Disaster Risk Reduction for Natural Hazards:

Putting Research into Practice

November 4th-6th 2009 at University College London

TSUNAMI HAZARD MAPPING AND RISK ASSESSMENT FOR THE CITY OF PADANG / WEST SUMATRA

by: N. Goseberg and T. Schlurmann

(DFG/BMBF Förderkennzeichen: 03G0666A-H)
www.last-mile-evacuation.de

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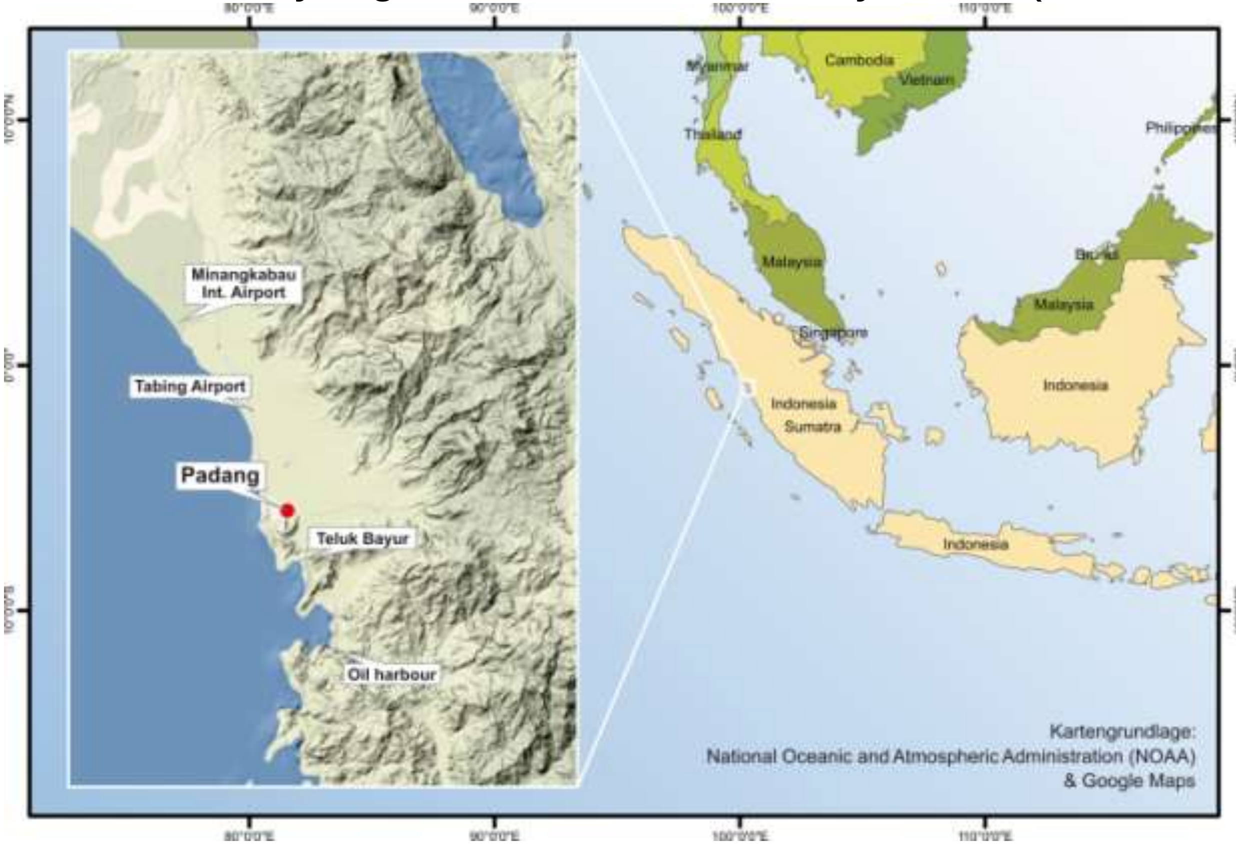
Brief outline of presentation

1. Background & Motivation
2. Project Organization
   - (Geo)Data collection and household survey
   - Methodological approach (transdisciplinary collaboration)
3. Preliminary findings
4. Disaster Management in consequence of Sept. 2009 quake
5. Summary and Outlook -> Urgent demands for DRR in Padang

Facts about Padang, West Sumatra, Indonesia

- Approximately **900.000 inhabitants**, Low-lying coastal region (<10m)
- Net of **urban waterways**, Major historical tsunamis 1797: 9m and 1833: 6m
- **Seismically "locked" area**, likelihood of earthquake and subsequent tsunamis is extremely high in near future: 5-10 years?! (i.e. McCloskey et al., UCL-DRR)



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Motivation and major research objectives

- Assess characteristic **tsunami inundation dynamics** for urban agglomeration (Padang) on micro-scale temporal and spatial resolution based on newly derived geodata-basis and credible future earthquake scenarios
- Determine socio-economic **hotspots of vulnerability** (special assistance) and assess disaster preparedness (determine: "evacuation readiness")
- Outline best **evacuation routes** (optimize) and detect time-dependent **bottlenecks**
- Determination of **safe areas** in Padang and assist authorities in DRR

- Improve **decentralized, vertical evacuation** and develop **tsunami proof shelters**
- **Initiate spatial planning processes** (ICZM) to minimize tsunami disaster risk in Padang by means of **Capacity Building**, i.e. individuals and institutions
- Communicate with stakeholders and **assist to transfer and implement DRR methods/strategies** within other coastal communities in the region

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Project Organization

- Project duration: May 2007 – Apr 2010, Financial volume: approx. 1.3 Mio. €

WP: Hazard – inundation and flow analysis

FRANZIUS-INSTITUT für Wasserbau und Küsteningenieurwesen

N. Goseberg, T. Schlurmann, LUH, Franzius-Institute, Coastal Engineering

WP: Remote sensing aspects

H. Taubenböck, G. Strunz and S. Dech, University Würzburg, Remote Sensing

WP: Socio–economic vulnerability

N. Setiadi, J. Birkmann, UNU-EHS, Spatial Planning and Vulnerability Assessment

WP: Evacuation Analysis and Traffic Optimization

G. Lämmel, K. Nagel, TU Berlin, Traffic and Congestion Modelling

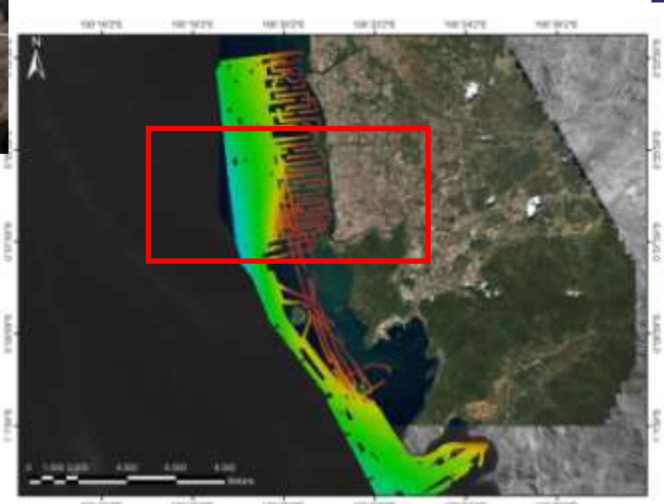
WP: Visualization 3D-model of Padang

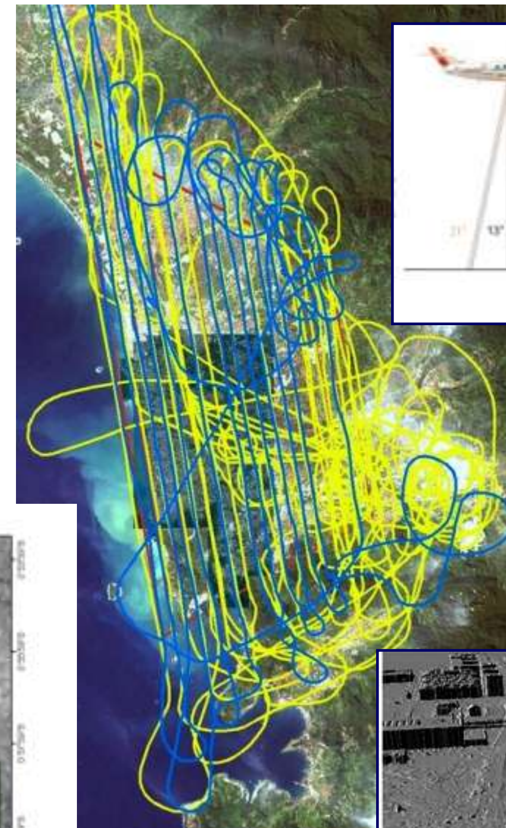
F. Moder, F. Lehmann and F. Siegert, DLR and RSS GmbH (SME)

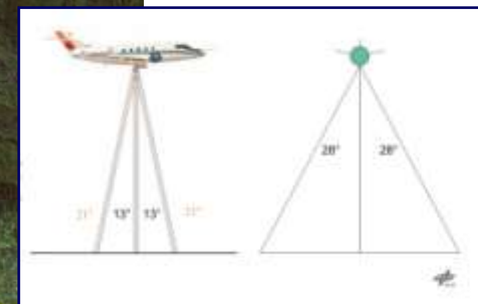
Project Organization – (Geo)data collection and HH-survey

- Multibeam echosoundings (bathymetry), Airborne HRSC (topography & terrain)

Bathymetrical Survey
3x3m spatial res.



