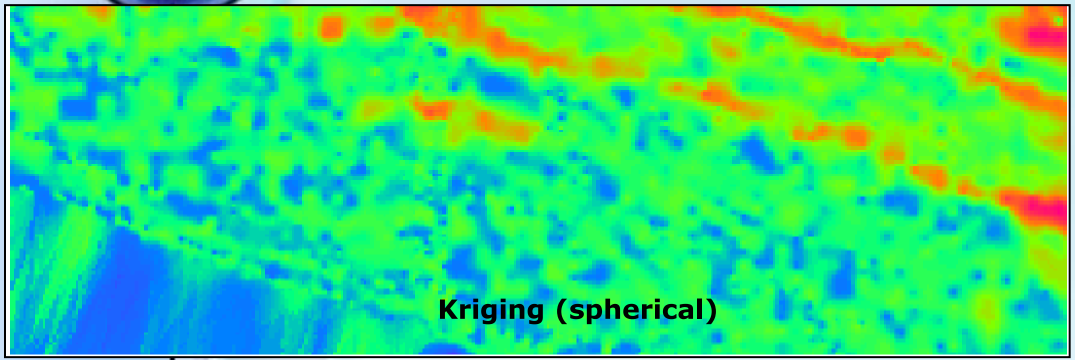
Iteration with Roughness Coefficient
Calculation of wave height reduction in wave height of 5 meters (Overlay between the land use by slope degree)

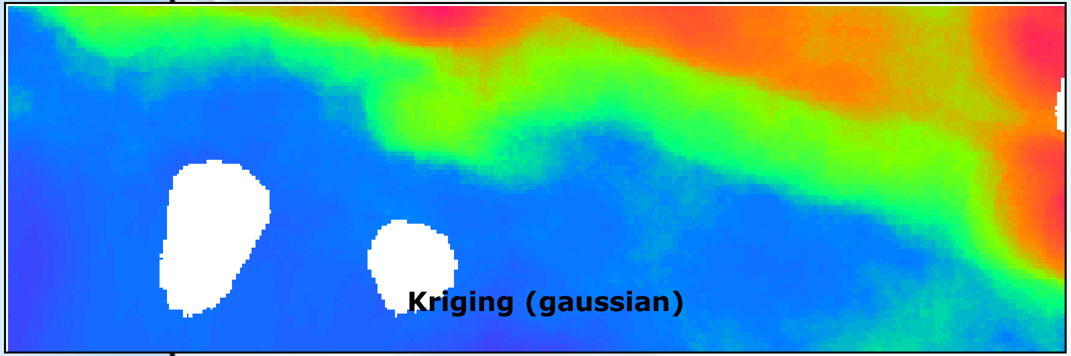


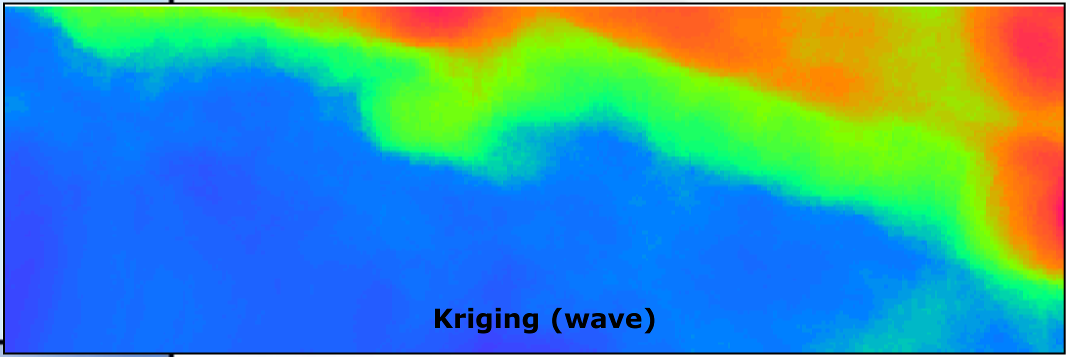
In this research tsunami run-up elevation are independent variable. Since run up elevation are independent variable so the adding data to solve that equation are slope and roughness coefficient form land use map.


Evacuation Zone
(Area 1)
H = 73,75 m

DIGITAL ELEVATION MODEL







To make DEM for this research, there are needed contour to interpolate. Contour interpolation is an operation which first rasterizing contour lines of a segment map with a value domain, and then calculates values for pixels that are not covered by segments by means of a linear interpolation. Furthermore, on the command line, this operation can also use an input raster map.

The test is done to comparing between DEM from SRTM resolution 90x90 M and topographic map in 1: 25,000 scales with contour interval of 12.5 m. Both of them are test by Root Mean Square Error (RMSE) by point that picked in fieldwork by using DGPS Trimble Geo-XT.

