

Near- and Onshore Tsunami Effects: Ongoing and Planned Research in Sri Lanka

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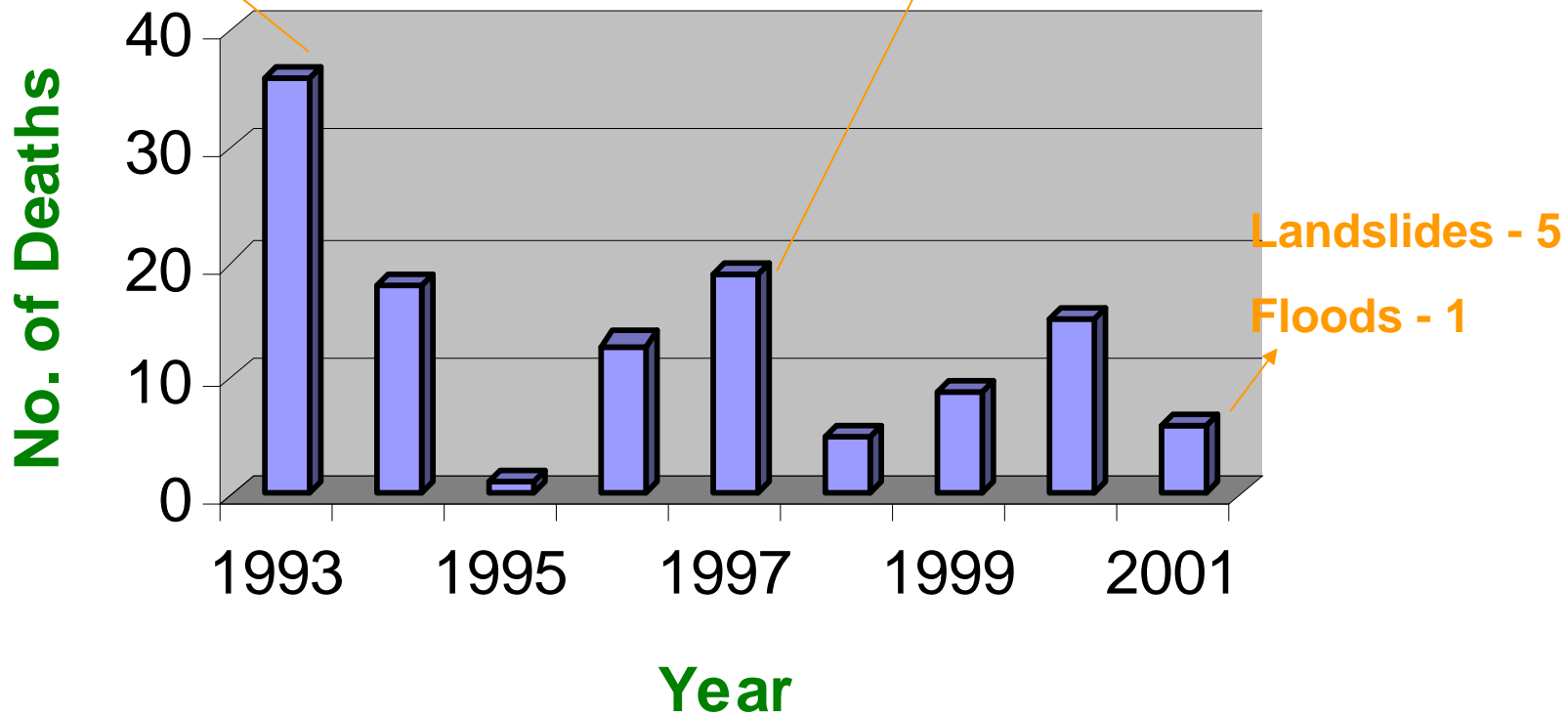
Deaths due to Natural Disasters in Sri Lanka 1993 - 2001

Landslides - 29

Floods - 6

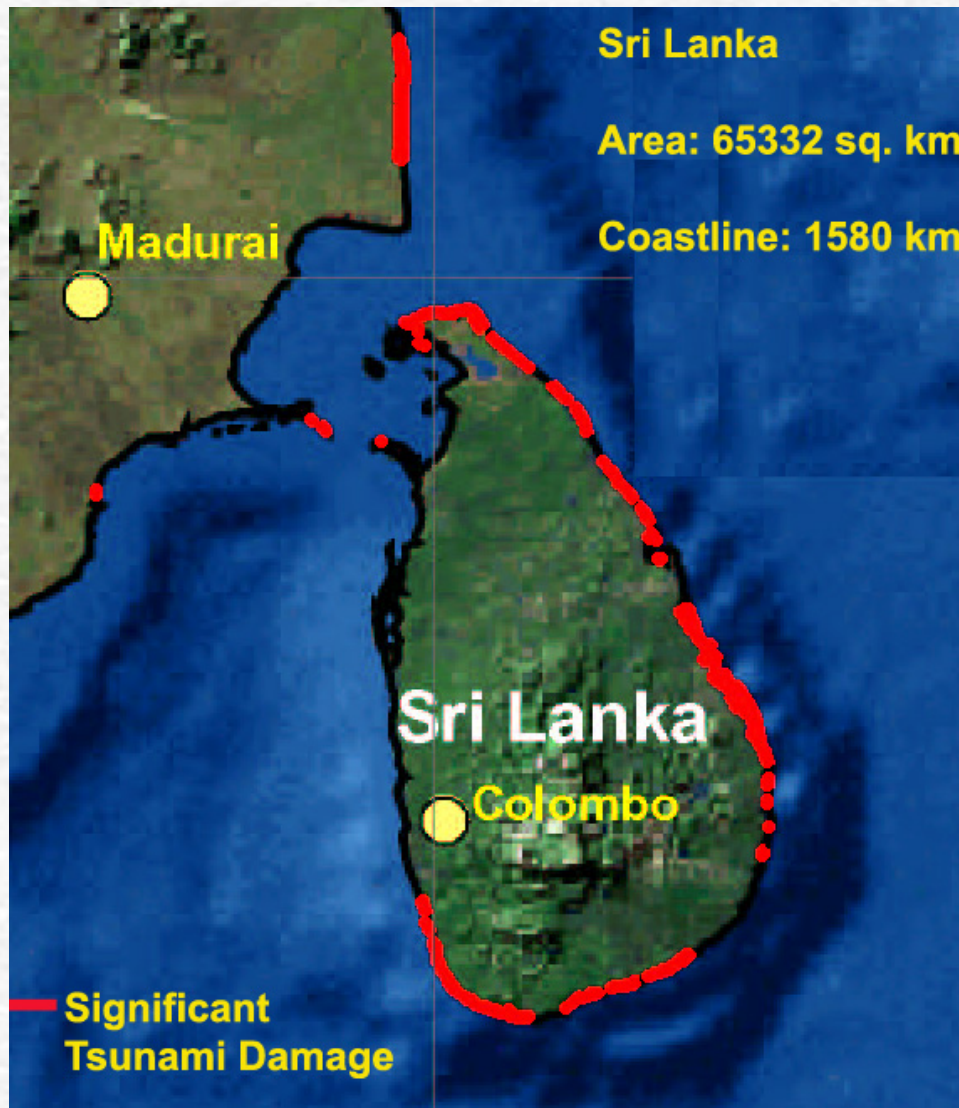
Landslides - 15

Floods - 4



Landslides - 5

Floods - 1



Tsunami Disaster in Sri Lanka – Human Aspects



Death toll: 35,322

Injured: 21,441

Homeless: 516,150

Destruction – Coastal Settlements



No. of Houses Damaged - 89,000

Destruction – Coastal Settlements



No. of Lost Livelihoods – 150,000

Destruction – Roads, Railways & Bridges



800 km of national and 1500 km of provincial & local government roads damaged

Destruction – Roads, Railways & Bridges



Sections of track, bridges, communication systems, buildings and some rolling stock were severely damaged on the 160 km long southern line.