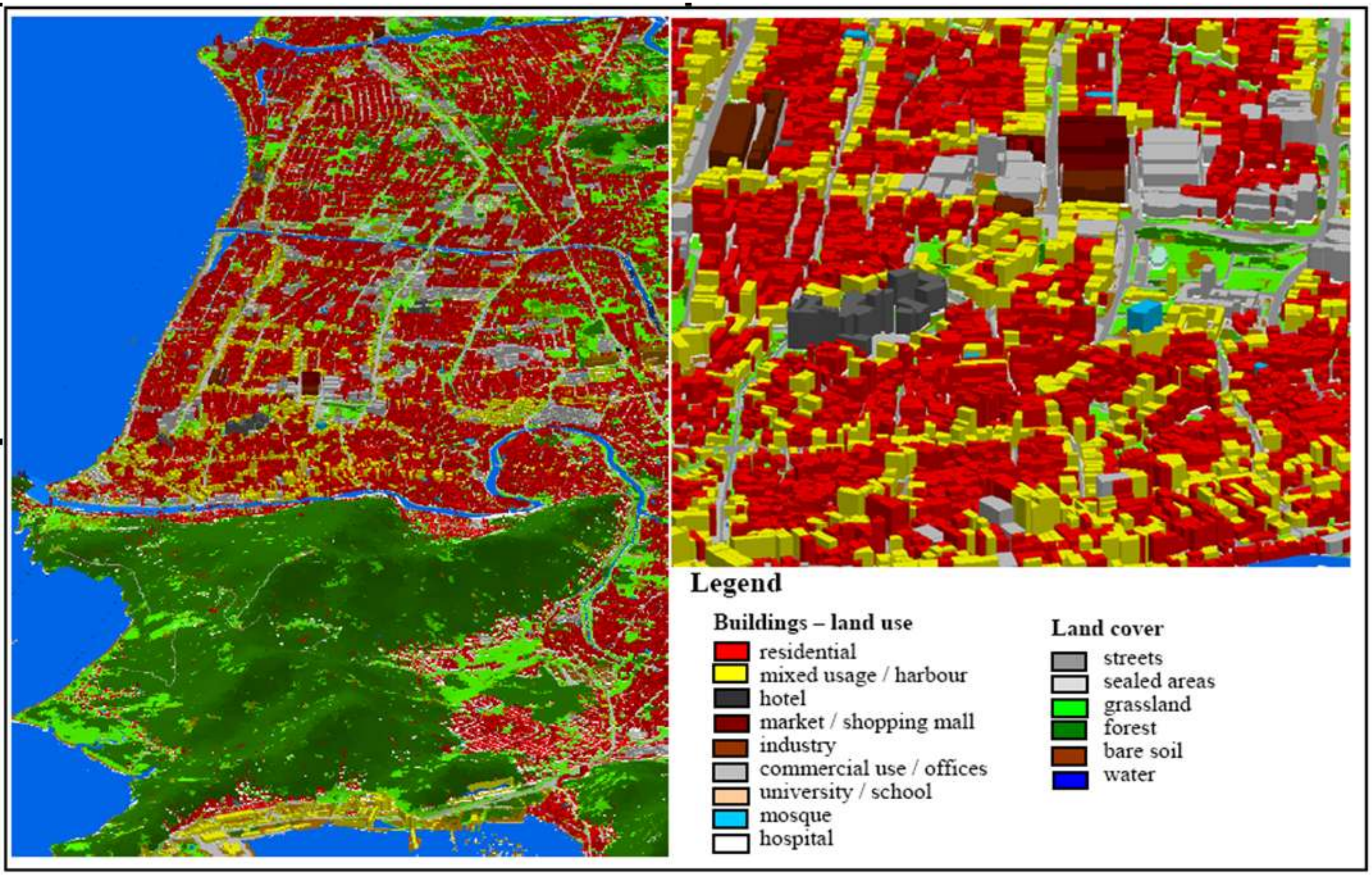




Flight campaign
20x20cm sp. res.
+/- 40cm abs. vert. resolution

Project Organization – (Geo)data collection and HH-survey

- Geodatabase derived from satelite images and (physical) vulnerability indicators



Project Organization – (Geo)data collection and HH-survey

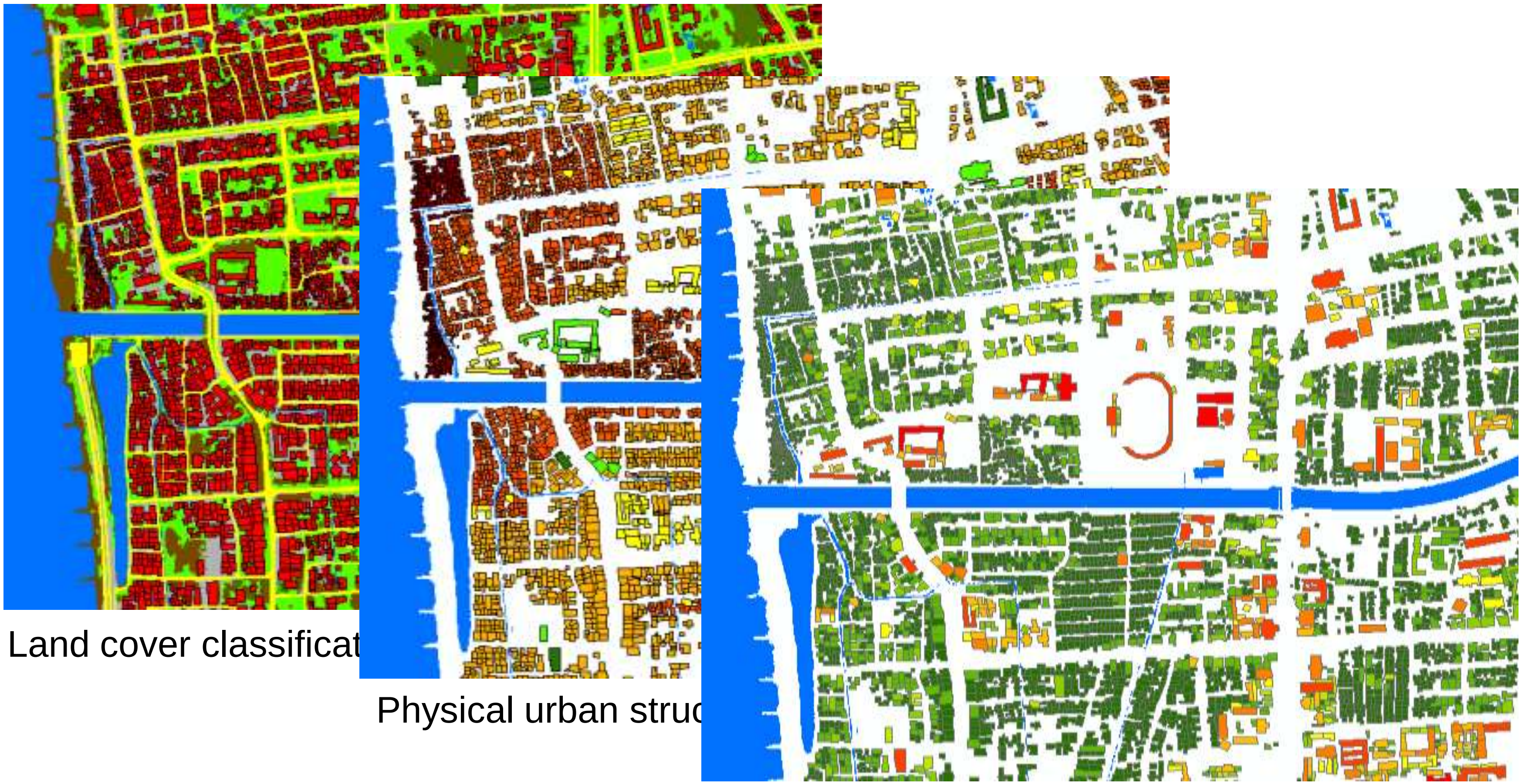
- Household survey (Sample size 1000 HH) - Collection and evaluation of existing statistical data questionnaire-based survey, in co-operation with UNAND

VULNERABILITY

BBC framework categories	Warning and response phases	Thematic areas for indicator development	Potential indicators
Exposure	Warning decision	Exposed People	Indicators
		Exposed critical infrastrctures	Indicators
Susceptibility	Warning dissemination	Receiving the warning	Indicators
		Understanding the warning	Indicators
Coping Capacity	Evacuation	Decision to evacuate	Indicators
	Evacuation	Capability to evacuate	Indicators

