# Inundation modeling due to hypothetical tsunami scenarios for the city of Padang, West Sumatra within "Last-mile - Evacuation"


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## Introduction and background

The disastrous Indian-Ocean tsunami has strongly emphasized the need for an assessment of scientific methodologies and engineering approaches to intensify basic as well as applied research leading to a greater insight into tsunami run-up and inundation mechanisms [Schiermeyer, 2005]. The vastly exposed urban coastal agglomeration of Padang, West Sumatra, Indonesia, has been broadly taken into consideration for further evaluation and risk assessment to the potential threat of tsunami due to the amplified risk of future earthquakes in the region [McCaffrey, 2007]. It is well documented that Sumatra's third largest urban area counting more than 1 million inhabitants is one of the most imperiled cities in the Indian Ocean rim due to potential tsunami hazards originating off the coasts of Padang. The city is located directly on the coast, partially sited beneath the sea level and drained by numerous waterways and rivers [e.g. see fig. 1]. Thus, the city of Padang is located in a zone of extreme risk due to severe earthquakes and tentatively triggered tsunamis. Figure 2 sketches the region of interest in which the investigation is being conducted.

## Geodata base and numerical model

The investigation highlighted herein is one of the core elements of a large interdisciplinary research project which develops a "Numerical *Last-mile* Tsunami Early Warning and Evacuation Information System" on the basis of detailed earth observation data as well as unsteady, hydraulic numerical simulation of inundation dynamics of the tsunami in the urban coastal hinterland for the city of Padang. The research project focuses on the assessment of the physical-technical susceptibility and the socio-economic vulnerability of the population with the objective to mitigate human and material losses due to possible tsunamis.

Fig. 1: City of Padang, West Sumatra, Indonesia

By means of discrete multi-agent techniques risk-based forecasts of the evacuation behavior of the population and the flow of traffic in large parts of the road system dependent on the time of evacuation in the urban coastal strip are simulated and concurrently linked with the other components. Thus, the detailed tsunami inundation dynamics as well as the performance of evacuation processes in Padang city are successfully modeled. The anticipated results of the project will then be set into a disaster information system for the city authorities in Padang as an adequate disaster preparedness measure.

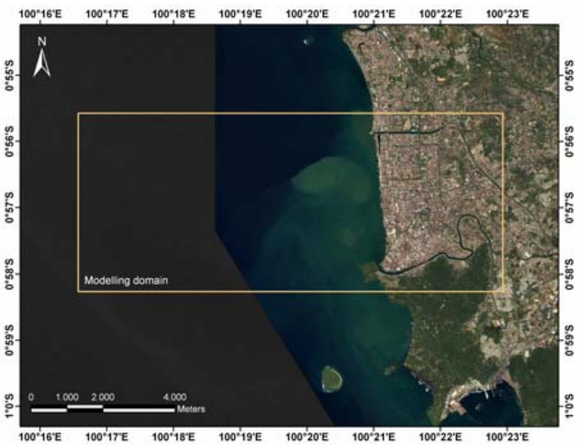


Fig. 2: Coarse topographic map of Padang, West Sumatra, and attributive bathymetrical data based on the GEBCO dataset.

Within the present investigation detailed hydro-numerical modeling of tsunami near- and onshore run-up scenarios are conducted in order to derive distinct inundation dynamics which characterize the incoming tsunami wave front in the city of Padang. This chief objective demands modeling the interaction between the shoreline and the shoaling wave fronts approaching from offshore. Wave overtopping mechanisms as well as inland penetrating water volumes and the propagation of wave induced bores on dry land interacting with the built infrastructure must be taken into consideration and adequately modeled.

This ambitious goal strongly stipulates for a detailed geodata base from validated sources. Accordingly, highly-resolved bathymetrical surveys based on a multi-beam echo-sounding device and a DGPS system were carried out to gather data in order to develop a distinctive digital elevation model (DEM) of the near-shore environment of Padang. In addition to the bathymetrical data collection, airborne topographical field data surveys with a high resolution camera system (HRSC) were conducted. The spatial distribution of bottom roughness due to different surface materials and infrastructures onshore is being derived by interpreting detailed satellite images and validated by field studies on the ground.

By means of the detailed DEM macro- and micro-scale numerical simulations of near-shore tsunami wave dynamics have been conducted for the rectangular area sketched in Figure 1. The shallow-water equations are solved by a finite-volume technique (Nielsen et al 2005). The flexible mesh capabilities and a robust wetting and drying algorithm allow modeling run-up, overtopping and inundation as well as wave-structure interaction.

The study area is discretized by a triangular mesh with cell sizes ranging from 1000 m² offshore to ~50 m² onshore. Special emphasis is set to the detailed modeling of the numerous waterways and rivers as well as the interaction with the infrastructure. In order to prepare simulations of larger model areas within this particular hazard zone some preliminary studies on a rectangular area of 800 x 400 m were carried out to ascertain and evaluate the influence of bottom roughness and structure induced energy dissipation.

Initial water levels were always set to the mean sea level established from an analysis of the annual time series from Padang tidal gage stations in 2007. The boundary conditions consider a hypothetical earthquake source of MW=8.5 (1.656° S/99.723° E) based on data from the TsunAWI model (Harig et al 2007).

## CONCLUSIONS

Numerical studies of credible tsunami run-up and inundation scenarios in urban agglomerations confirm that the impact of a tsunami and the extent of inundation areas generally depend on the roughness parameters, but if buildings and structures are explicitly considered in the numerical grid the situation changes. In this case flow velocities between structures get remarkably higher and near shore water levels at the Padang sea wall rise while areas onshore are less inundated. This additional information is essential for adequate evacuation planning in the city of Padang and can further be employed into an upcoming decision support system (DSS).

## References


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