Destruction – Fisheries Sector



75% of the country's fishing fleet destroyed

Destruction – Tourism related infrastructure



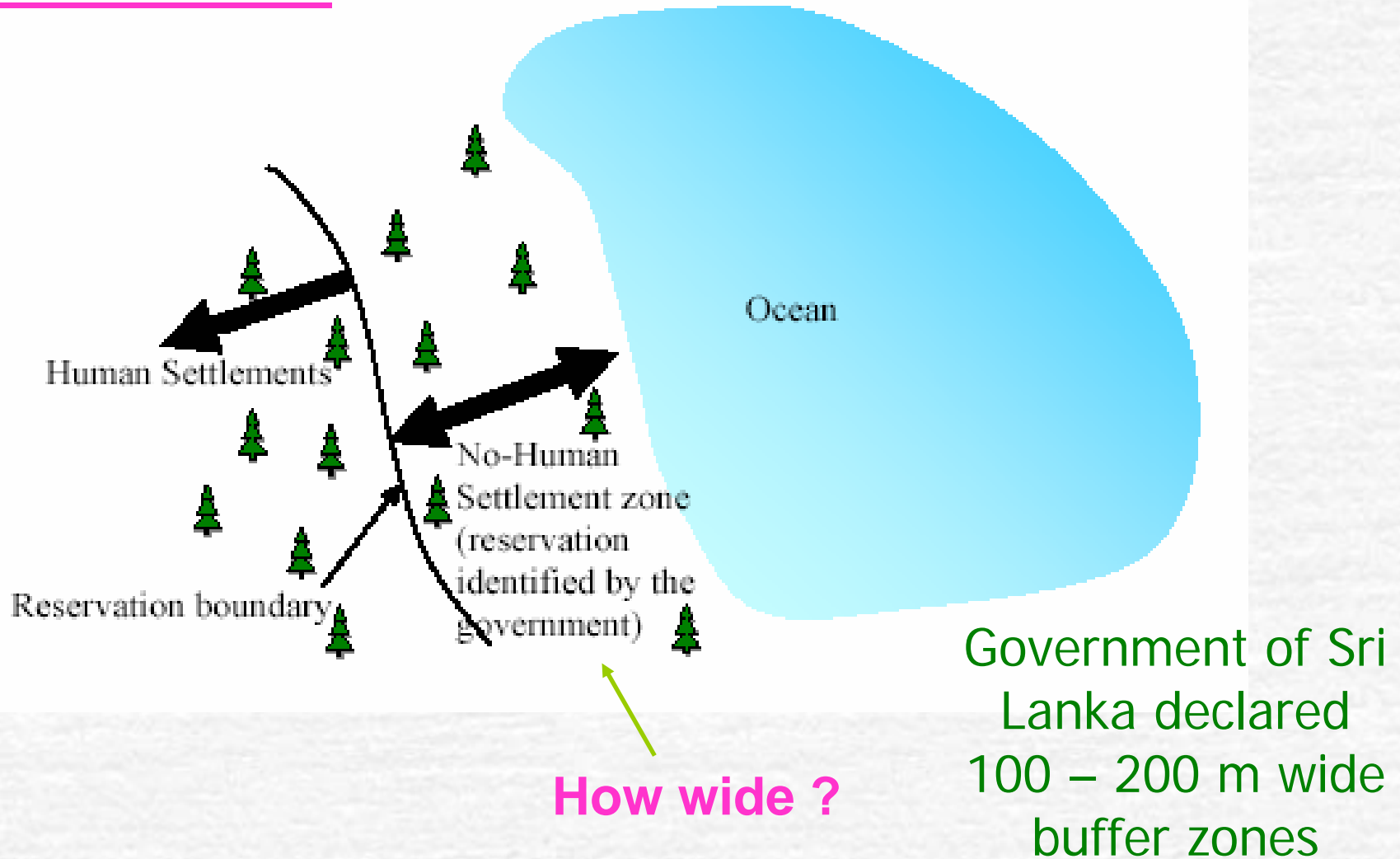
Where Yala Safari Beach Hotel was

Large hotels: 53 out of 242
Small hotels: 248



Nilawali Beach Hotel

Post-tsunami



Living with Tsunami



Integrated Strategy for Disaster Reduction on Coasts

consisting of:

In General:

- Education/Awareness
- Early Warning Systems & Evacuation
- Hazard/ Risk Mapping
- Legislative Initiatives

+

But, at specific locations, where such non-structural measures alone would not be sufficient, for example, where critical facilities are to be located or to protect commercially important locations such as large coastal cities, we may have to include some structural measures as well:

- **Tsunami Breakwaters,**
- **Tsunami Walls/Dikes, and**
- **Other energy dissipation measures**

Revise/ Update Integrated Coastal Zone Management Plan (1990)


Four priority areas in ICZM Plan:

- Erosion management and land use,
- Cessation of coral mining and control of sand mining,
- Prevention of loss and degradation of coastal natural habitats,
- Protection of scenic areas and cultural, religious and historical sites.

Add

Protection against coastal natural hazards

due to tsunamis & storm surges



- ICZM with necessary revisions is a good tool because it can control development patterns, and combine coastal natural hazards mitigation with natural resource conservation.

DRM Institutional Framework in Sri Lanka



(Activities will be coordinated through Disaster Management Coordinators)

Some of the tsunami related research/projects being carried out in Sri Lanka

- ✔ Numerical modeling of tsunami propagation and inundation
- ✔ Planning and design of countermeasures against tsunami and other coastal hazards
- ✔ Investigating the performance of natural barriers against wave attack – simulation of coral reefs
- ✔ Effect of the 2004 tsunami on the nearshore coastal morphology
- ✔ National and local level tsunami warning systems
- ✔ Impact of the 2004 tsunami on groundwater resources in Sri Lanka
- ✔ Paleotsunami deposits in coastal lagoons
- ✔ Development of disaster resistant build environments; tsunami resilient/resistant structures; structural resistance against sliding, overturning and scouring caused by tsunamis
- ✔ Role of coastal vegetation in tsunami energy dissipation
- ✔ Effect of surface roughness on tsunami run-up

Living with Tsunami



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Capacity Building in Disaster Risk Management



Master's Degree Programme in Disaster Management

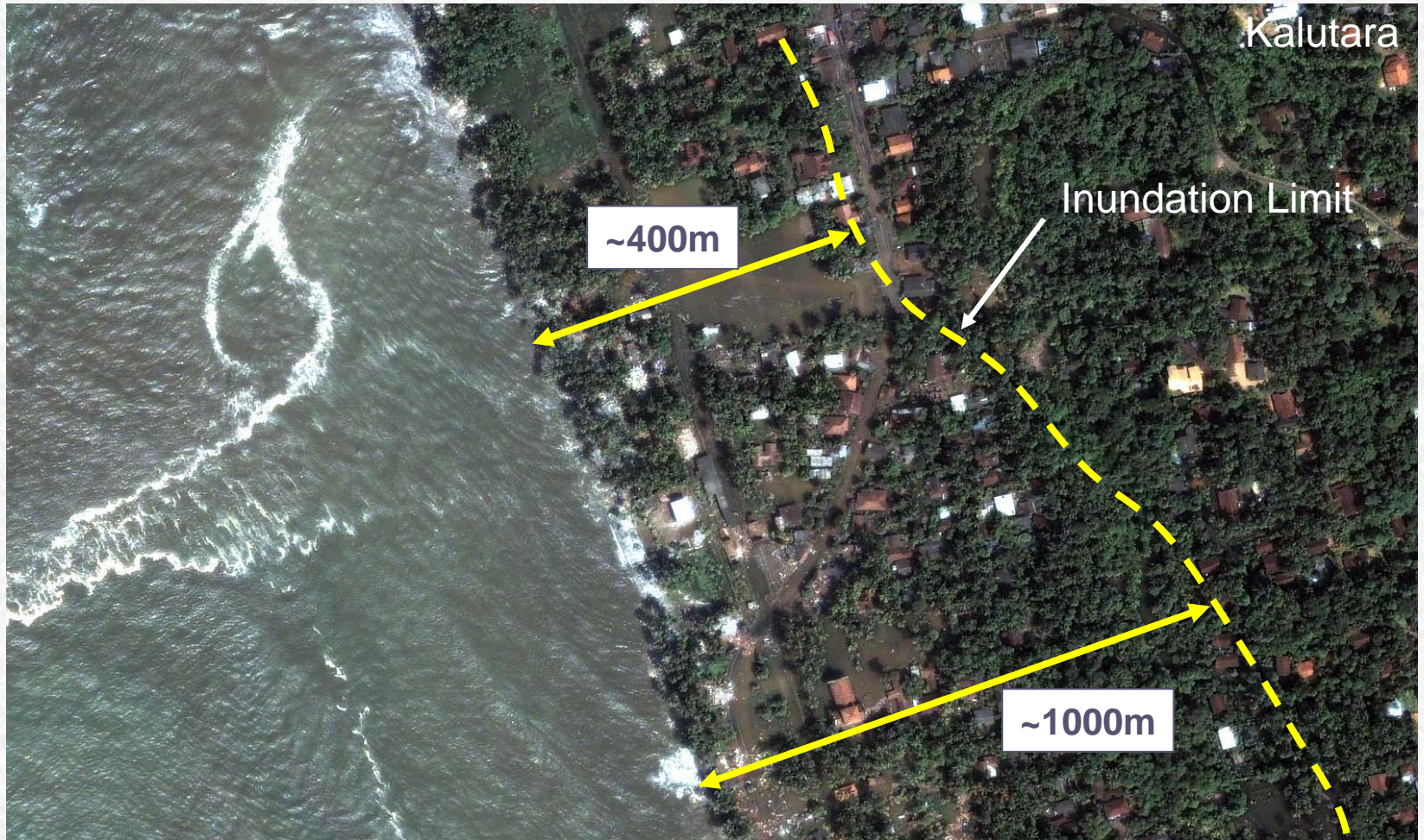
Conducted jointly by the Faculty of
Engineering and the Postgraduate
Institute of Science (PGIS) of the
University of Peradeniya, Sri Lanka

Collaborating Institutions: Emergency Management, Australia (EMA); Asian Disaster Preparedness Centre (ADPC), Thailand; ITC, The Netherlands; Pacific Tsunami Warning Center, USA



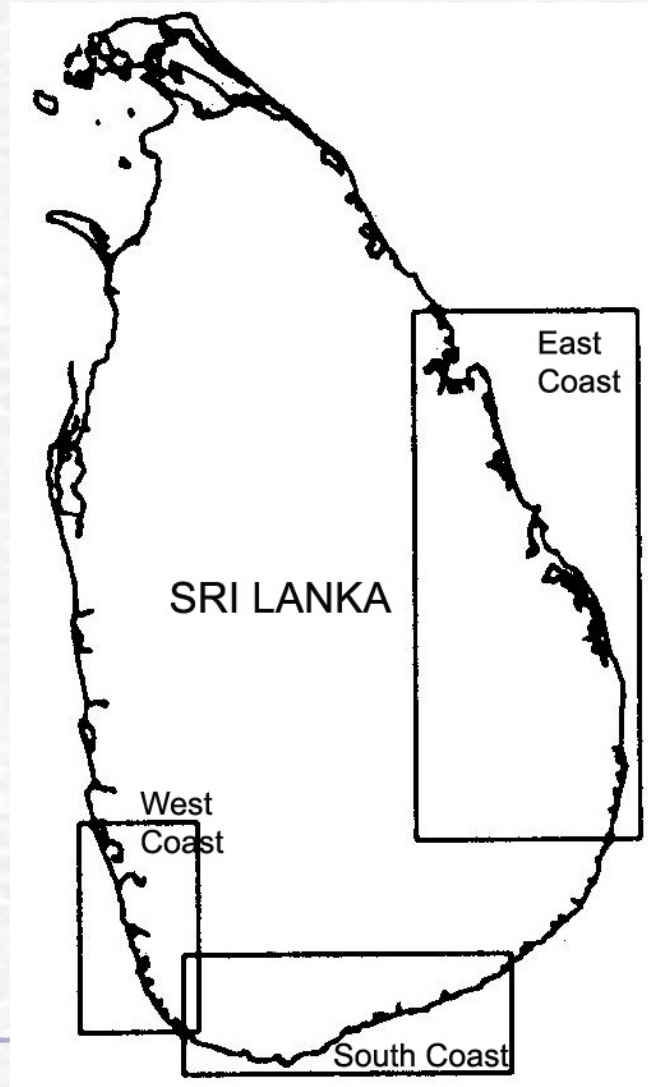
Tsunami Hazard Mapping for the Coastal Belt of Sri Lanka

Inundation Distance - How far inland?