Project Organization - Methodological approach (Collaboration)

- Land-cover and land-use classification, determination of mobility/activity patterns



Land cover classificat

Physical urban struc

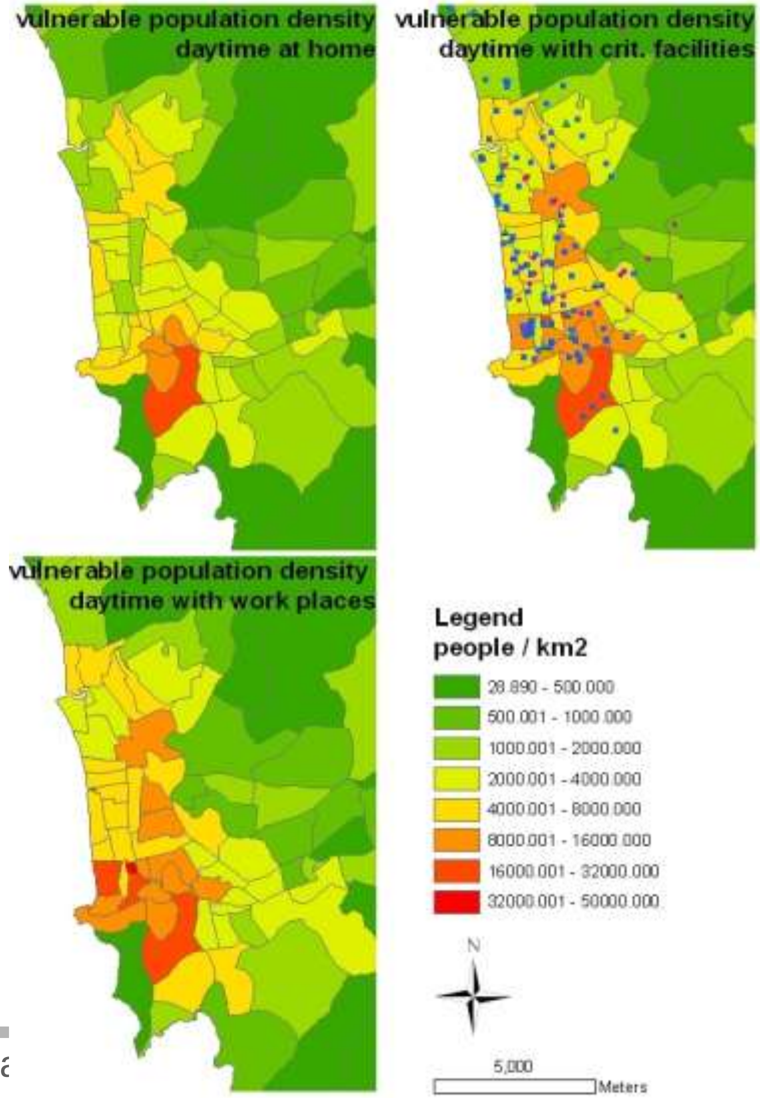
Population density function of time

Project Organization - Methodological approach (Collaboration)

- Dynamic Exposure & Vulnerability Map

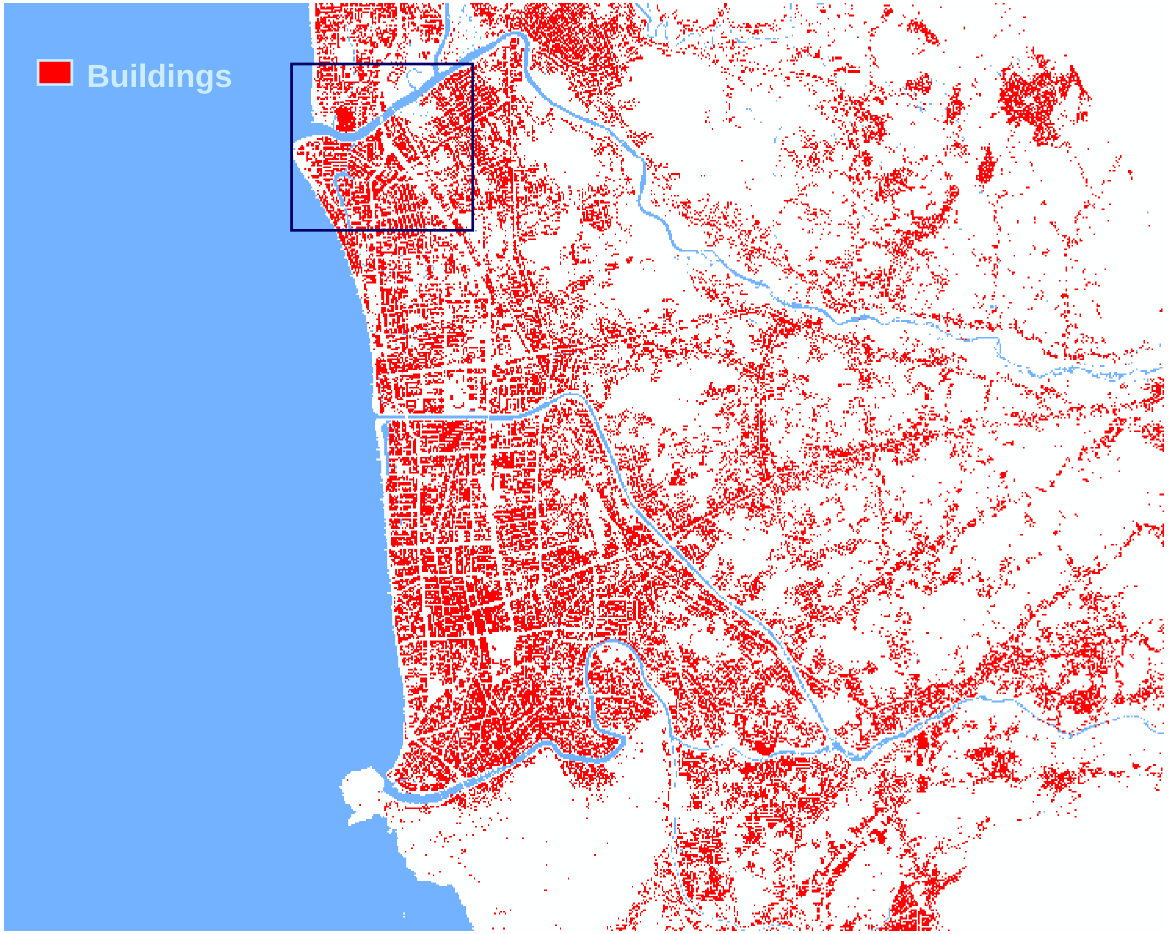
Precise **assessment of vulnerable population** through identification of main activities and mobility of the working activity (census & HH survey):

- Spatial distribution of **demographic groups** (gender, age, education, etc.)
- Household **income** and poverty status
- **Critical infrastructure** and facilities
- **Time-dependent, spatial distribution** of working places & settlement areas



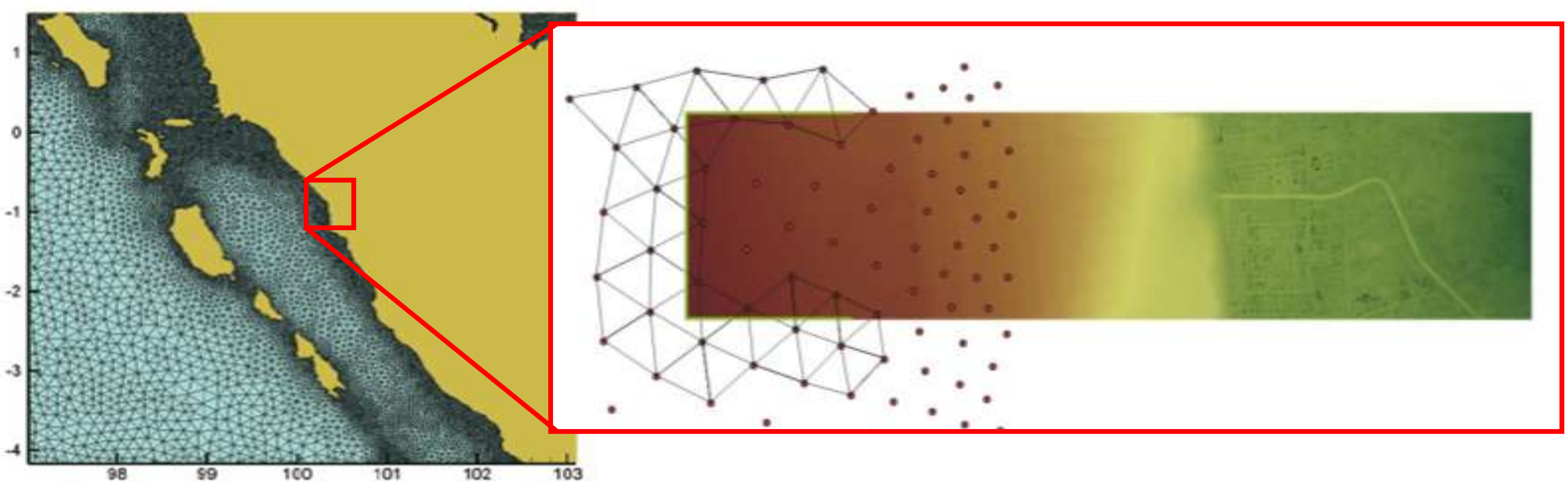
Project Organization - Methodological approach (Collaboration)