Conclusions

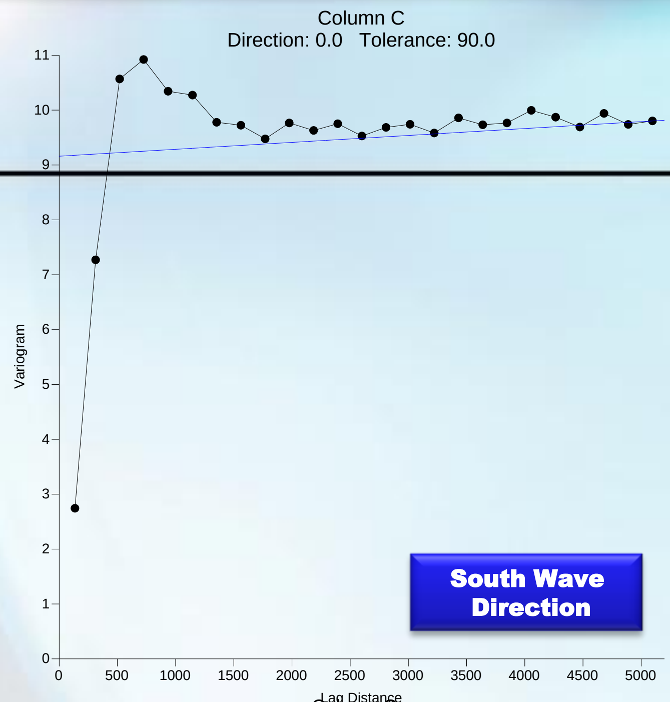
1. Estimates based on the variation of tsunami wave heights can be done with GIS applications. On the application of GIS is losing altitude calculation of wave height of tsunami inundation, that is the mainland shoreline to the study area.

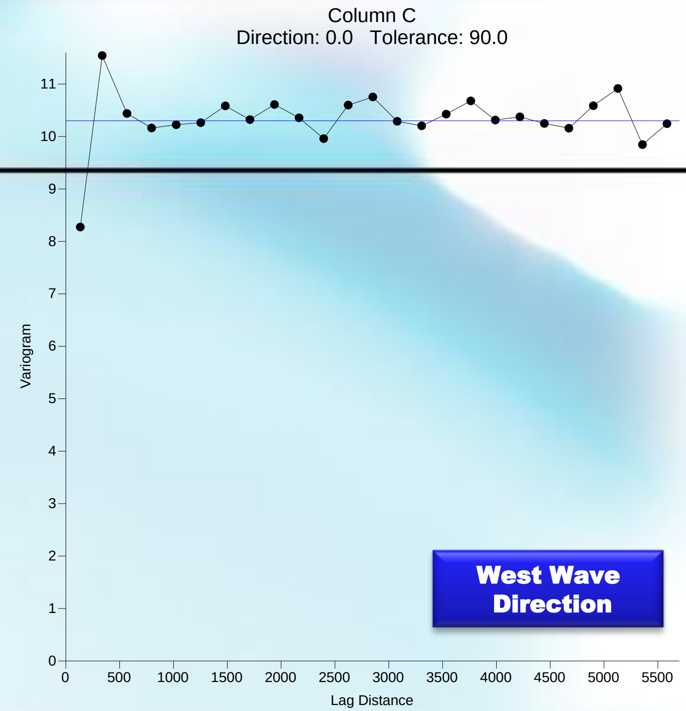
2. Distribution of inundation depends on the direction of the tsunami wave coming, wave height, surface roughness, and slope.

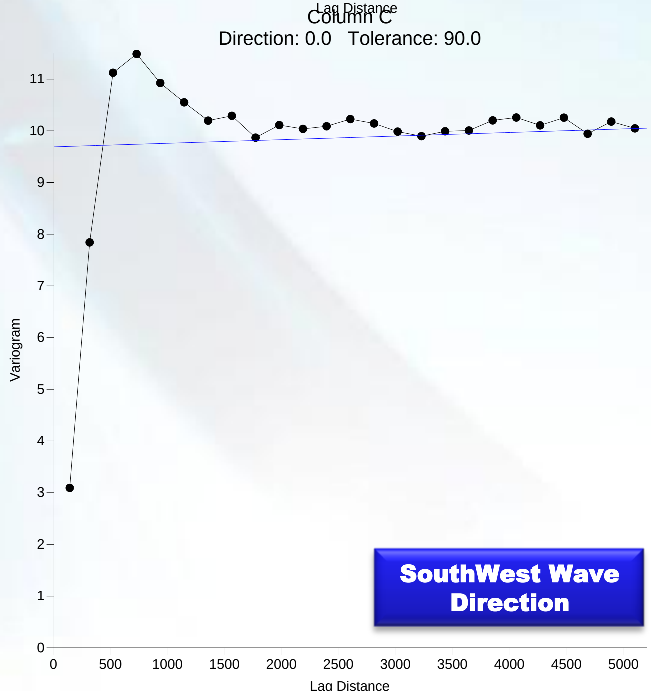
3. Distribution of inundation if the wave height of 30 meters width of 182.745 hectares, if from the west; 422.731 hectares if from the southwest; 402.184 hectares if from the south; and 285.293 hectares if from the southeast.