Detailed Inundation Measurements: Coastal Sectors Covered

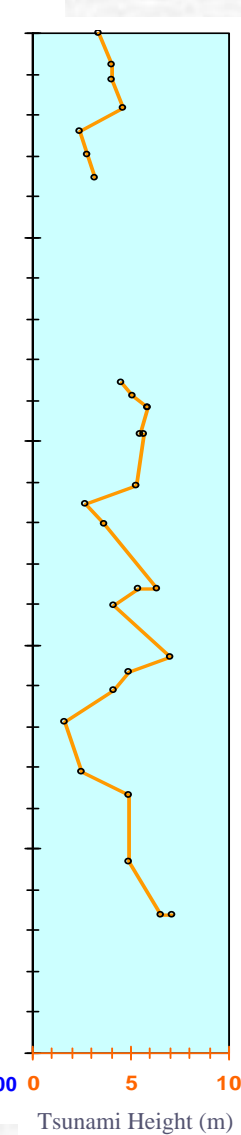
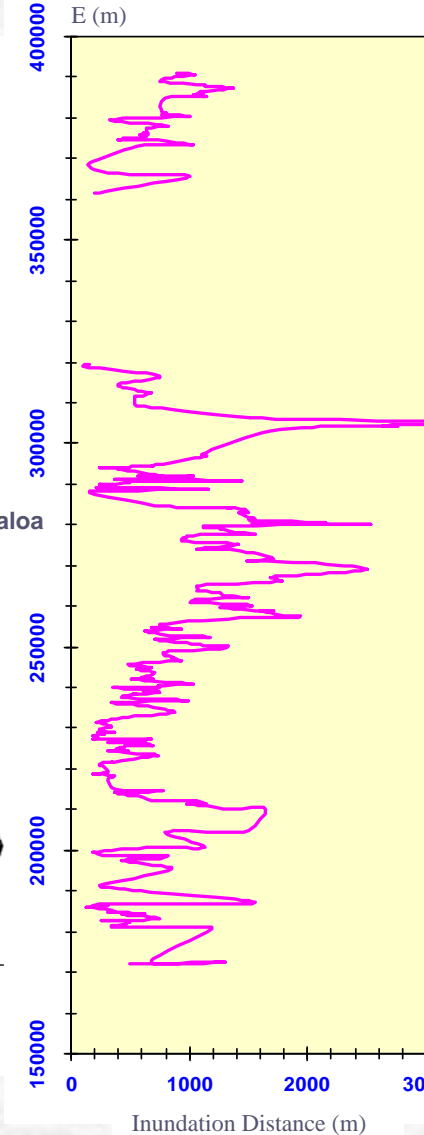
Detailed inundation
measurements at
300-400 m intervals



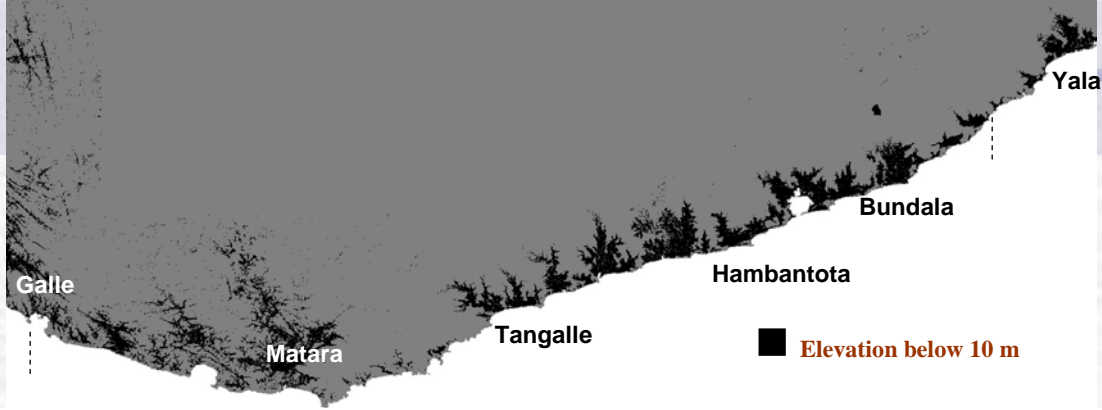
How high and How far Inland? – East Coast



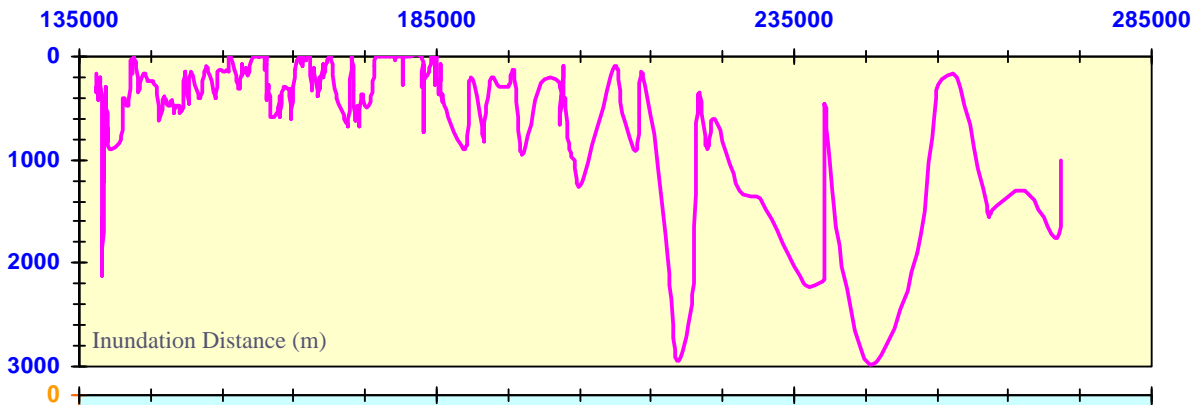
Population Density



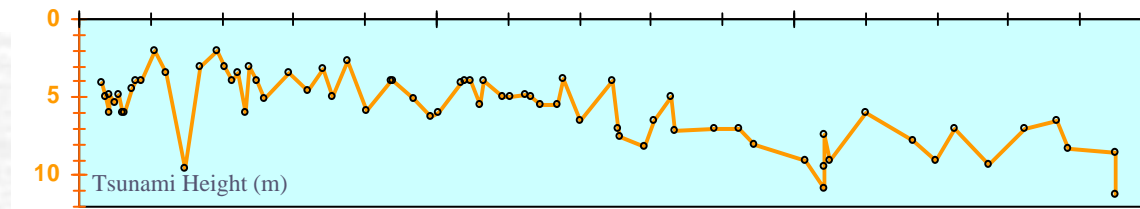
South Coast



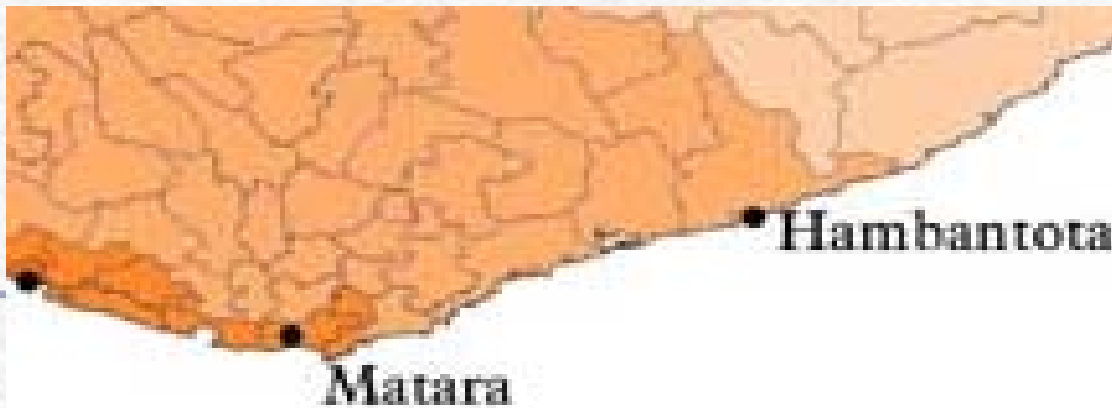
Inundation Distance (m)



Tsunami Height (m)