- Idea of „semantic classification“ – Interrelation between complex urban morphology and the socio-economic characteristics of residents in Padang



Project Organization - Methodological approach (Collaboration)

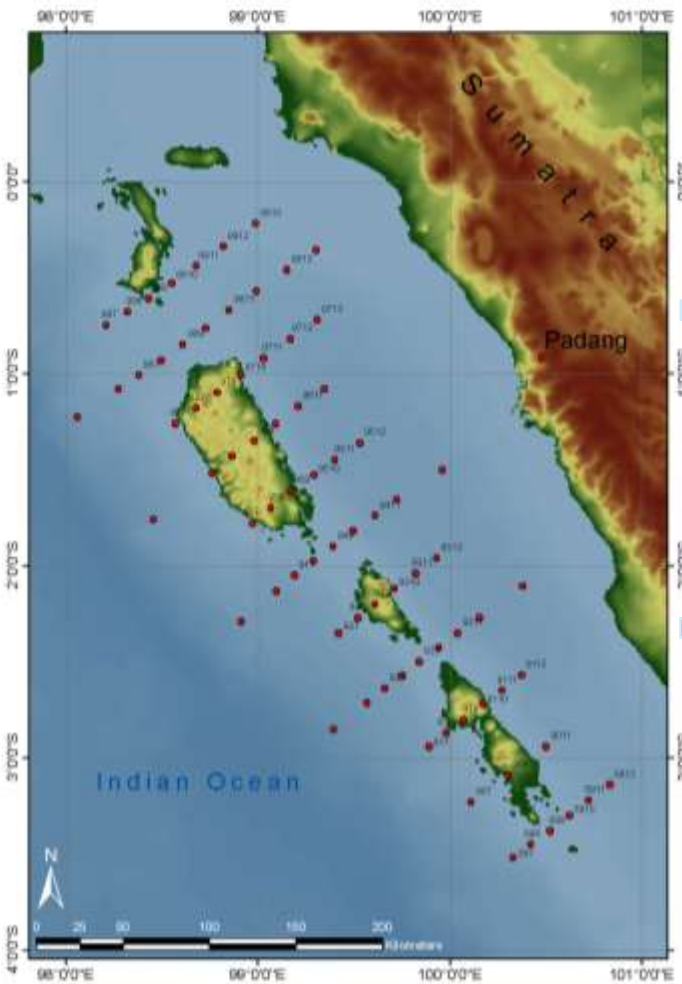
- Hydronumerical modelling - Coupling ANUGA with TsunAWI **(<u>later</u> w/ Hilman et al.)**

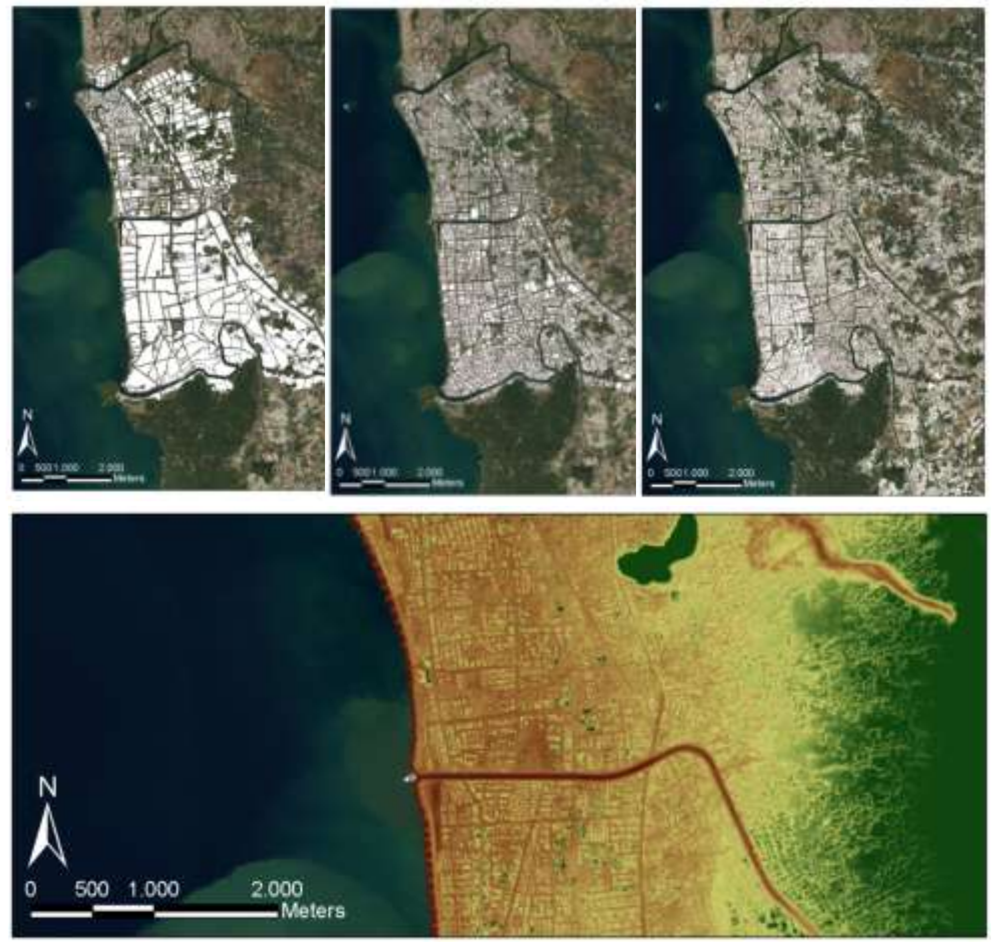


- TsunAWI
  - NLSW equation, source generation (RuptGen)
  - FE-method on unstructured meshes
- ANUGA
  - NLSW equation, on land flow
  - FV-method, unstructured triang. cells
  - Open Source, wetting/drying, captures hydraulic jumps, MPI-implementation

Project Organization - Methodological approach (Collaboration)

- Multi-scenario approach (GITEWS), footprint of houses, structures and vegetation





