Boxing Day Earthquake of 2004 – Impact on Sri Lanka

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Sri Lanka - History

Aborigines: ??

Sinhalese: From Northern India
           6th Century BC

Tamils: From Southern India

Portuguese Arrival: 1505 AD

Dutch Arrival: 1658 AD
Sri Lanka – History (Contd...)

British Arrival: 1786
British Conquering: 1815
Independence: 1948
Republic: 1972
Sri Lanka - Some Facts

Area: 65610 sq km (432 km↑, 224 km)
Population: 21.3 million
Government: Democratic Socialist Republic
Currency: Rupee (about 0.008 A$)
Literacy: 91%
Coastline: 1340 km
Sri Lanka - Topography

- Centrally located Highland region

- Lowland Plain
Sri Lanka - Natural Disasters

Frequent: Landslides, Floods, Droughts

Less Frequent: Cyclones

Rare: Tsunami, Earthquakes
Effects of Natural Disasters
(Discounting Tsunami !!!)

- Relief Expenditure – Droughts, Cyclones
- Deaths – Landslides
- Houses damaged – Cyclones and Floods
- Families affected – Drought
The Numbers (1993-2001)

<table>
<thead>
<tr>
<th>Type of Disaster</th>
<th>Deaths</th>
<th>Houses damaged/100</th>
<th>Families affected/100</th>
<th>Expenditure /million US$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Floods</td>
<td>46</td>
<td>1308</td>
<td>9411</td>
<td>2.7</td>
</tr>
<tr>
<td>Landslides</td>
<td>75</td>
<td>9</td>
<td>29</td>
<td>0.1</td>
</tr>
<tr>
<td>Sea Erosion</td>
<td>1</td>
<td>91</td>
<td>122</td>
<td>1.8</td>
</tr>
<tr>
<td>Cyclone</td>
<td>38</td>
<td>893</td>
<td>4366</td>
<td>5.8</td>
</tr>
<tr>
<td>Drought</td>
<td>0</td>
<td>0</td>
<td>8976</td>
<td>8.6</td>
</tr>
<tr>
<td>TOTAL</td>
<td>86</td>
<td>2301</td>
<td>22904</td>
<td>19.0</td>
</tr>
</tbody>
</table>
After 2001....

• 2003 — Cyclone induced floods and landslides
  – 240 deaths
  – over 200,000 displaced
  – over 80 million US$ direct damage

• 2004 — Boxing Day Tsunami
  – 35,000 deaths
  – 1 million affected
  – over 1.5 billion US$ direct damage
Boxing Day Tsunami
• Triggered by an earthquake that occurred off the coast of Sumatra, Indonesia

• Earthquake occurred at about 6:30 am, Sri Lankan time, on 26th December 2004

• Tsunami waves reached Sri Lanka around 8:30 am, SL time

• First on the east coast and continued to devastate 900 km (~67 %) of the Sri Lankan coastline
Tsunami Induced Inundation

Time – (Wave Height)
• Waves reached heights up to 15 m

• West coast was hit about 40 - 60 minutes after the east coast

• If there was some awareness, people could have run for safety

• 35000 lives lost mainly because of not having any Tsunami experience and no warning of any kind
Engineering Input

1. Assessment
2. Early Warning Systems
3. Recovery and Reconstruction
   - Housing,
   - Transport etc.
3. Research
4. Education
Assessment

- Is this the biggest tsunami that can be expected in Sri Lanka?

- Nearshore tsunami amplitudes corresponding to all identified “maximum credible” potential geophysical scenarios have been computed and evaluated.

- These evaluations suggest that the tsunami of boxing day 2004 could be considered as the “worst case” for Sri Lanka\(^1\)
Early Warning Systems in Sri Lanka

Sri Lanka was considered immune from seismic activities. Systems were in operation for floods, landslides, droughts etc.

Although some research in possible seismic related hazards were being carried out at Universities\(^3\),\(^4\), there was no implementation policy.

For example, although there were sufficient no. of installed seismographs in the country there was no systematic real time analysis of recorded data.
Early Warning Systems in SL (contd..)

Some systems adopted after the Boxing Day Tsunami are:

- Early warning towers
- Police and Military communication systems\(^2\)
Early Warning Systems in SL (contd..)

- Disaster Emergency Warning Network (phone/sms)²
Early Warning Systems in SL (contd..)

- Intra Governmental Network

- Satellite Communication Network\(^2\)
Early Warning Systems in SL (contd..)

- Land Line Telephones, Fax,
- Radio Communication Network\(^2\)
Early Warning Systems in SL (contd..)

- Mobile Network
- Email, internet, media, social media
- Call centers$^2$
Early Warning – Reaching Vulnerable Communities
Use of New technologies for Early Warning - Japan Vs Sri Lanka

The graph compares the use of new technologies for early warning in Japan and Sri Lanka across different categories:

- **Available new technological early warning methods**
  - Japan: 90%
  - Sri Lanka: 60%

- **Public response for new technological early warning**
  - Japan: 90%
  - Sri Lanka: 80%

- **Operational arrangement of new early warning system**
  - Japan: 95%
  - Sri Lanka: 70%

- **Reliability of new early warning systems**
  - Japan: 80%
  - Sri Lanka: 60%

- **Maintenance and upgrades**
  - Japan: 90%
  - Sri Lanka: 80%

The different impact of New technological EW Methods is visualized with bars and dotted lines, indicating the percentage of effectiveness in each category.
Recovery and Reconstruction

Reconstruction phase commenced immediately after the disaster. Swift actions were taken by the authorities.