4. Distribution of inundation if the height of the waves 20 meters width of 129.250 hectares, if from the west; 337.960 hectares if from the southwest; 319.125 hectares if from the south; and 197.976 hectares if from the southeast.

5. Distribution of inundation if the wave height of 10 meters width of 71.927 hectares, if from the west; 197.563 hectares if from the southwest; 190.186 hectares if from the south; and 106.910 hectares if from the southeast.

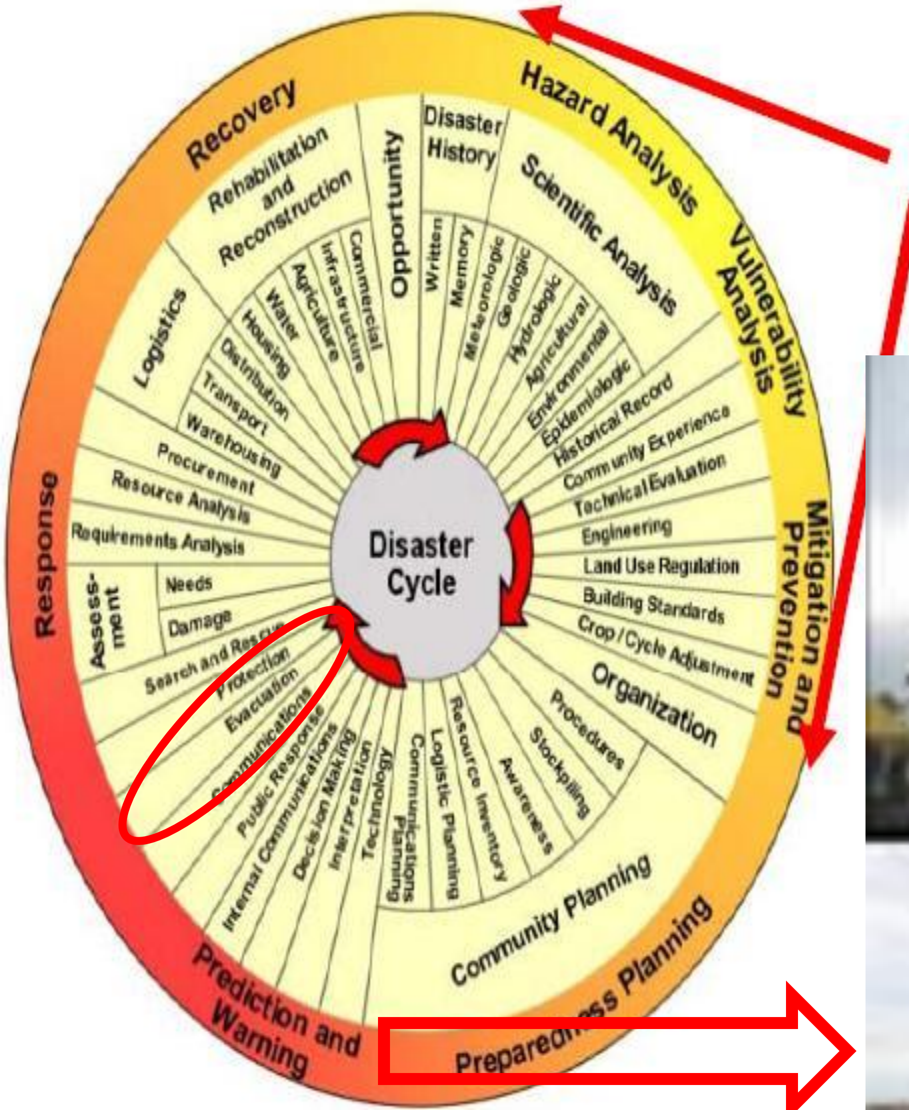






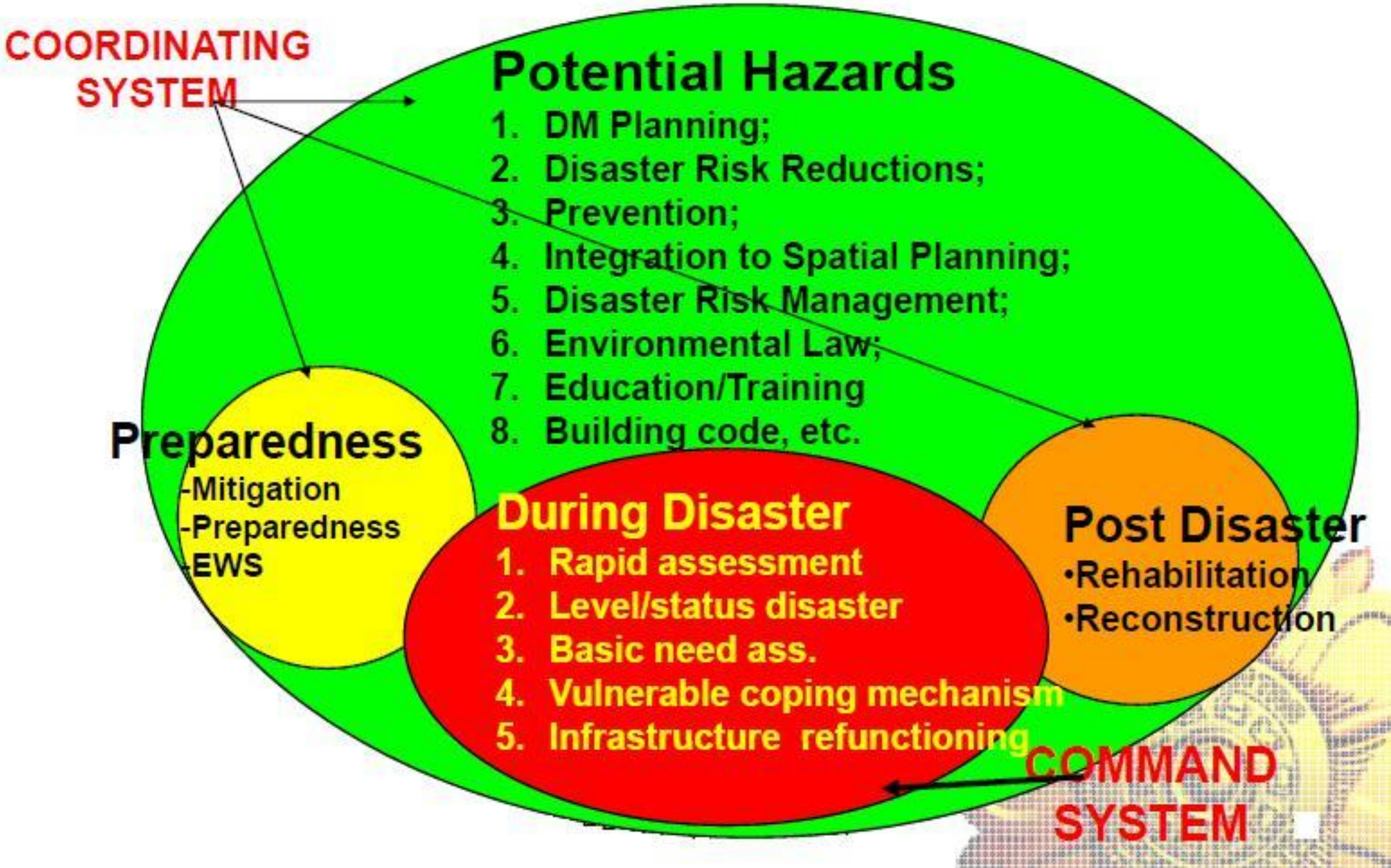
Semivariogram Tsunami Scenario 10 Meters