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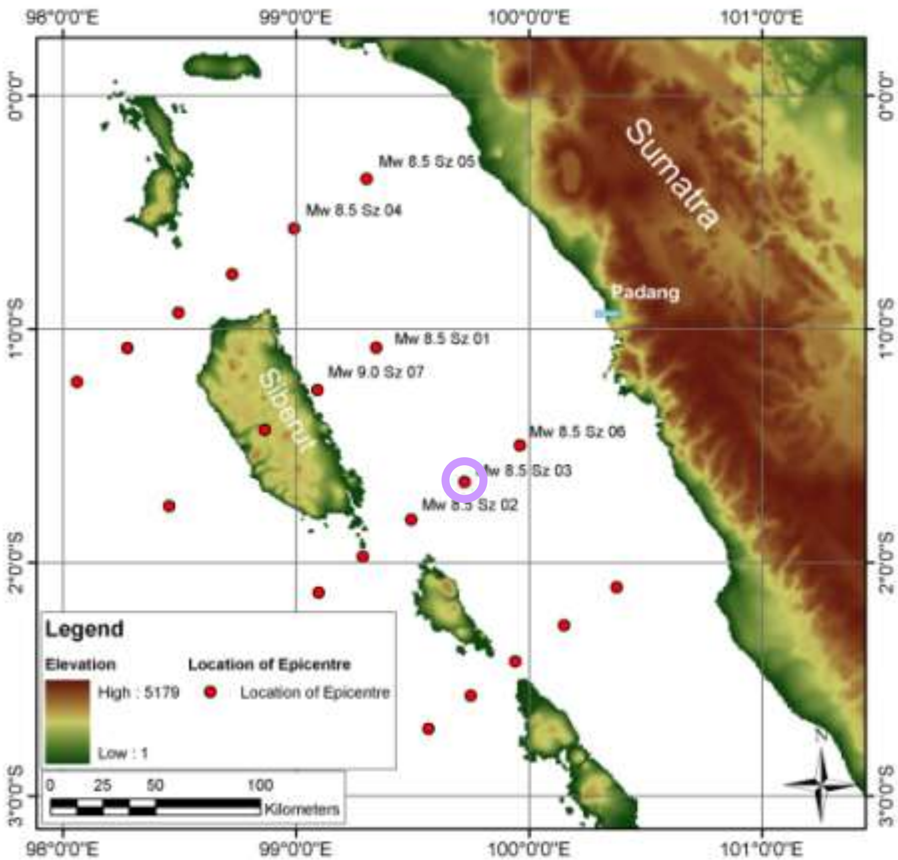
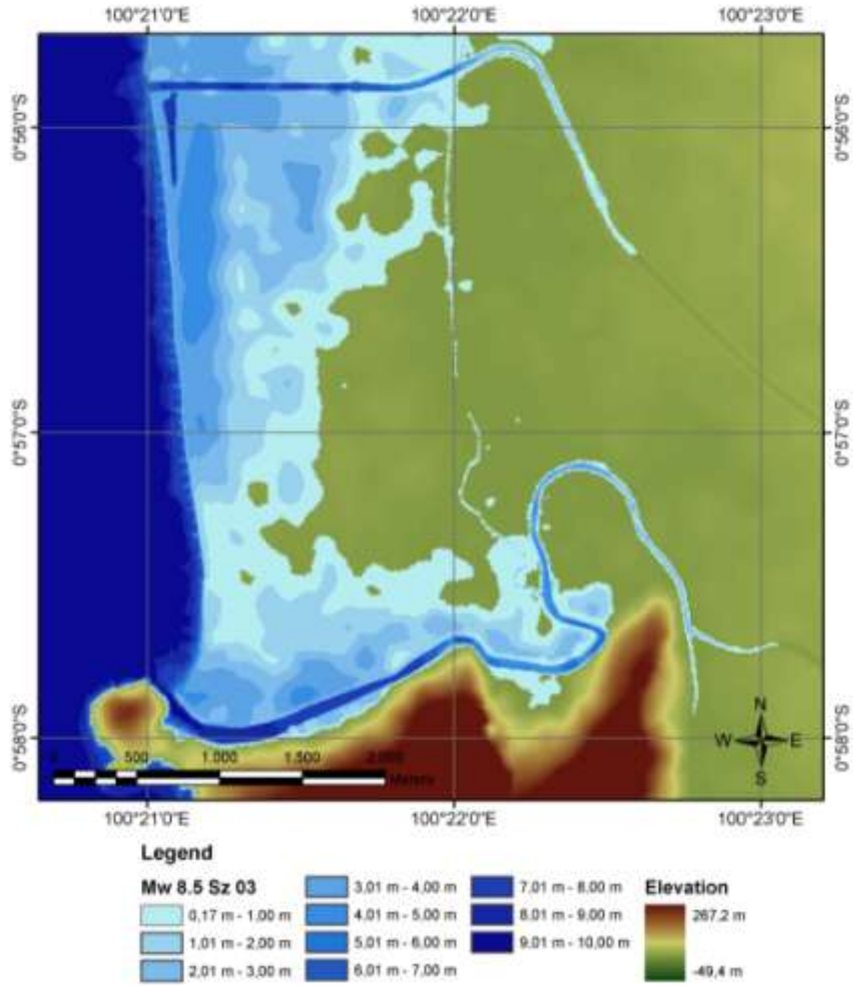
Preliminary findings

- **Sensitivity study I**: Maximum inundation scenario Mw 8.5, Sz 03





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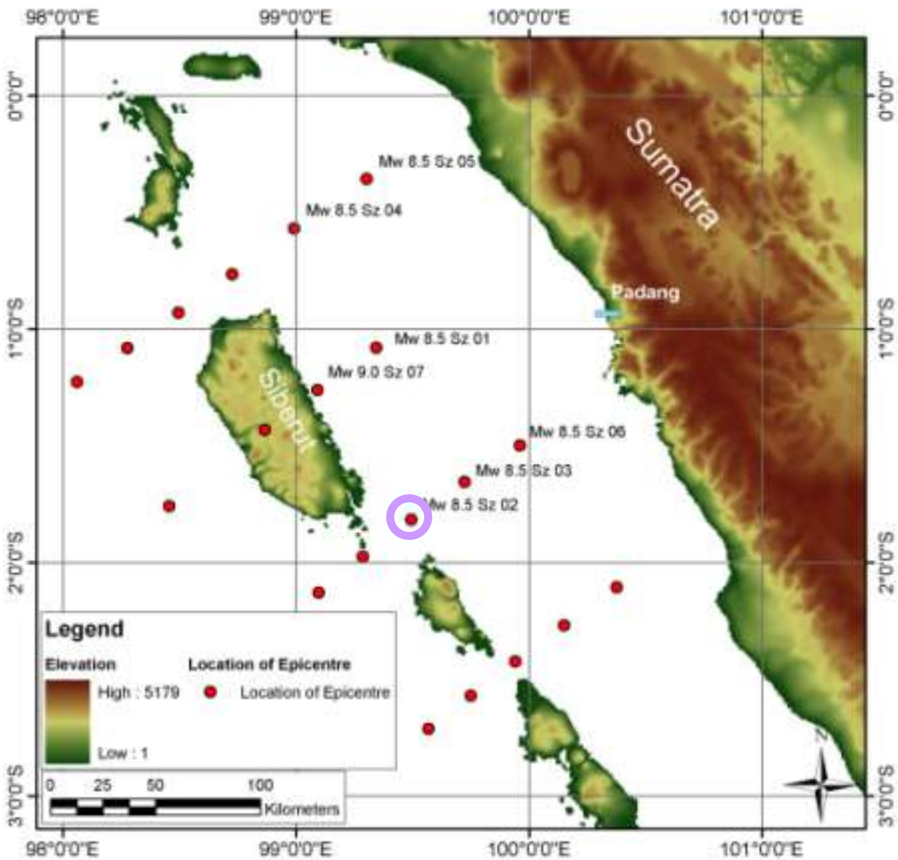
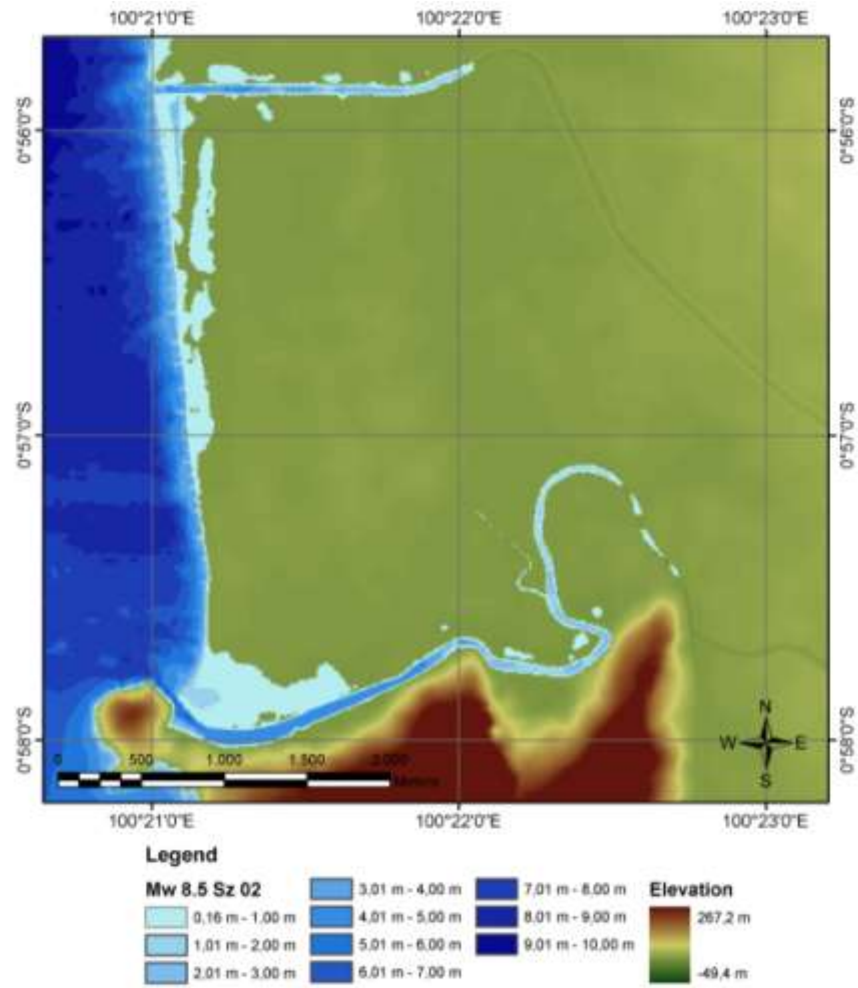
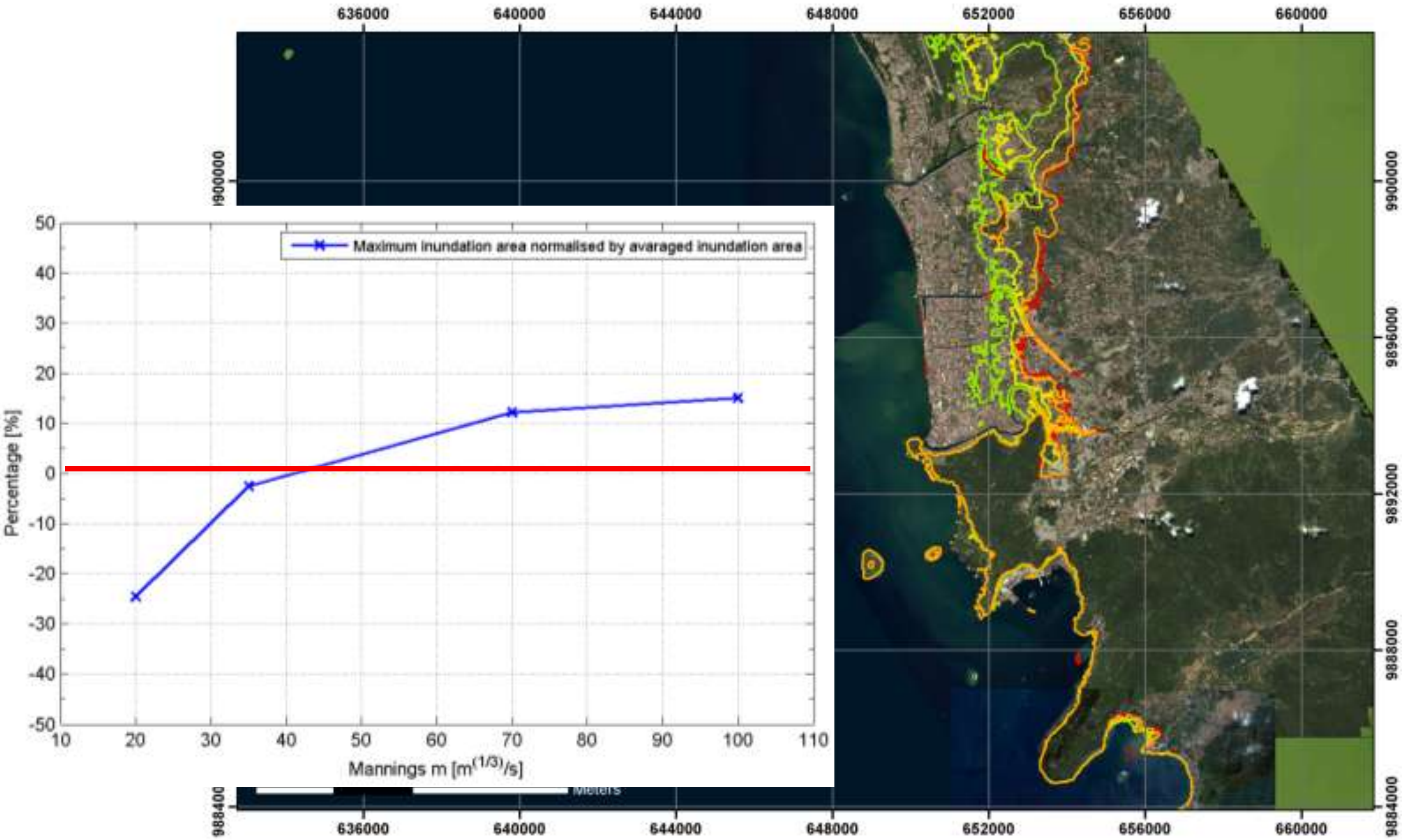