Combined Local and International assistance helped Sri Lanka in recovery and reconstruction.

A report from Asian Development Bank summarized the losses and needs in monetary terms.\(^5\)
# Losses and Financing Needs

**Note:** Output loss is not included

<table>
<thead>
<tr>
<th>Sector</th>
<th>Asset Loss</th>
<th>Output Loss***</th>
<th>Short Term</th>
<th>Medium Term</th>
<th>Total Needs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Housing</td>
<td>306-341</td>
<td>-</td>
<td>50</td>
<td>387-437</td>
<td>437-487</td>
</tr>
<tr>
<td>Roads</td>
<td>60</td>
<td>-</td>
<td>25</td>
<td>175</td>
<td>200</td>
</tr>
<tr>
<td>Water and Sanitation</td>
<td>42</td>
<td>-</td>
<td>64</td>
<td>53</td>
<td>117</td>
</tr>
<tr>
<td>Railways</td>
<td>15</td>
<td>-</td>
<td>40</td>
<td>90</td>
<td>130</td>
</tr>
<tr>
<td>Education</td>
<td>26</td>
<td>-</td>
<td>13</td>
<td>32</td>
<td>45</td>
</tr>
<tr>
<td>Health</td>
<td>60</td>
<td>-</td>
<td>17</td>
<td>67</td>
<td>84</td>
</tr>
<tr>
<td>Agriculture*</td>
<td>3</td>
<td>-</td>
<td>2</td>
<td>2</td>
<td>4</td>
</tr>
<tr>
<td>Fisheries*</td>
<td>97</td>
<td>200</td>
<td>69</td>
<td>49</td>
<td>118</td>
</tr>
<tr>
<td>Tourism*</td>
<td>250</td>
<td>130</td>
<td>130</td>
<td>-</td>
<td>130</td>
</tr>
<tr>
<td>Power</td>
<td>10</td>
<td>-</td>
<td>27</td>
<td>40-50</td>
<td>67-77</td>
</tr>
<tr>
<td>Environment</td>
<td>10</td>
<td>-</td>
<td>6</td>
<td>12</td>
<td>18</td>
</tr>
<tr>
<td>Social Welfare**</td>
<td>-</td>
<td>-</td>
<td>30</td>
<td>-</td>
<td>30</td>
</tr>
<tr>
<td>Excluded Items plus</td>
<td>90</td>
<td></td>
<td>30</td>
<td>120</td>
<td>150</td>
</tr>
<tr>
<td>Contingency ***</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Total ($ Millions, rounded)</strong></td>
<td><strong>970-1,000</strong></td>
<td><strong>330</strong></td>
<td><strong>500</strong></td>
<td><strong>1,000-1,100</strong></td>
<td><strong>1,500-1,600</strong></td>
</tr>
<tr>
<td><strong>Percent of GDP</strong></td>
<td><strong>4.4-4.6</strong></td>
<td><strong>1.5</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Recovery and Reconstruction (contd...)

>99000 houses completely destroyed

>35000 houses damaged

~450000 people were made homeless

Revival of communities – restoration of lives, livelihoods and social networks – via reconstruction of physical assets and infrastructure
Recovery and Reconstruction (contd…)

Many coastal structures were damaged. These can be broadly classified as:

- Transport structures (one main railway line and several highways)
- Single and multi-storey structures
- Boundary walls
- Water tanks
Damaged Railway Line
Scouring of Foundations
Effect of Weight
Wave height can be singled out as one of the primary parameters that defines the damage

<table>
<thead>
<tr>
<th>Wave Height</th>
<th>Effect</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt; 2 m</td>
<td>Damage of Boundary walls of 1 – 2 m height</td>
</tr>
<tr>
<td>2 - 3 m</td>
<td>Damage of single storey masonry structures</td>
</tr>
<tr>
<td>3 - 4 m</td>
<td>Damage and complete tilting and sliding of single storey masonry structures</td>
</tr>
<tr>
<td>4 - 5 m</td>
<td>Damage to multi storey structures, mostly due to scouring of foundations</td>
</tr>
</tbody>
</table>
Recovery and Reconstruction (contd...)

Some cities/towns were completely wiped out and it was decided to adopt state of the art city planning concepts in re-development.

Reconstruction was carried out focusing on new and improved design methods so that the damage is minimized in any future event of similar nature
Recovery and Reconstruction (contd...) 

Some structural considerations are:

- Avoiding masonry construction at least for heights up to 5m
- Strengthening of corner columns
- Use of plinth level beams
- Tying down of structures
- Use of improved soil for backfilling of foundations
- Focus on piers and foundations more than the deck in case of bridge construction
Reconstruction with new designs (courtesy, Prof. Priyan Dias, University of Moratuwa, Sri Lanka)
Recovery and Reconstruction (contd...)

Other possible suggested measures are:

- Use of columned ground (first) floor in multi storey buildings
- Use of sand dune barriers
- Provision of vegetation barriers
Research (in Engineering)

• Sri Lanka was considered aseismic
• Several new research areas emerged
• Seismicity of Sri Lanka
  - Determination of Possible ground accelerations\(^3,4,7,8\)
  - Inclusion of their effects in design codes
• Tsunami waves and their effects
  - Design of Coastal structures
  - Preservation of the coast
Education

Revision of curricula
  – universities
  – schools of primary and secondary levels

General public
  – seismicity of Sri Lanka and possible effects
  – new design aspects of coastal structures
References


References (contd...)


Thank you very much