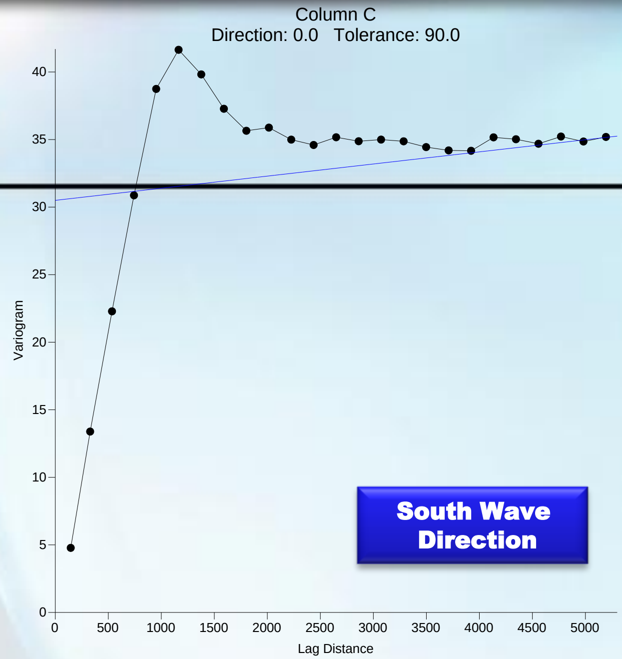
Tsunami Disaster Management

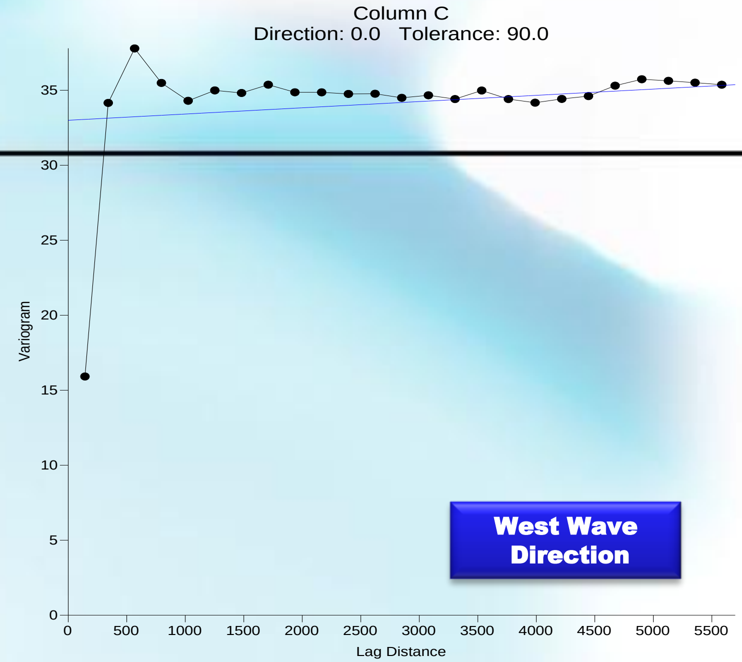


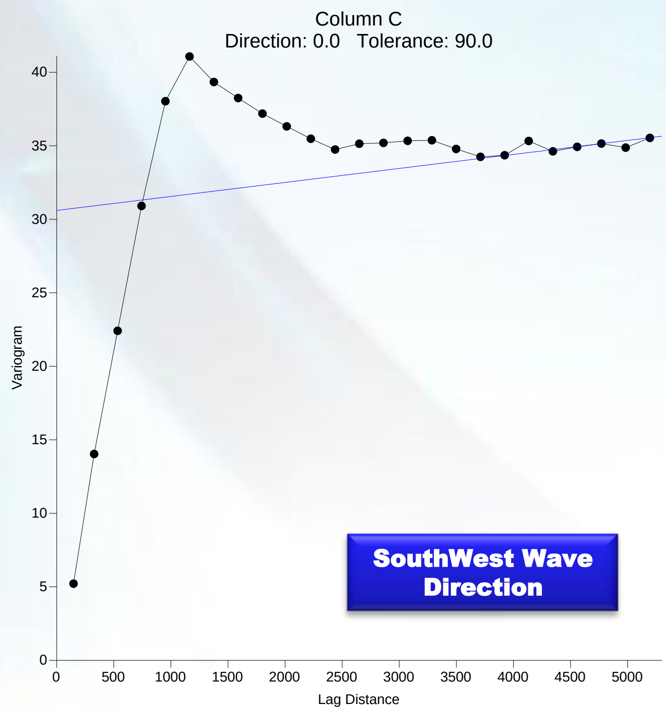
National
DM System

DISASTER MANAGEMENT LAW No. 24/2007

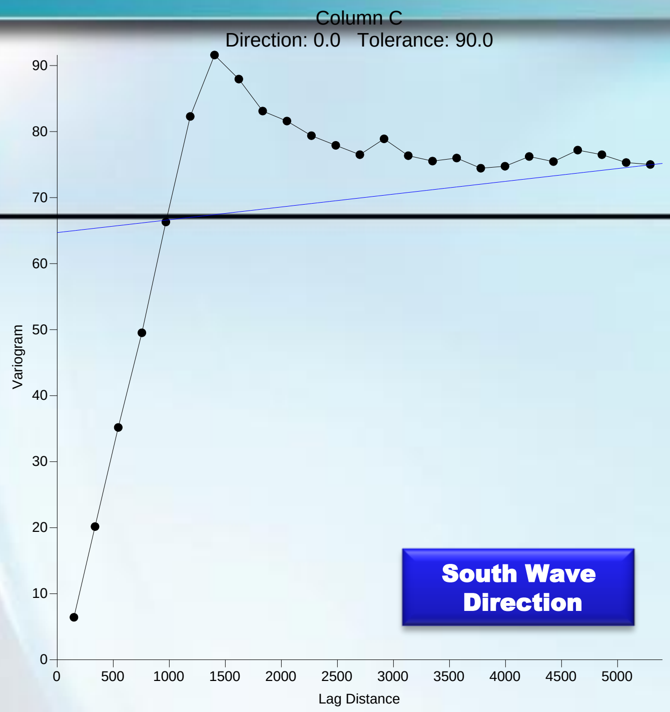


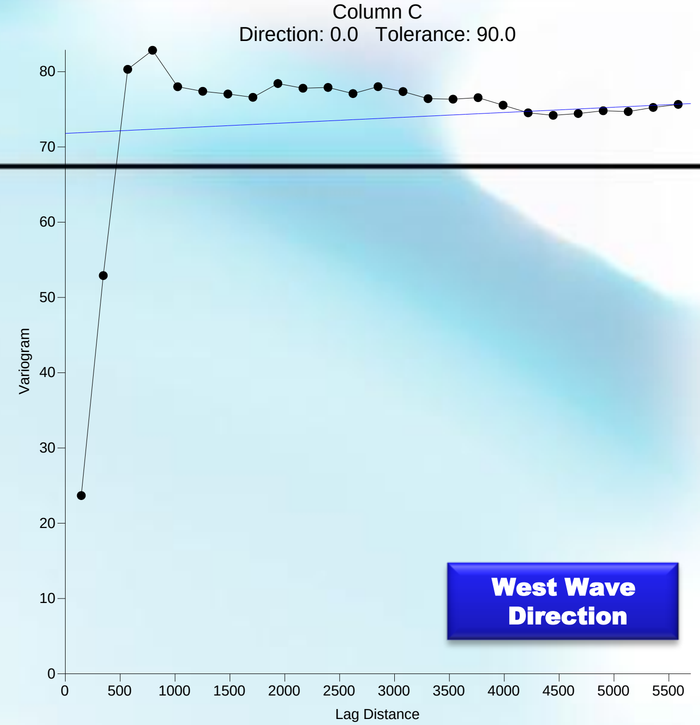


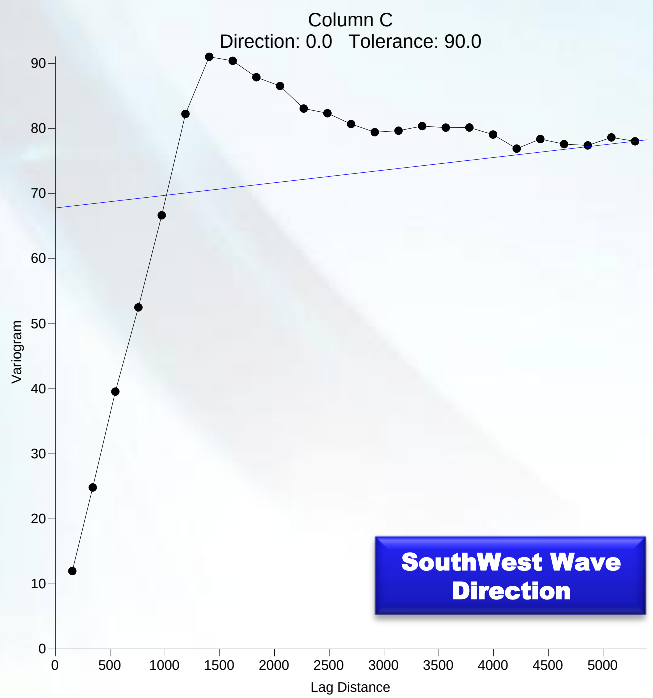




Semivariogram Tsunami Scenario 20 meters

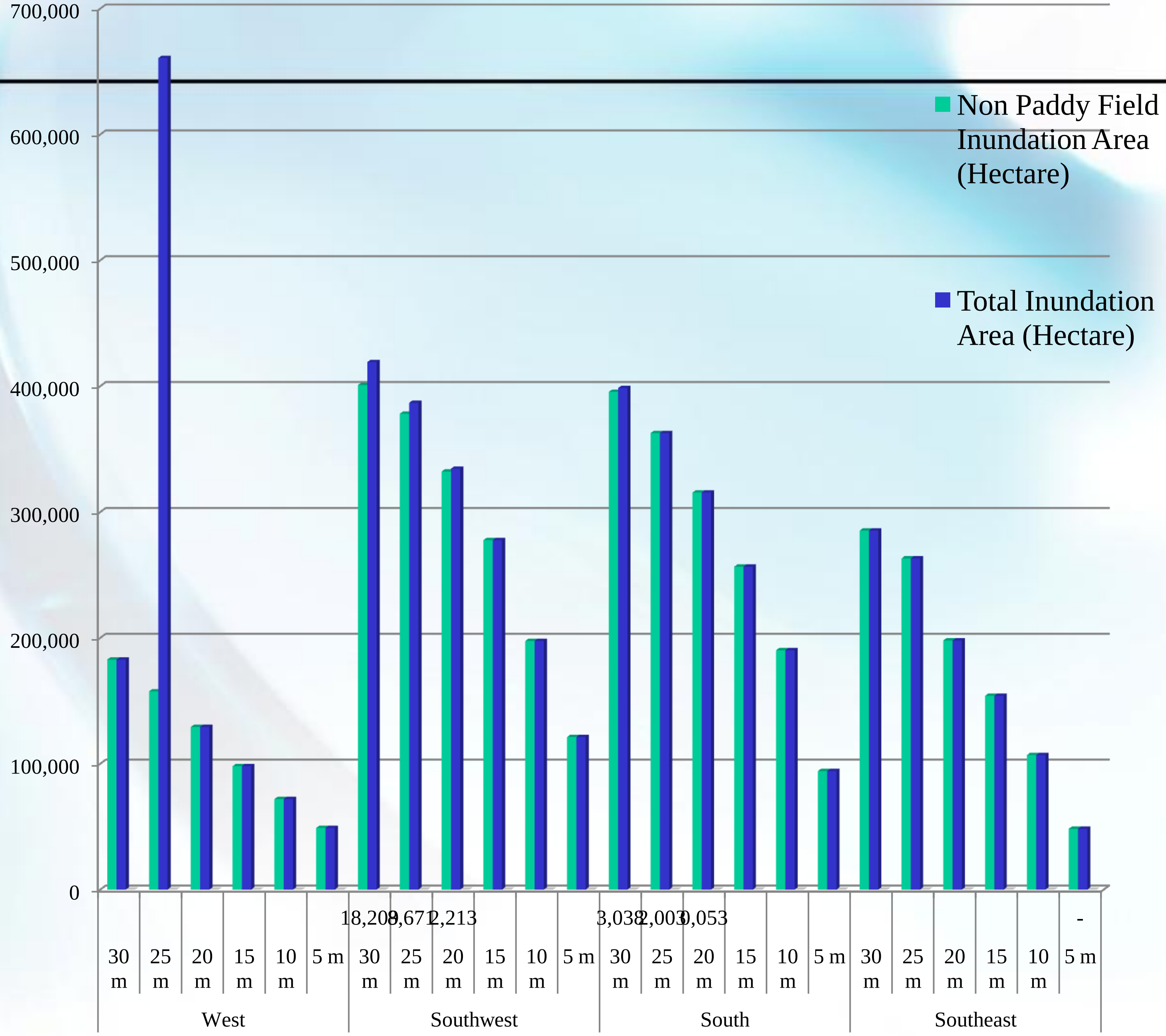


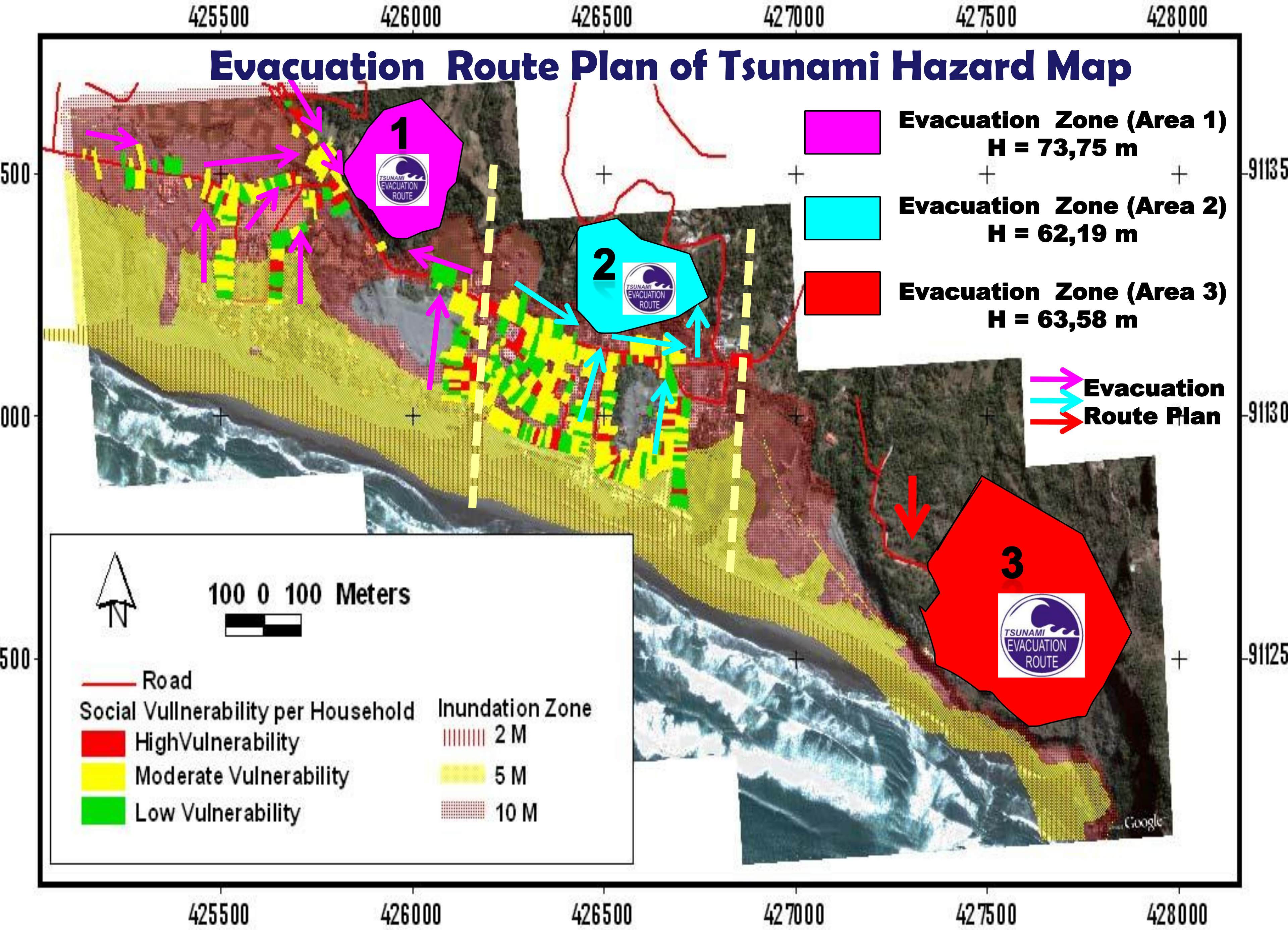




Semivariogram Tsunami Scenario 30 Meters

Tsunami Inundation of Non Paddy Field Area




Evacuation Route Plan of Tsunami Hazard Map
Evacuation Zone (Area 1)
H = 73,75 m
Evacuation Zone (Area 2)
H = 62,19 m
Evacuation Zone (Area 3)
H = 63,58 m
Evacuation
Route Plan
1
2
3
TSUNAMI EVACUATION ROUTE
N
100 0 100 Meters
Road
Social Vullnerability per Household
HighVulnerability
Moderate Vulnerability
Low Vulnerability
Inundation Zone
2 M
5 M
10 M
425500
426000
426500
427000
427500
428000
Google


Evacuation Zone (Area 1)
H = 73,75 m


Evacuation Zone (Area 2)
H = 62,19 m


Evacuation Zone (Area 3)
H = 63,58 mdpal
Settlement

Recommendations for Tsunami Disaster Mitigation