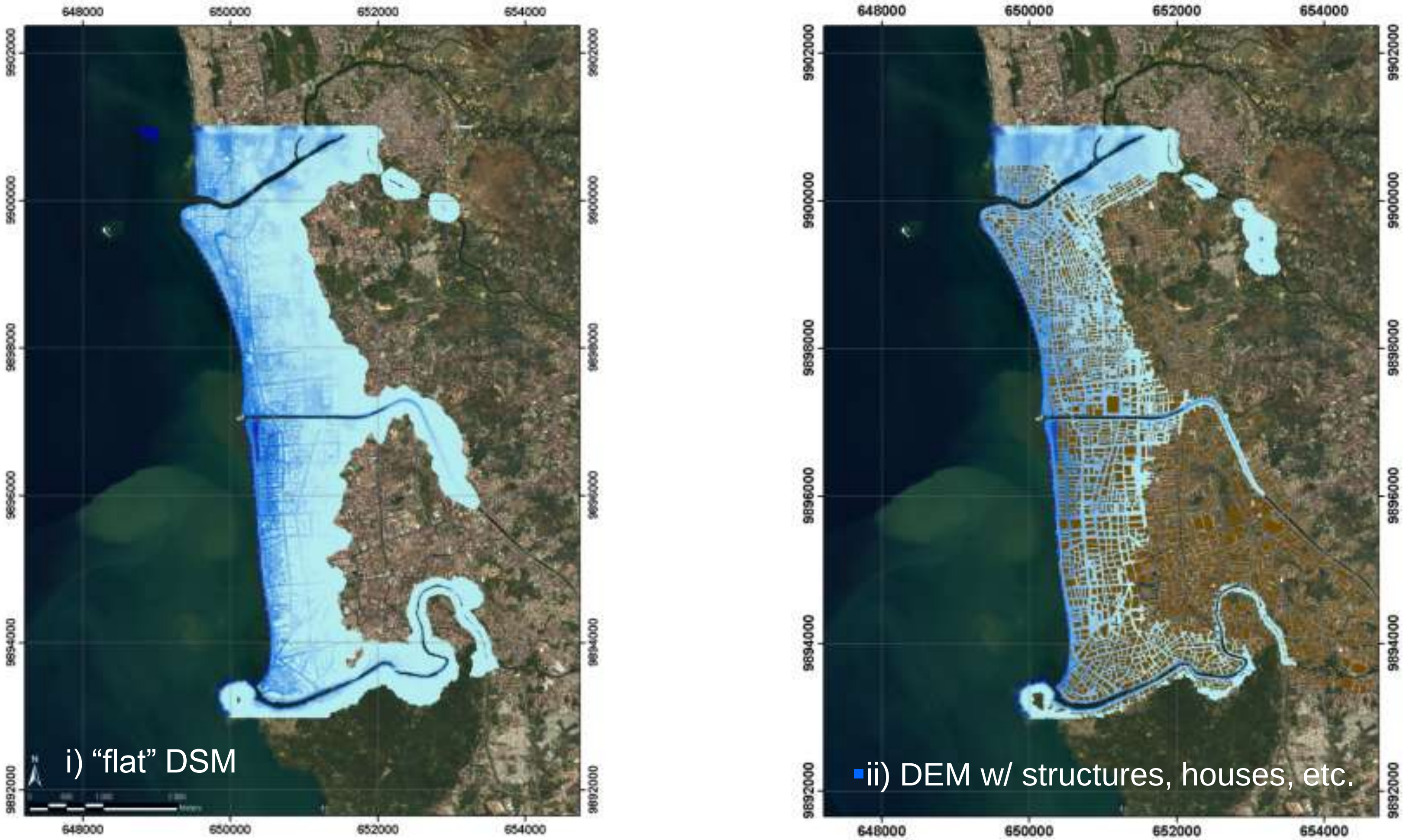
Preliminary findings

- **Sensitivity study II:** Manning's roughness value "m" of surface terrain - Variation of roughness parameters m = 20, 35, 70, 100 $m^{1/3}/s$ yield major differences



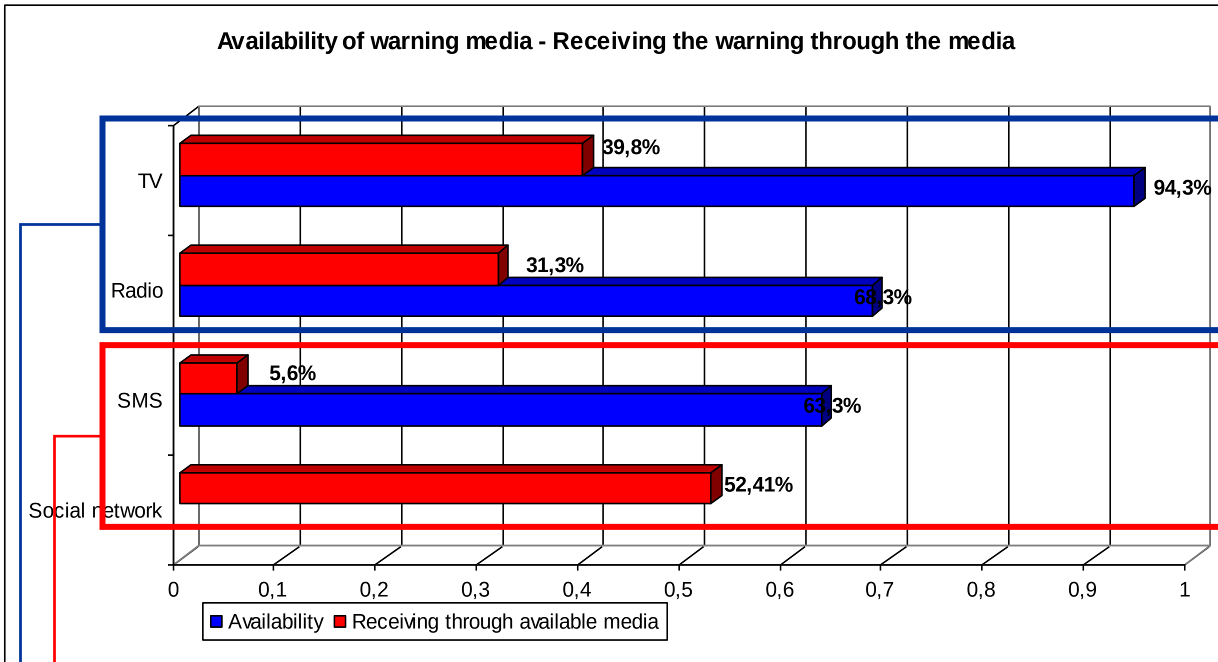
Preliminary findings

- **Sensitivity study III:** Strong deviations in between maximum tsunami inundation scenarions derived from i) "flat" DSM and ii) DEM w/ structures, houses, etc.