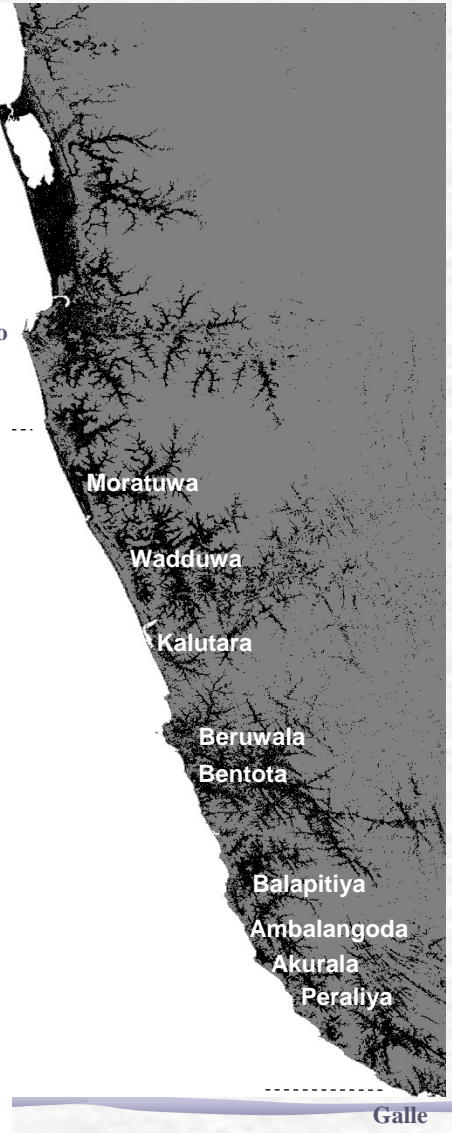
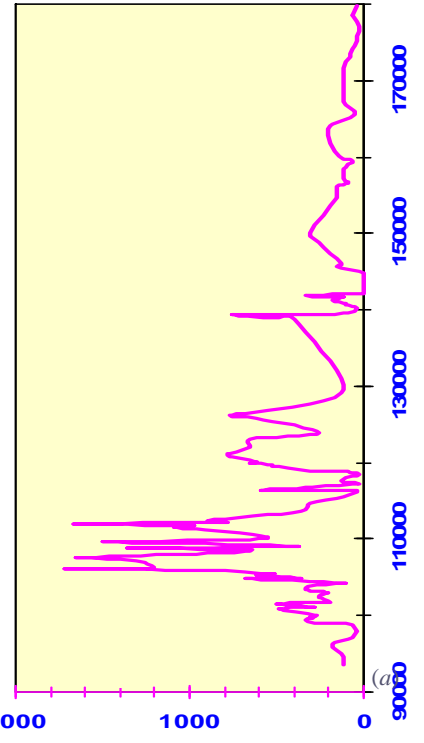
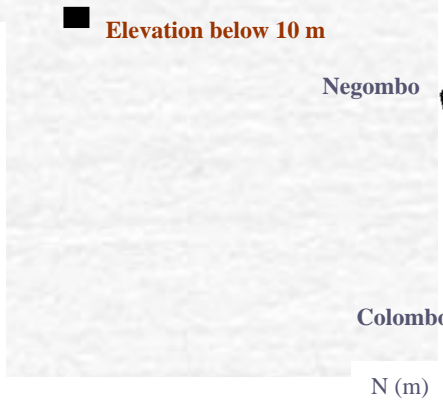
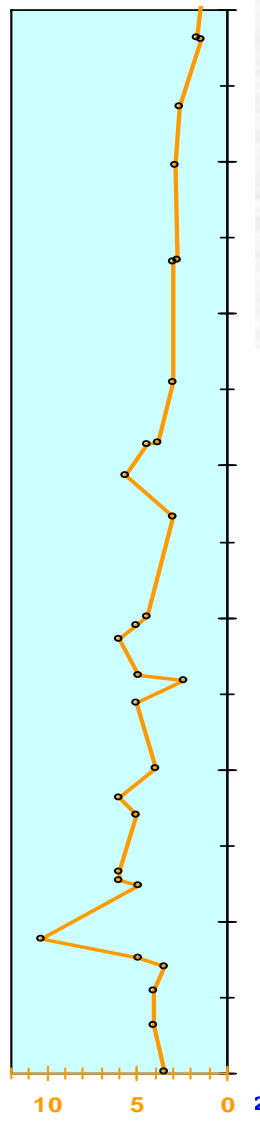


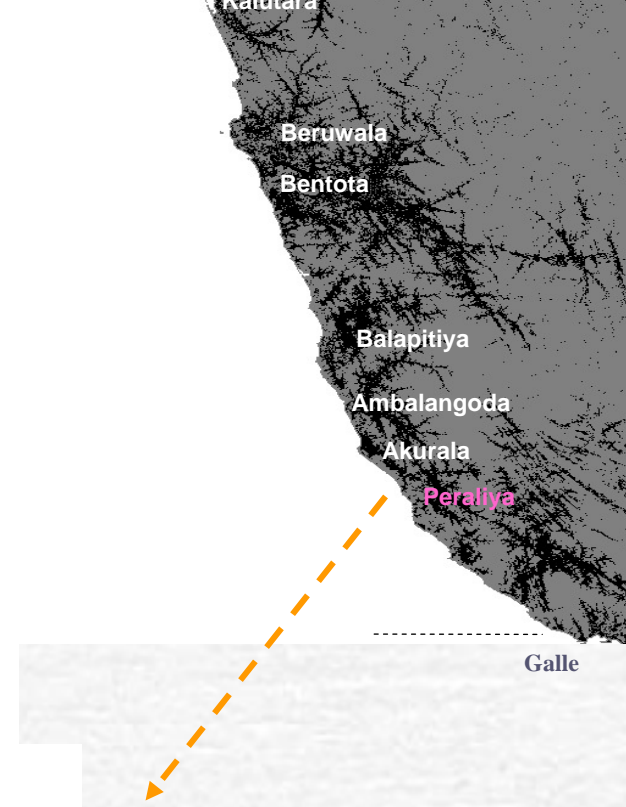
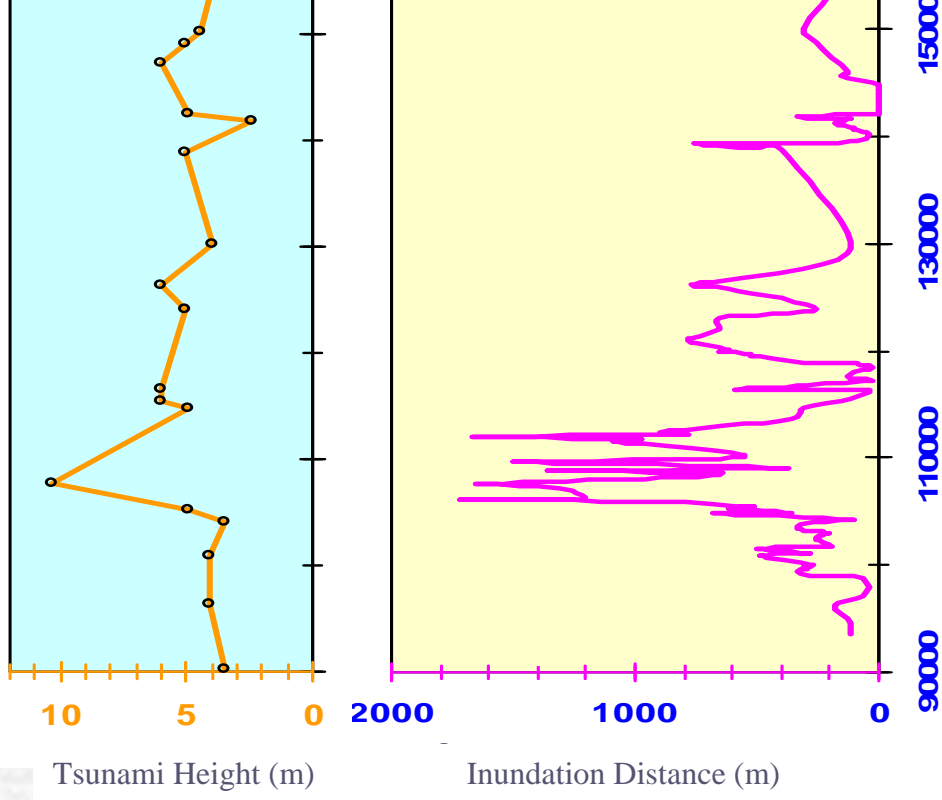
Population Density



