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

Janaka Wijetunge
Faculty of Engineering
University of Peradeniya, Sri Lanka
Deaths due to Natural Disasters in Sri Lanka
1993 - 2001

Landslides - 29
Floods - 6

Landslides - 15
Floods - 4

Landslides - 5
Floods - 1

Source: Dept. of Social Services, Sri Lanka
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
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

Large hotels: 53 out of 242
Small hotels: 248

Where Yala Safari Beach Hotel was ....
Nilawali Beach Hotel
How wide?

Post-tsunami

Government of Sri Lanka declared 100 – 200 m wide buffer zones
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
Post-Tsunami

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

- Ministers in charge of:
  - Reconstruction & Development - RADA
  - Social Services
  - Home Affairs
  - Health
  - Science & Technology
  - Housing
  - Coast Conservation
  - Irrigation
  - Power
  - Defence

- National Council for Disaster Management
  - Chair Person: H.E. President
  - Vice Chairmen: Prime Minister, Leader of Opposition

- Chief Ministers
- Opposition MPs

- DMC

- Provincial Councils
  - Local Authorities

- District Secretariats
  - Divisional Secretariats
  - Grama Niladaries
  - Village Task Forces

- Line Departments

(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?

Kalutara

Inundation Limit

~400m

~1000m
Detailed Inundation Measurements: Coastal Sectors Covered

Detailed inundation measurements at 300-400 m intervals
How high and How far Inland? – East Coast

Elevation below 10 m

Elevation (m)

Inundation Distance (m)

Tsunami Height (m)

Nilaveli
Trincomalee
Vakarai
Kalkudah
Batticaloa
Akkaraipattu
Potuvil
Panama

Population Density
Inundation Distance (m)

Tsunami Height (m)

Population Density
Tsunami Inundation Distance with Ground Slope

\[ y = 12.329x^{-0.7245} \]

\[ R^2 = 0.9026 \]
Sand Dunes on the South & South East Coasts of Sri Lanka

Shore-connected water bodies
City of Beruwala, West Coast

Extent of Inundation

HARBOUR

~ 3 km

175 m
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
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Civil & Environmental Engineering,
and funded by

[Logos of USAID and ASIA]
Topo & Bathy Data for Modeling

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

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

**Bathy Data:**

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

**DSM**
- Elevation from the first-return LiDAR pulse
- No segregation as to whether surface is man-made or natural
Modelling Tsunami Inundation
Cornell Multi-grid Coupled Tsunami Model (COMCOT)

The COMCOT tsunami model is a dynamically coupled combination of the following three components:

a) source model which creates the initial water surface disturbance given the earthquake parameters,

b) tsunami propagation from its origin to the nearshore coast,

c) tsunami run-up and inundation with a moving boundary.

It solves the linear/non-linear shallow-water equations.
Nested Grids for COMCOT Model

Layer 1: Galle
Layer 2: 250 m grid
Layer 3: 50 m grid
Layer 4: 10 m grids
Layer 41: Galle
Layer 42: Matara
Layer 43: Hambantota
Layer 1: $\Delta x = \Delta y = 0.6765$ min

### Source Model of Chen Ji

<table>
<thead>
<tr>
<th>Layer No.</th>
<th>Grid Spacing</th>
<th>Coordinate System</th>
<th>Linear/ Non-linear Equations</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.6765 min (~1250 m)</td>
<td>Spherical</td>
<td>Linear</td>
</tr>
<tr>
<td>2</td>
<td>0.1353 min (~250 m)</td>
<td>Spherical</td>
<td>Linear</td>
</tr>
<tr>
<td>3</td>
<td>50 m</td>
<td>Cartesian</td>
<td>Linear</td>
</tr>
<tr>
<td>4</td>
<td>10 m</td>
<td>Cartesian</td>
<td>Non-Linear</td>
</tr>
</tbody>
</table>
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??

LI DAR DGM:
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City map of roads, buildings, etc

City of Galle (part of)