Preliminary findings

- Quantitative approach: Household survey
- Qualitative approach: Discussion with local experts



Dissemination (availability / receiving)	*Clearness of the warning*	*Technical failure in emergency (qualitative)*
= 42%	*= 90%*	- -
= 46%		-
= 9%	*= 68%*	- -
= 52%		+

Media for official notification

Media for informal notification

Community-based dissemination through community response team or mosques empowerment is more effective for early warning!

Media effectiveness:

1 Social network (community-based)
2 Radio
3 TV
4 SMS

Preliminary findings

- Awareness and Household Response to Early Warning

Basic knowledge of tsunami
Definition, natural signs

+

Awareness of tsunami hazard & own exposure
distance to the coast, personal concern

+

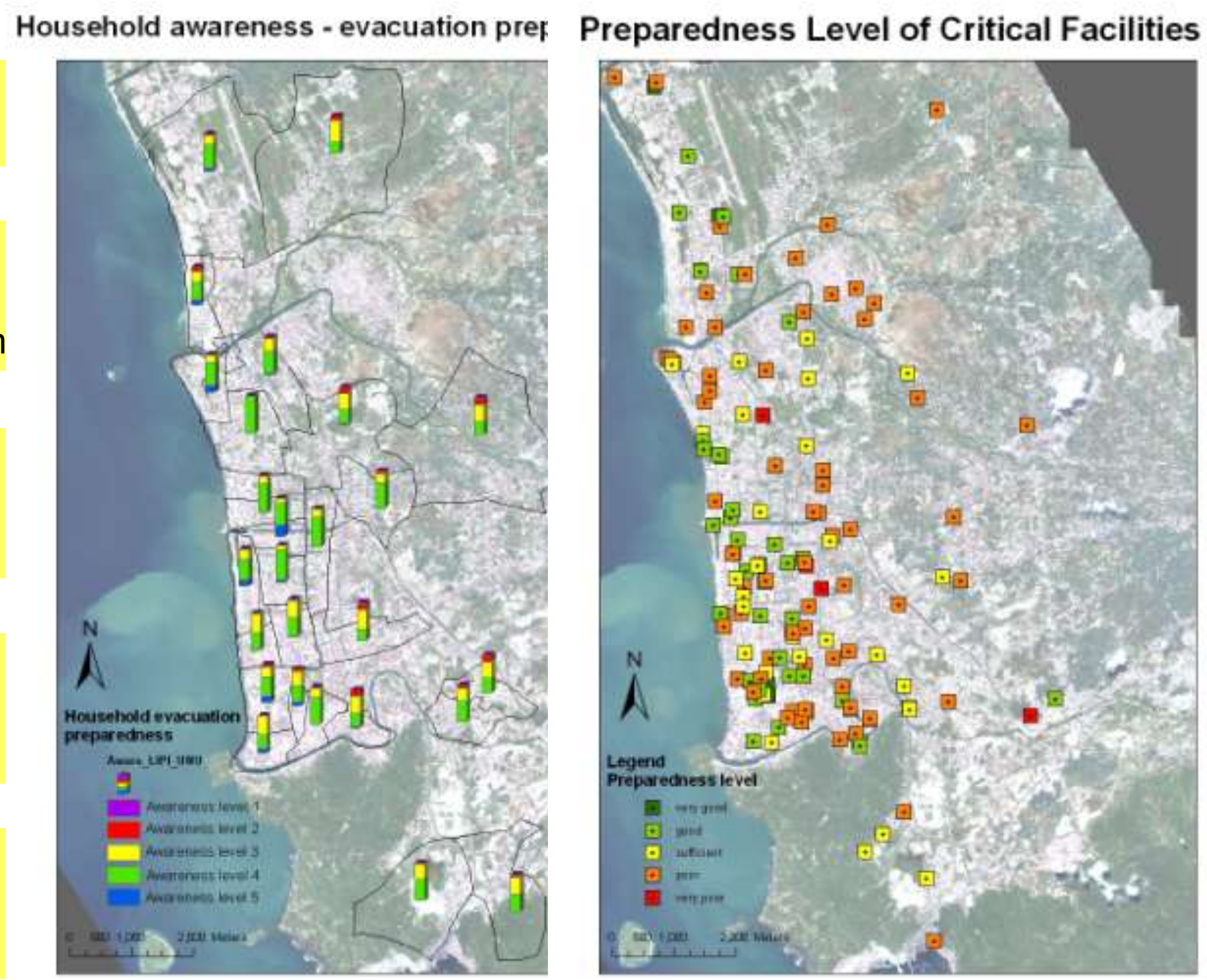
Awareness of getting prepared
determinant of harm, discussion about tsunami and TEWS

+

Knowledge of what to do
Warning interpretation, evacuation places, estimation of own capability

-

Constraints
existence of elderly in the household, household size, low HH income



Preliminary findings

- Highly-resoved 3D-city model and virtual reality landscape of Padang

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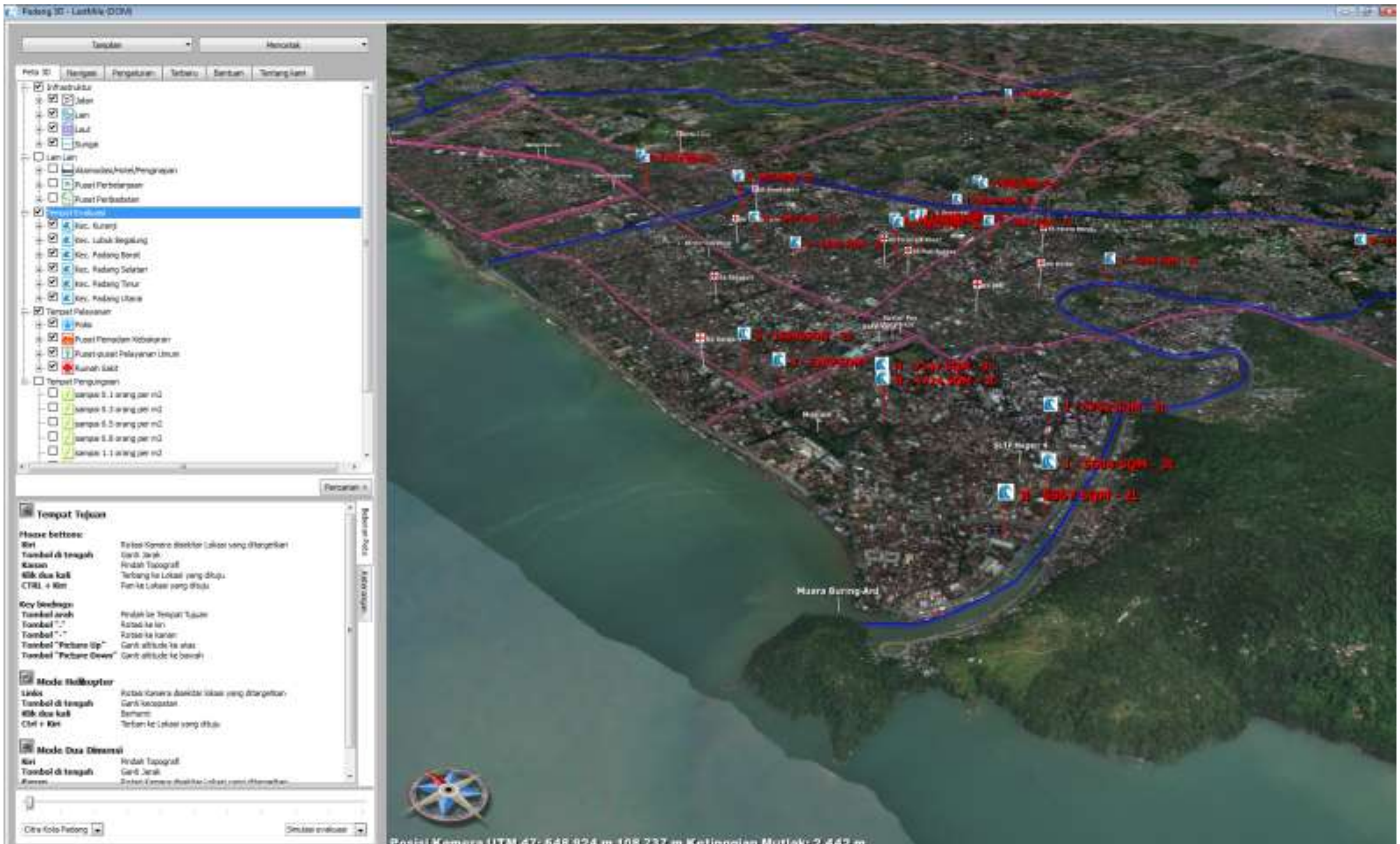