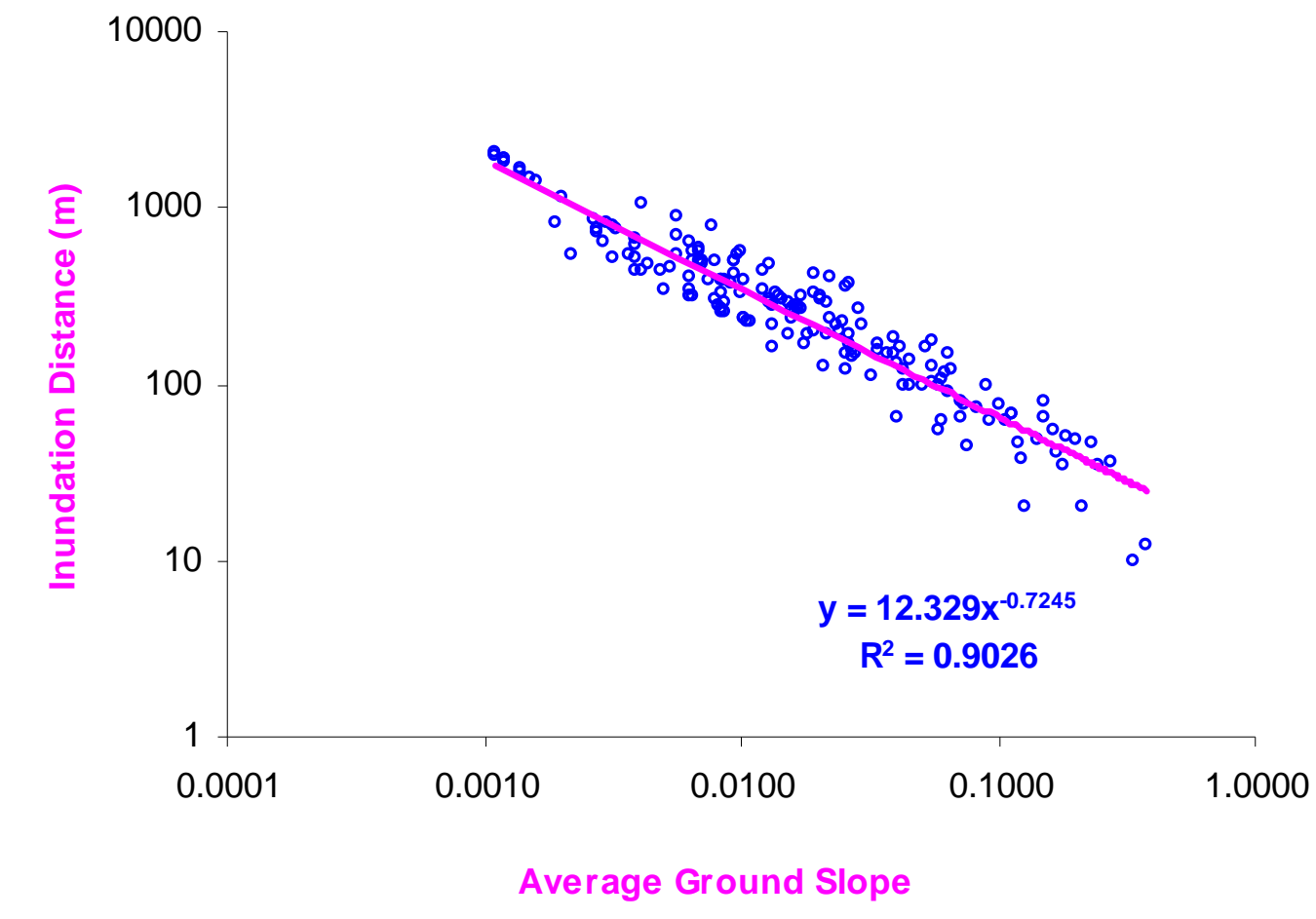
West Coast

Population Density





Tsunami Inundation Distance with Ground Slope



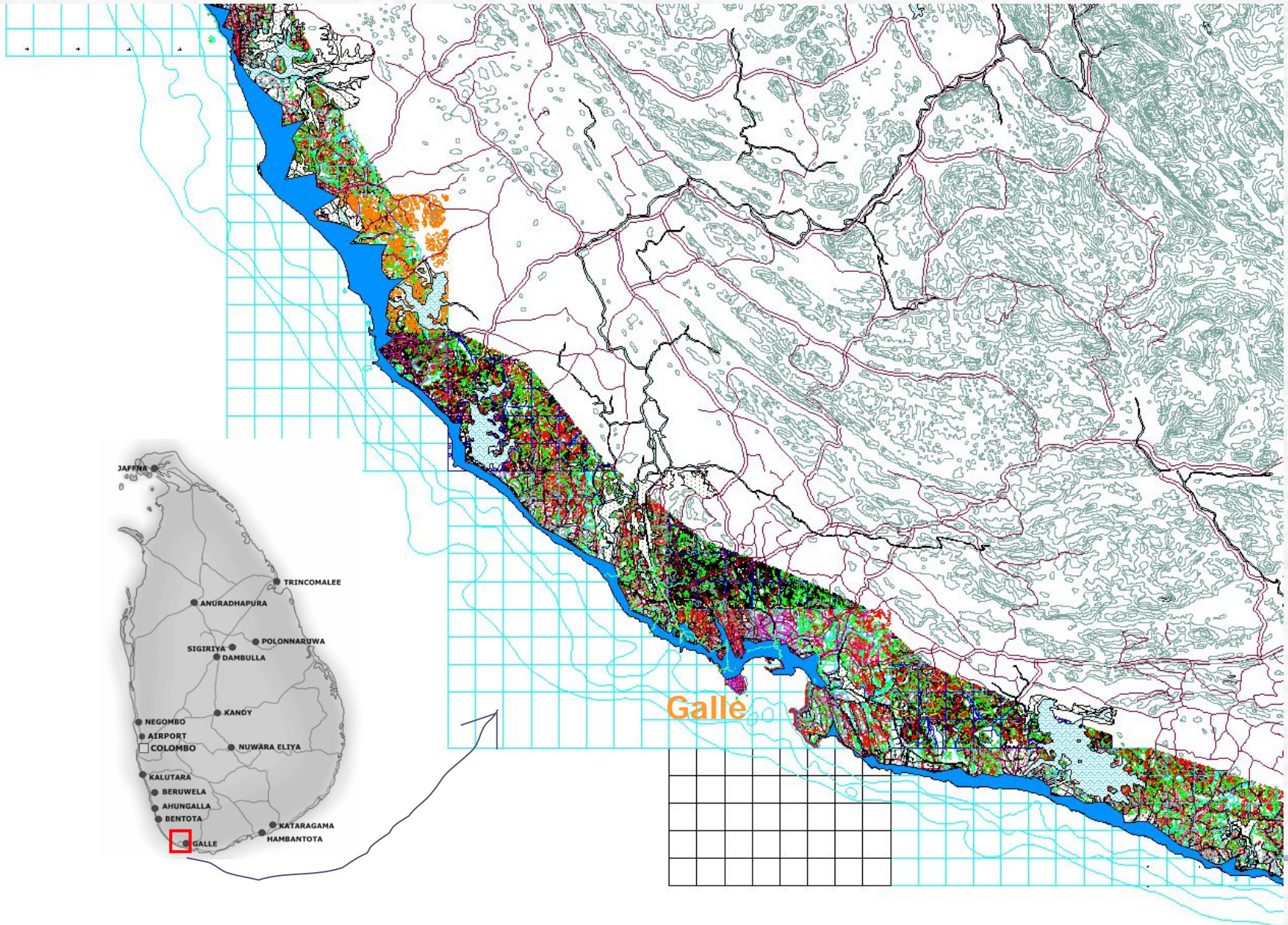
Sand Dunes on the South & South East Coasts of Sri Lanka



Shore-connected
water bodies



Extent of Tsunami Inundation

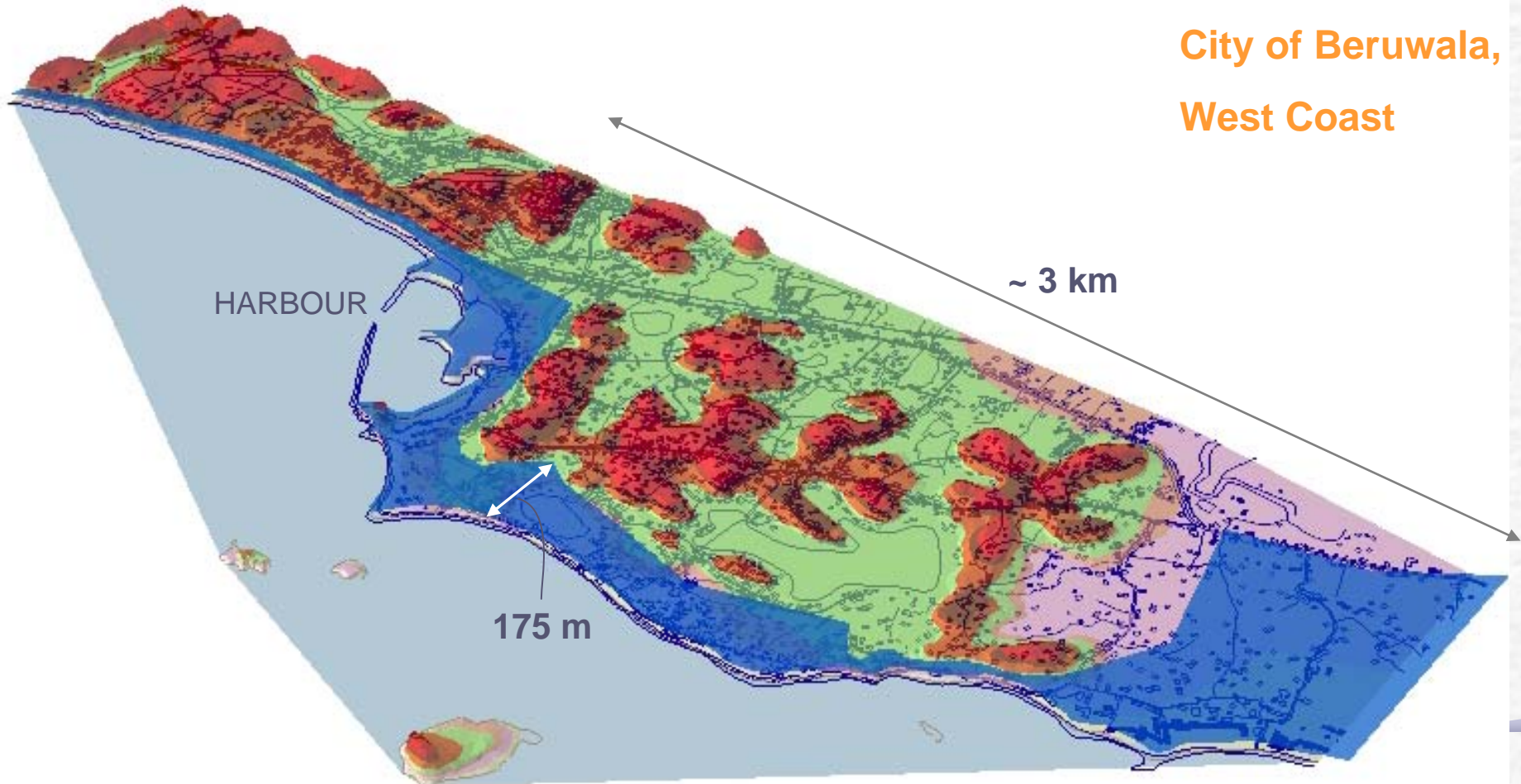


SRI LANKA

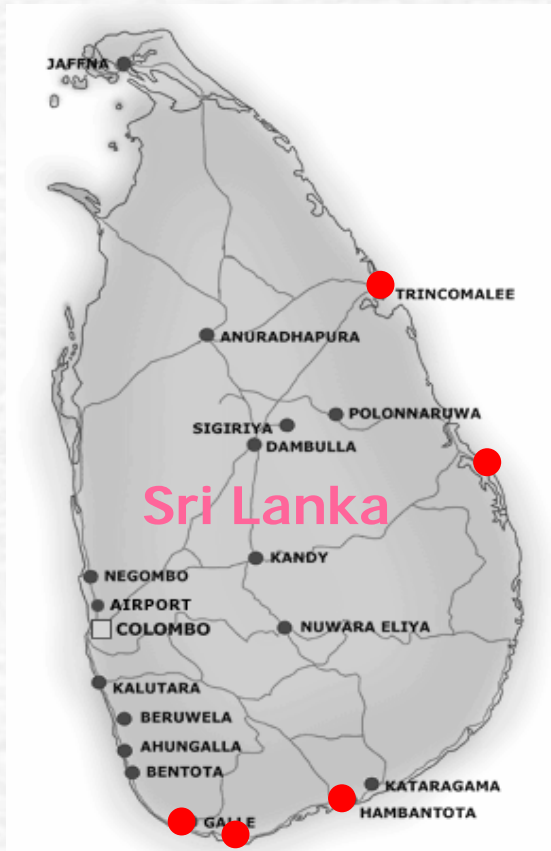


Extent of Inundation

City of Beruwala,
West Coast



Development of Tsunami Hazard Zonation Maps for the Coastal Belt of Sri Lanka



- Tsunami hazards maps are developed for these five coastal cities severely affected by the tsunami in 2004.