Mitigation and preparedness are important to society both practically (to organizations and the emergency management community) and theoretically (to the academic community).

First, mitigation and preparedness can make it easier for organizations to survive disasters by providing opportunities to lessen their severity. For example, before an earthquake and tsunami, it is possible to institute building codes that will help to strengthen buildings. Once an earthquake and tsunami occurs, it will be too late to carry out this measure.

Recommendations for Tsunami Disaster Mitigation

- **Second**, if organizations have mitigation and preparedness strategies in place, they are likely to be less reliant on emergency responders, thus freeing up resources for other purposes. It is important to emphasize here that effective mitigation and preparedness programs and policies for disasters do not preclude the need for emergency responders.

- **Third**, mitigation and preparedness can help to lay a solid foundation for effective disaster response and serve as a first step in understanding recovery in organizations. For instance, mitigation and preparedness can assist researchers in understanding why some organizations fail and others survive disasters.

Recommendations for Preparedness of Tsunami Disaster

- **Go to high ground, at least 15 m (50 ft) above sea level. If we are unable to get to high ground, go inland away from the ocean as far as possible. If you are unable to evacuate but are near a multi-story, reinforced concrete building, go to the third floor or higher. If you need assistance evacuating, tie a large white sheet or towel to the front door knob to notify officials that you need help. Tsunami evacuation maps for Parangtritis communities indicate the safest evacuation routes and assembly areas.**

Tsunami Disaster Management Planning

- **Bantul Local government cooperation with Yogyakarta Central Government has been install siren systems in Parangtritis area where the vulnerable area of tsunami. Those completed systems are: 6 Public addresses, 1 tower, 1 amplifier and 1 receiver. This system install in 8 different locations with connecting in a repeater which place in hilly then correlate with active system in Head of local government Bantul.**

- **This system is based on radio analogue technology with FM wave. The other advantages of this system beside give siren for evacuation are also give information what the kind of earthquake which can trigger a tsunami**

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Evacuation Route Plan

- An emergency evacuation place on the way to a hill top is effective for saving lives. The height of the place should be higher than the expected tsunami. In case of tsunami at midnight, it will be much more dangerous for the villagers to evacuate, because of the complete darkness without electricity, so indications to let them know the evacuation route should be considered. For successful evacuation, therefore higher evacuation places than the expected tsunami should be set in and/or near residential areas.

- There are two alternative paths disaster evacuation for this area, evacuation path to the Yogyakarta city and evacuation path to the mountain area on the east side of area which is the more save zone from the tsunami disaster. The city area can be reach by the roadway.

- Meanwhile the mountain side can be reach by road way and the footpath which is well known by local people

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