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Disaster Management in consequence of Sept. 2009 quake

- Earthquake 09/30/2009, 5.16pm, Mw 7.6, depth: 81km, 50km off coast of Padang

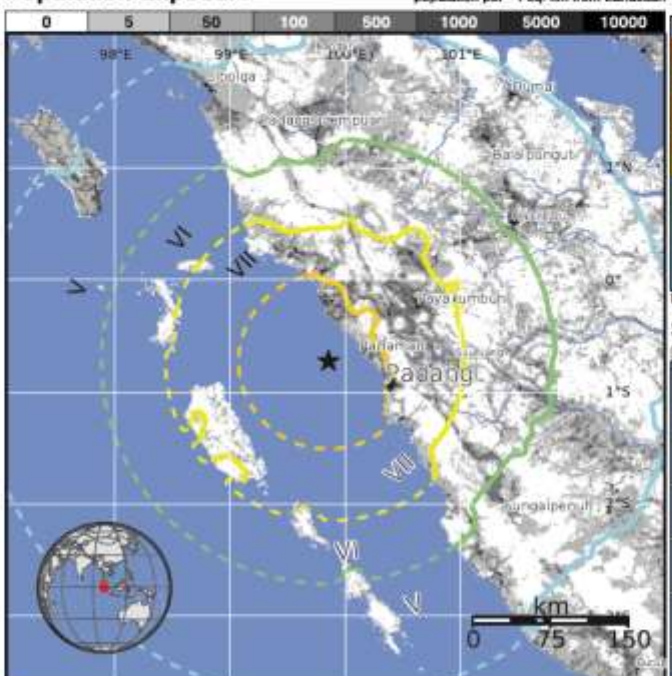
Estimated Population Exposed to Earthquake Shaking

ESTIMATED POPULATION EXPOSURE (k = x1000)		--*	262k*	2,235k*	6,215k	1,683k	3,249k	977k	0	0
ESTIMATED MODIFIED MERCALLI INTENSITY		I	II-III	IV	V	VI	VII	VIII	IX	X+
PERCEIVED SHAKING		Not felt	Weak	Light	Moderate	Strong	Very Strong	Severe	Violent	Extreme
POTENTIAL DAMAGE	Resistant Structures	none	none	none	V. Light	Light	Moderate	Moderate/Heavy	Heavy	V. Heavy
	Vulnerable Structures	none	none	none	Light	Moderate	Moderate/Heavy	Heavy	V. Heavy	V. Heavy

*Estimated exposure only includes population within the map area.

Population Exposure

population per ~1 sq. km from Landscan



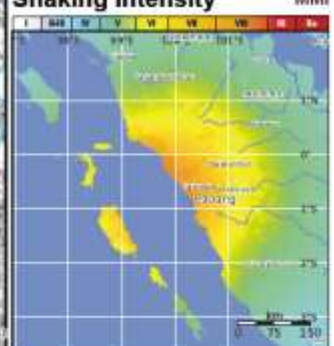
Selected City Exposure

MMI	City	Population
VII	**Pariaman**	92k
VII	Bukittinggi	99k
VII	**Payakumbuh**	122k
VII	Solok	48k
VII	**Padang**	840k
VI	**Sijunjung**	28k
IV	**Dumai**	144k
IV	**Pekanbaru**	0
III	Lubuklinggau	148k
III	Muar	128k
III	Melaka	181k

bold cities appear on map (k = x1000)

Shaking Intensity

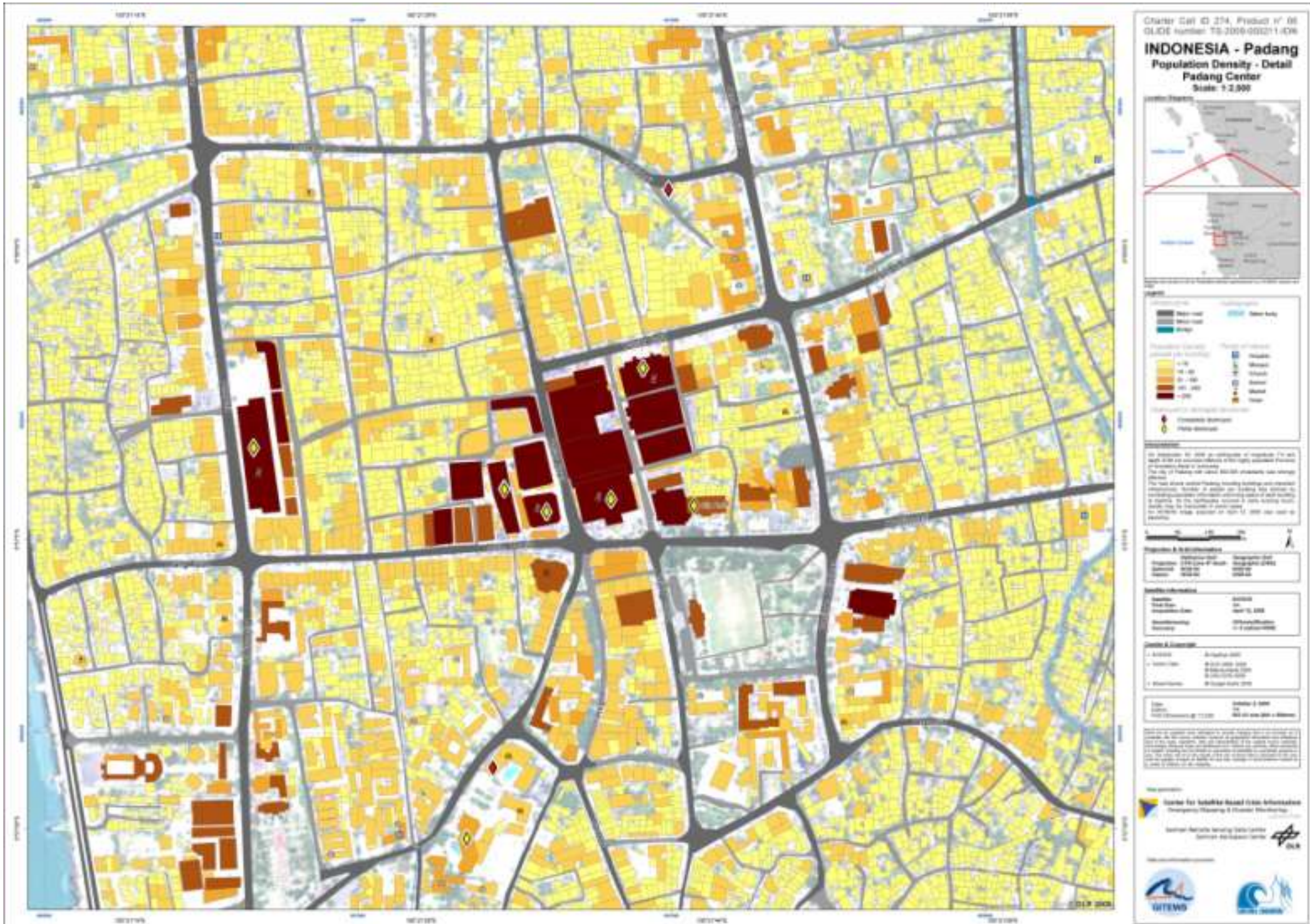
MMI



Courtesy of USGS, 2009

Disaster Management in consequence of Sept. 2009 quake

- Current Rapid Mapping and Disaster Management Activities



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Summary & Outlook

- Transdisciplinary approach in "Last-Mile – Evacuation" proves to establish **new dimension of DRR research** on a spatially and time-dependent micro-scale
  See: **Taubenböck et al., NHESS, Vol. 9, Number 4, 2009, pp. 1509-1528**

- **Further sensitivity analysis** and calibration with other hydronumerical models and initial slip distribution needed (account results from McCloskey et al., 2009)
- Closely evaluate **evacuation analysis and traffic optimization** (not shown here!)
- Summarize and **synthesize** work packages and implement in online 3D-viewer
- **Broad dissemination** of DRR research results in Padang to scientific communities

Urgent demands for DRR in Padang

- **Present and discuss results** of study with stakeholders and local decision makers -> Continue to support the so-called **"Padang Consensus"** process
- Strong need to construct **tsunami evacuation shelters** nearshore (SOP)
- Try to achieve to implement results into local **spatial planning & co-ordination**
- **Capacity Building** (additional workshops) with UNAND and disaster management agencies (BNPB) and other city authorities
- **Mainstream findings as well as recommendations** from Padang to transfer outcome to other imperiled coastal regions in West Sumatra, Indonesia

Thank you very much for your attention!