Carried out by
Department of Civil Engineering,
University of Peradeniya, Sri Lanka
in collaboration with
Cornell University School of
Civil & Environmental Engineering,
and funded by



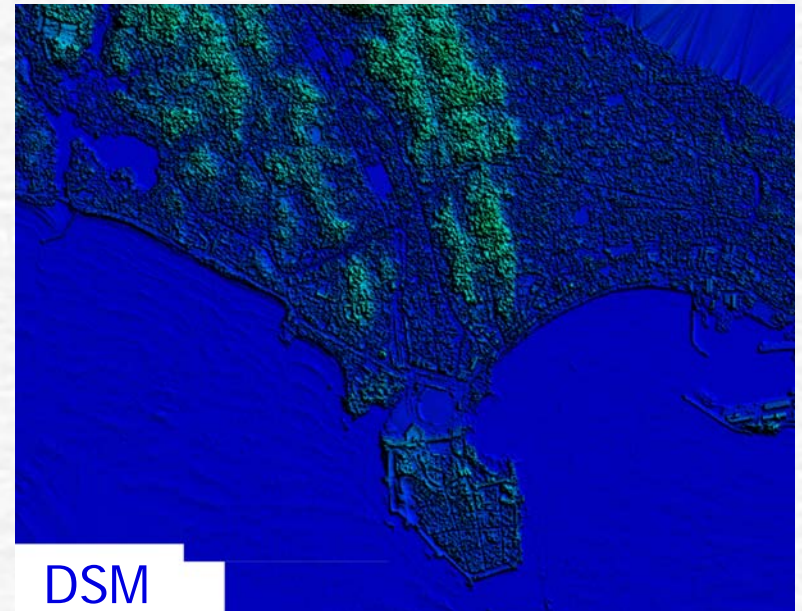
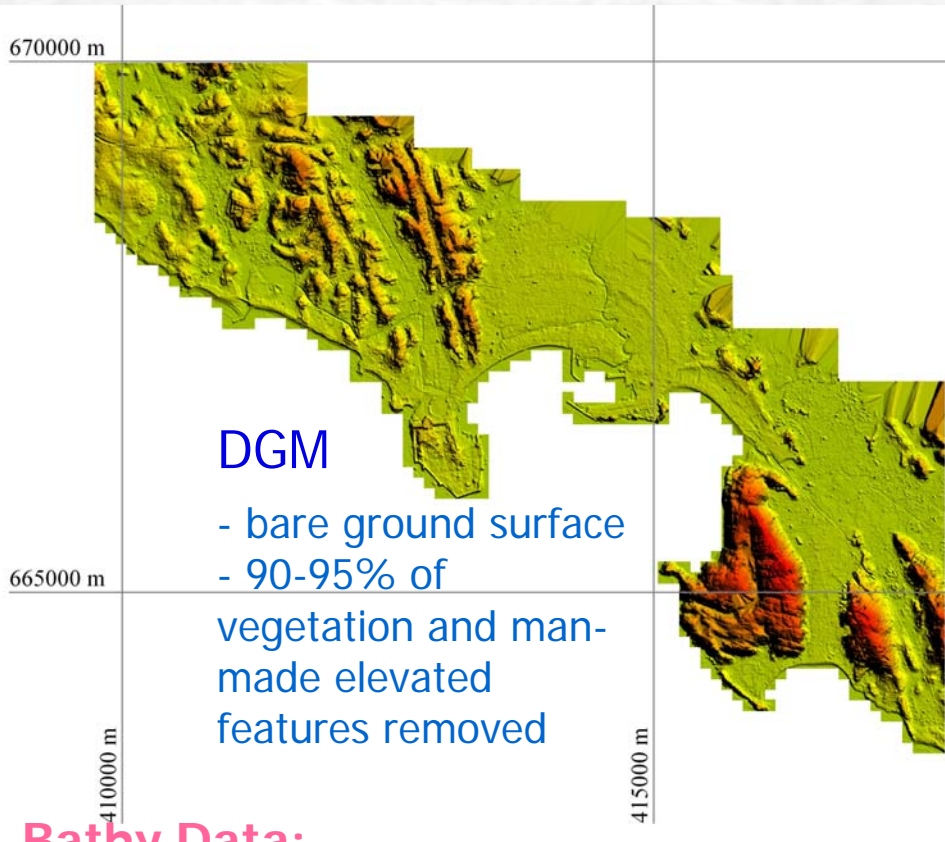
USAID
FROM THE AMERICAN PEOPLE

ASIA



Topo & Bathy Data for Modeling

Topo Data: LIDAR DGM - Resolution: Horizontal = 1 m; Vertical < 0.3 m



DSM

- Elevation from the first-return LIDAR pulse
- No segregation as to whether surface is man-made or natural

Bathy Data:

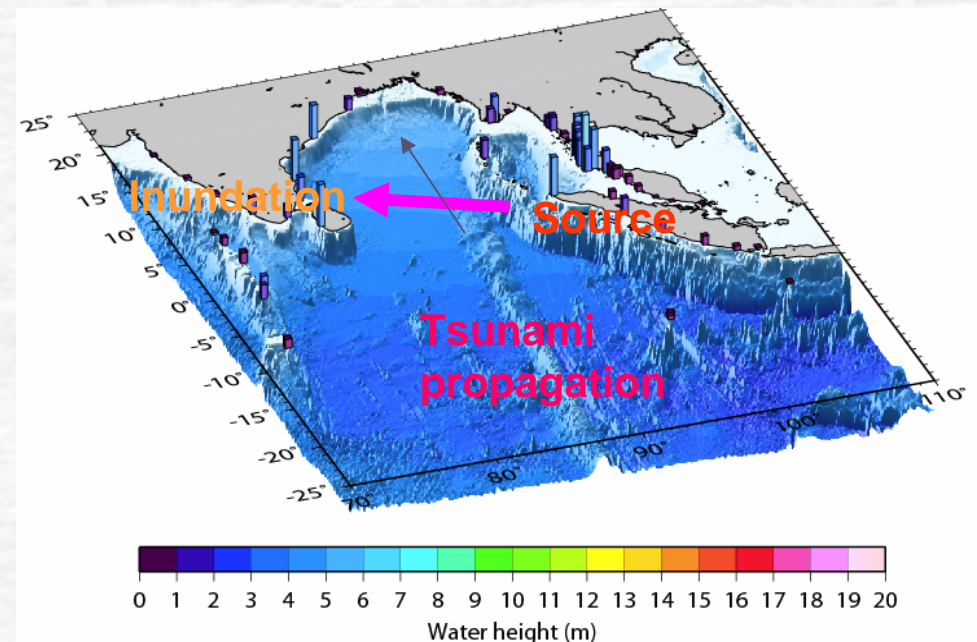
UK Admiralty Charts – Scale: 1:10,000; 1:25,000; 1:50,000; 1:300,000

Modelling Tsunami Inundation

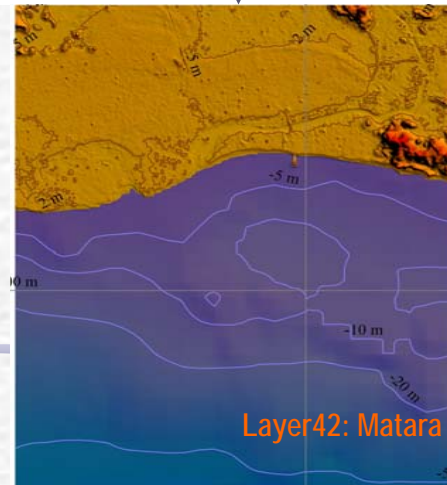
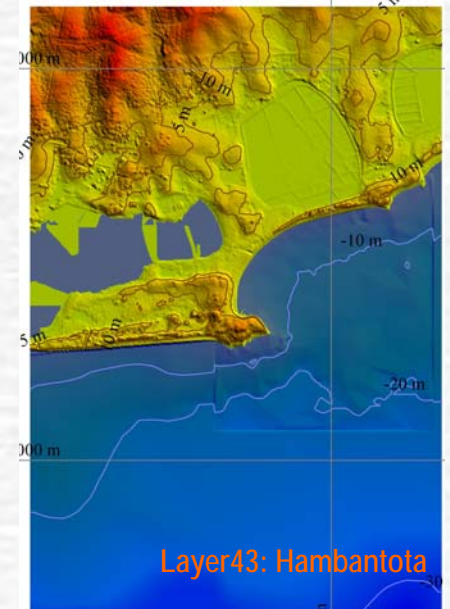
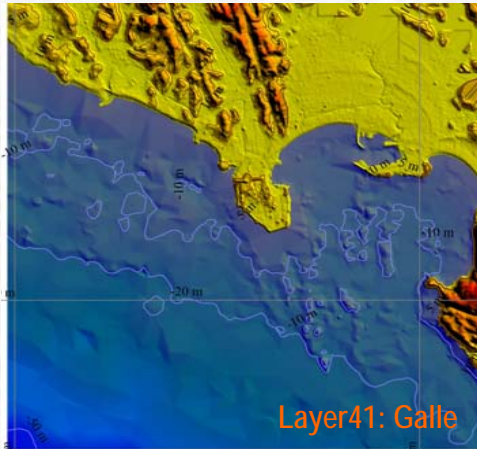
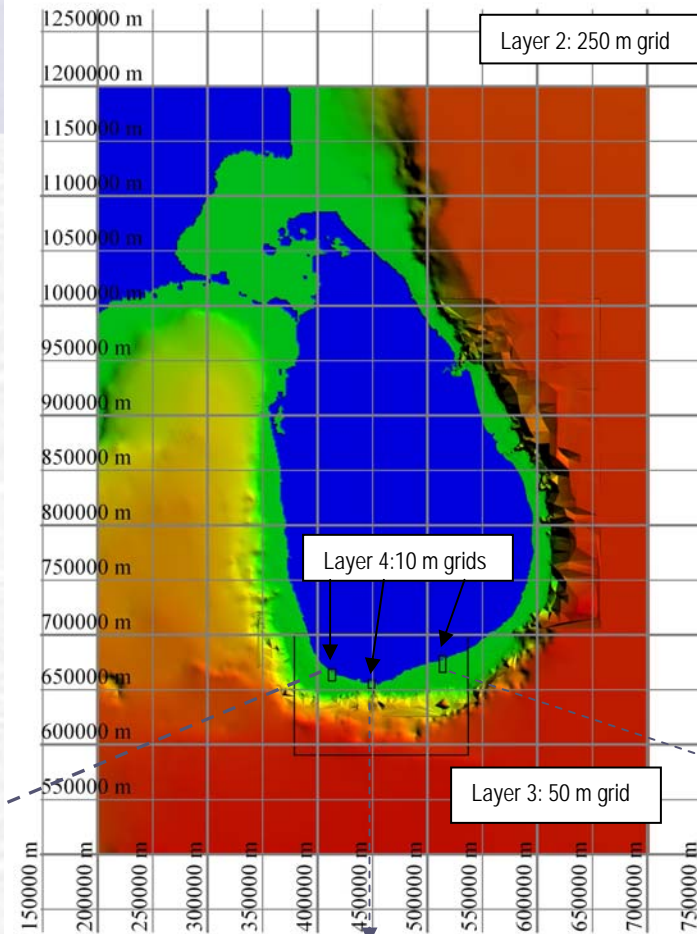
Cornell Multi-grid Coupled Tsunami Model (COMCOT)

- The COMCOT tsunami model is a dynamically coupled combination of the following three components:
 - source model which creates the initial water surface disturbance given the earthquake parameters,
 - tsunami propagation from its origin to the nearshore coast,
 - tsunami run-up and inundation with a moving boundary.
- It solves the linear/non-linear shallow-water equations.

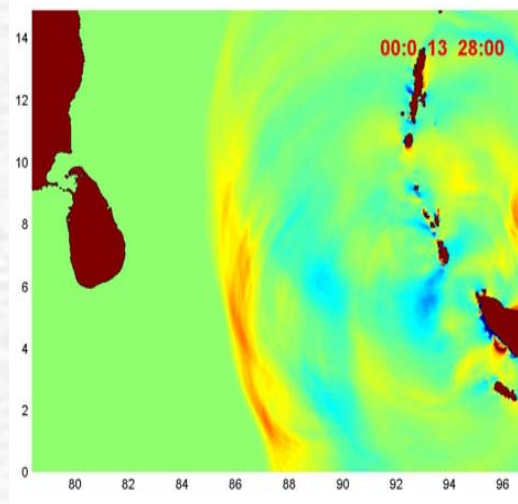
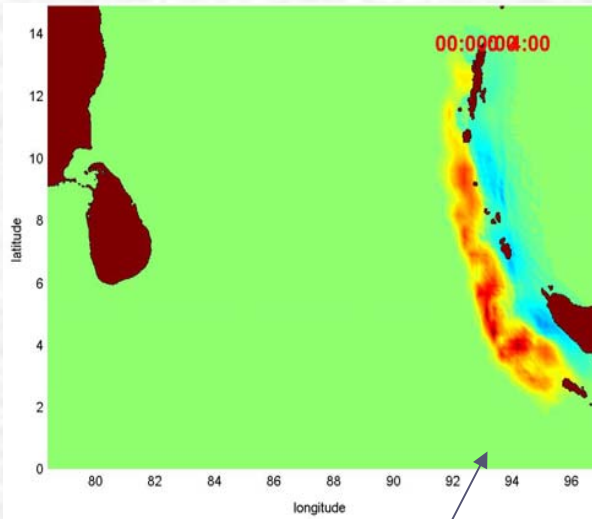
Source, Propagation and Inundation Models



Nested Grids for COMCOT Model



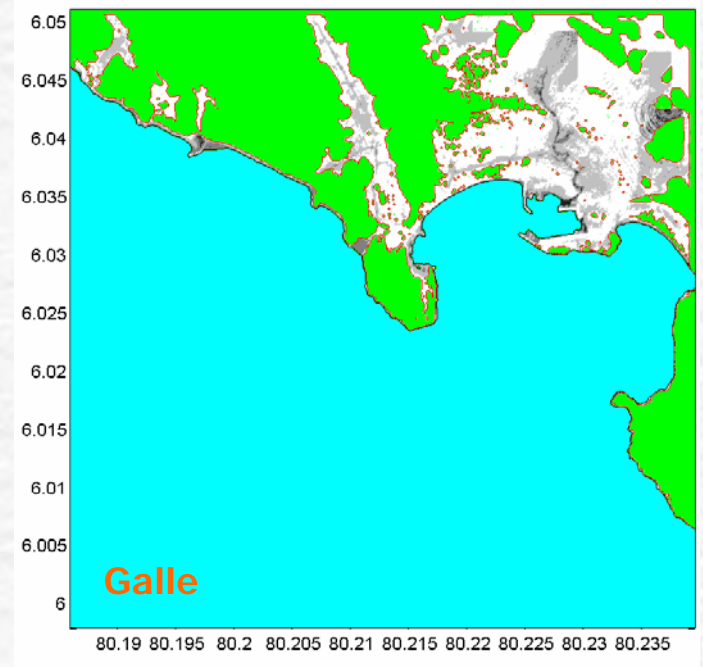
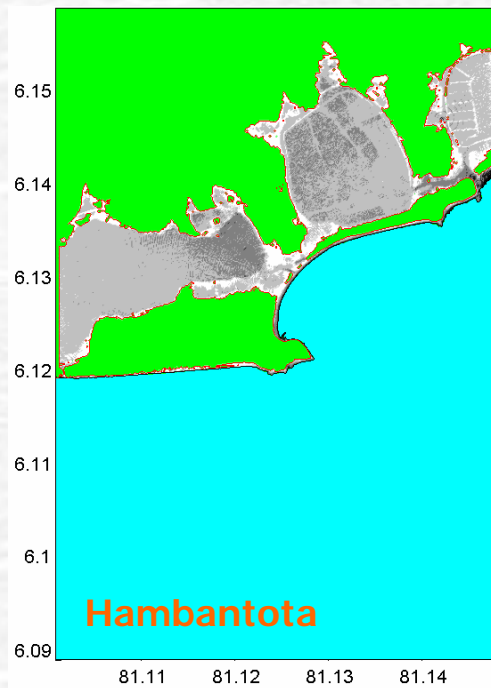
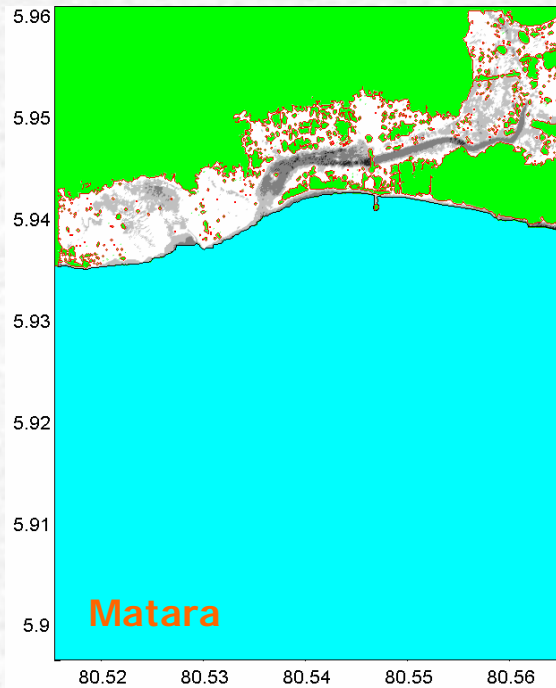
Layer 1: $\Delta x = \Delta y = 0.6765$ min



Source Model of Chen Ji

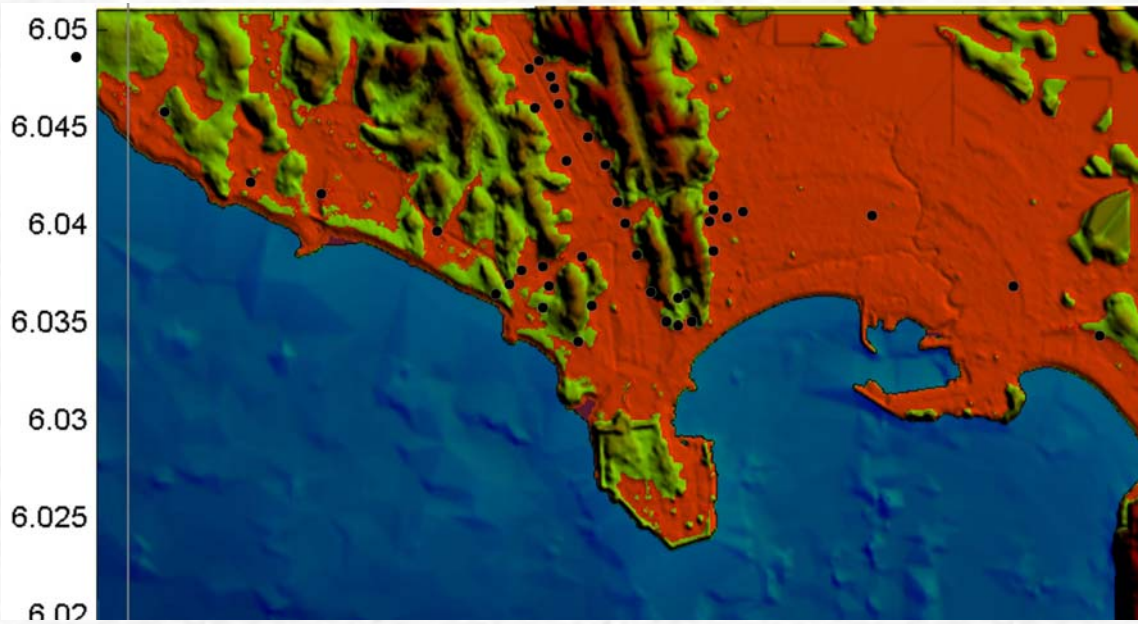
Layer No.	Grid Spacing	Coordinate System	Linear/ Non-linear Equations
1	0.6765 min (~1250 m)	Spherical	Linear
2	0.1353 min (~250 m)	Spherical	Linear
3	50 m	Cartesian	Linear
4	10 m	Cartesian	Non-Linear



Preliminary Model Results: Extent of Inundation



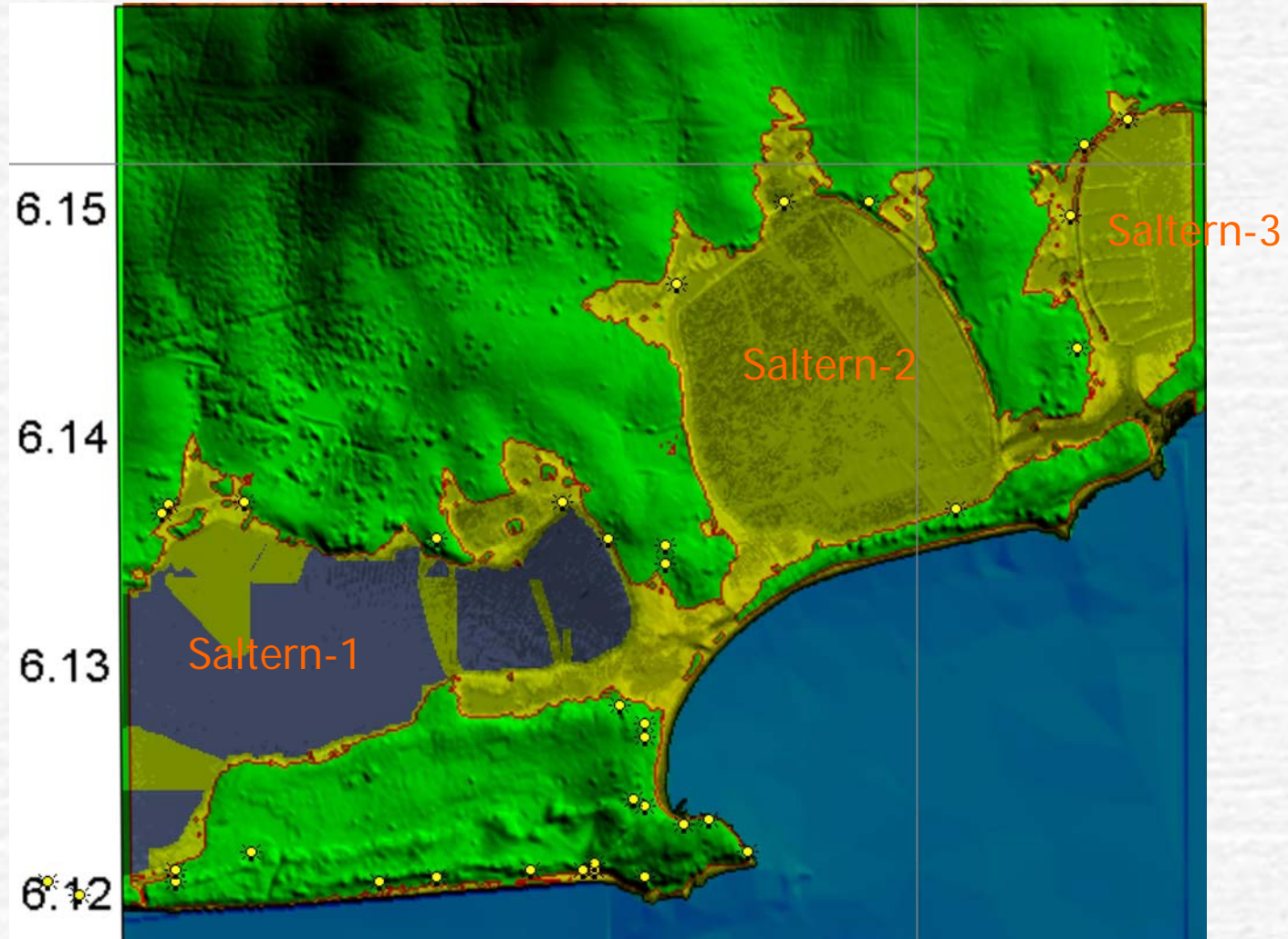
No bottom friction

Preliminary Model Results: Comparison with Field Measurements

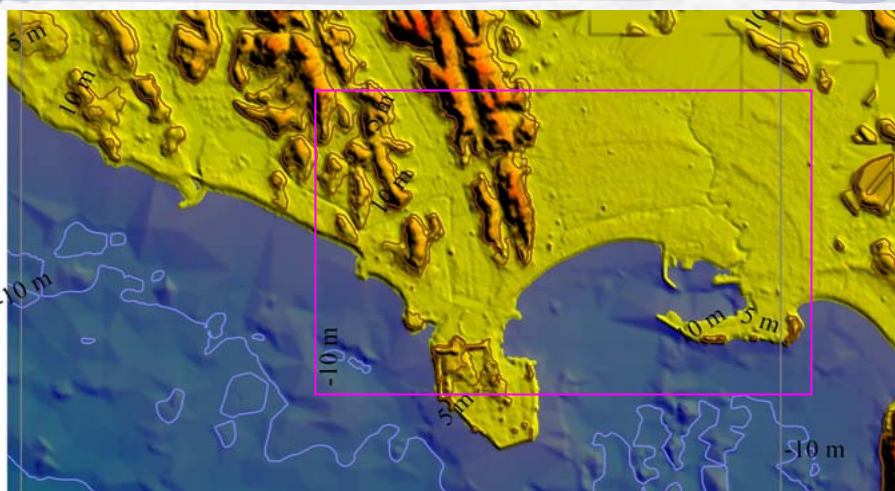


-  Area Inundated – Model Results (No Bottom Friction)
-  Field measurements of inundation

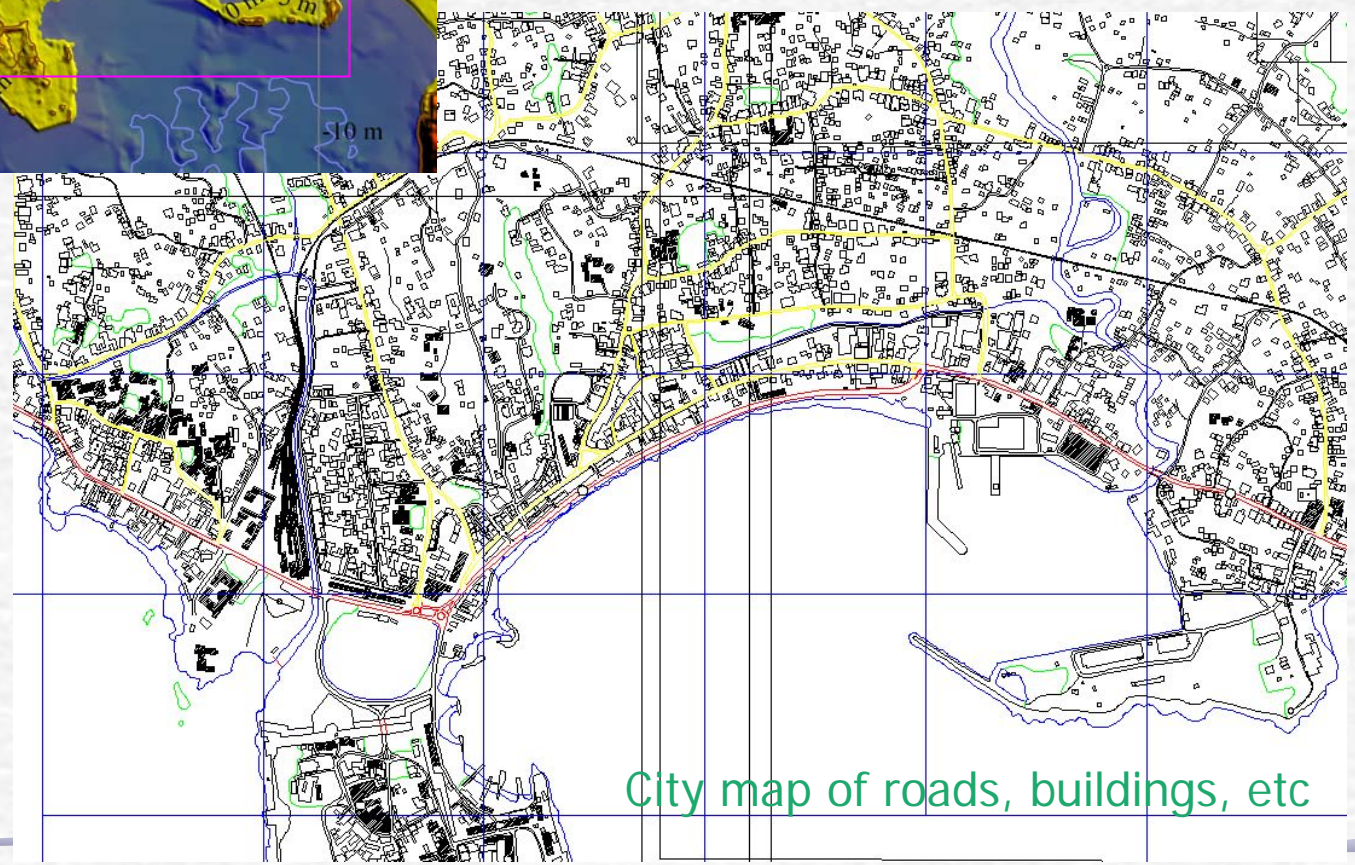
Preliminary Model Results: Comparison with Field Measurements



Simulation of Roughness, Effect of Obstructions & Vegetation, etc ??



LIDAR DGM:
- bare ground surface
- 90-95% of vegetation and man-made elevated features removed



City map of roads, buildings, etc



City of Galle (part of)