Coastal Hazard and Climate-Change Risk Exposure in New Zealand: Comparing Regions and Urban Areas

Rob Bell, Ryan Paulik and Sanjay Wadhwa
NIWA
New Zealand
Background to the national coastal risk-exposure study

• No consistent national study has previously been undertaken in NZ:
  – Inaccurate national DEM (10-m contours + Shuttle Radar Topography)
  – National asset/building database only now available – but needed 11,300 more buildings added to coastal areas <10 m
  – Several regional vertical datums and no consistent definition of MHWS
  – Inconsistent protocols and standards for LiDAR surveys between regions

• NZ Parliamentary Commissioner for the Environment commissioned NIWA to proceed with such a national study focused on sea-level rise exposure, using LiDAR DEMs where available

• Opportunity to assess current national DEM and other geospatial datasets
National DEM ($\sigma = 3$-4 m) vs LiDAR ($\sigma = 0.15$ m)

0–5 m

0–1.5 m

Firth of Thames

Thames

(m) MHW
- $< 3$
- $3$ - $5$
RiskScape: overlays hazard & assets = risk exposure
Methodology: national coastal risk-exposure study

- Set MHWS on a consistent national basis: MHWS-10 plus MSL offset
- Intersect Digital Elevation Models (DEMs) with surfaces in elevation bands e.g. 0.25, 0.5, 1, 1.5, 2, 2.5, 3 m above MHWS-10
- Clip polygons to land-water boundaries (coast, estuaries, rivers)
- Overlay elevation-band polygons on RiskScape assets (<10 m elevation), NZ LandCover Database (v4) & Stats NZ 2013 Census
- Enumerate point data & lengths of poly-lines
  - e.g. points = buildings, airports; lines = roads, railway
- Aggregate risk exposure (counts) to urban areas (UAs), council areas, regions and nationally
National aggregates: < 0.5 m above MHWS-10

- Population (NZ Census 2013)
  - ~40,000 people

- Buildings
  - Residential: ~9,000
  - All types: ~13,000
  - Replacement cost NZ$3B (2011)

- Jetties & wharves
  - ~1,500 structures
Main urban area:  < 0.5 m above MHWS-10

<table>
<thead>
<tr>
<th>Urban area</th>
<th>Houses</th>
<th>Roads (km)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dunedin</td>
<td>2,683</td>
<td>35</td>
</tr>
<tr>
<td>Napier</td>
<td>1,321</td>
<td>37</td>
</tr>
<tr>
<td>Christchurch</td>
<td>901</td>
<td>40</td>
</tr>
<tr>
<td>Whakatane</td>
<td>276</td>
<td>9</td>
</tr>
<tr>
<td>Auckland</td>
<td>108</td>
<td>9</td>
</tr>
<tr>
<td>Wellington/Hutt</td>
<td>103</td>
<td>2</td>
</tr>
<tr>
<td>Tauranga</td>
<td>77</td>
<td>3</td>
</tr>
<tr>
<td>Nelson</td>
<td>64</td>
<td>6</td>
</tr>
<tr>
<td>Motueka</td>
<td>45</td>
<td>4</td>
</tr>
</tbody>
</table>

These urban areas ~63% of national house total in elevation zone < 0.5 m
Building replacement cost (all types): by elevation band

- **Waikato**
- **Otago**
- **Wellington/Hutt**
- **Auckland**
Coastal risk exposure: 0–1.5 m above MHWS-10

BUILDINGS AFFECTED

$19 billion to replace all buildings (2011)
68,170 buildings total
43,680 homes
133,265 people in homes

NATIONAL INFRASTRUCTURE

382 critical-facility buildings
5 airports
1,547 jetties and wharves
2,121 km of roads (1,930 km local)
46 km of railway

Source: Build Magazine/NIWA
Comparison using DEMs in 0–3 m coastal elevation band

<table>
<thead>
<tr>
<th>Risk receptor</th>
<th>Existing national DEM</th>
<th>Available LiDAR DEMs*</th>
<th>Underestimate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total No. of buildings</td>
<td>89,780</td>
<td>166,750</td>
<td>54%</td>
</tr>
<tr>
<td>Residential buildings</td>
<td>60,900</td>
<td>109,117</td>
<td>56%</td>
</tr>
<tr>
<td>Critical-facility buildings</td>
<td>506</td>
<td>1,014</td>
<td>50%</td>
</tr>
<tr>
<td>Total replacement cost</td>
<td>$24B (2011)</td>
<td>$52B (2011)</td>
<td>46%</td>
</tr>
<tr>
<td>Population (resident)</td>
<td>163,643</td>
<td>281,902</td>
<td>58%</td>
</tr>
<tr>
<td>Land parcels</td>
<td>176,526</td>
<td>293,900</td>
<td>60%</td>
</tr>
<tr>
<td>km of road (all types)</td>
<td>1,706</td>
<td>3,908</td>
<td>44%</td>
</tr>
<tr>
<td>km of railway</td>
<td>72</td>
<td>154</td>
<td>47%</td>
</tr>
</tbody>
</table>

* excludes Taranaki, Manawatu-Wanganui, Marlborough, West Coast, Southland (~10% of NZ risk exposure)
Coastal risk exposure: Roads (km) 0–1.5 m above MHWS-10

![Bar chart showing the km of road for different regions with LiDAR data. The chart includes regions such as Waikato, Canterbury, Bay of Plenty, Otago, Hawke's Bay, Auckland, Tasman, Northland, Wellington, Nelson, Gisborne, Taranaki, Manawatu-Wanganui, West Coast, Southland, and Marlborough. The chart also indicates Local Road, Collector Road, Arterial Road, and Motorway/Expressway categories.](Image)
The rising challenge for NZ coastal areas

- Only 0.6% of NZ area below 3 m (MHWS-10)
- ~6% of NZ’s building replacement cost (2011)
- 6.6% of NZ’s resident population (2013)
- Increasing risk as sea levels rise by 0.5 to 1 m (or more) by 2100

**0→1.5 m elevation zone in NZ:**
- 68,000 buildings ($19B, 2011) – 133,000 residents
- 2,120 km road (~90% local roads) – 46 km railway
- 185,900 land parcels

**0→3 m elevation zone in NZ:**
- 3,900 km road [1.8×] – 154 km railway [3.3×]
- 293,900 land parcels [1.6×]
Key findings and gaps: geospatial datasets

- **LiDAR (essential)** – current national DEM underestimates risk by **half or more**
  - Land Information NZ project to develop a hi-res, accurate DEM
  - Procurement standards for LiDAR
- **Land-water boundaries** – need high-res plus as coastlines increasingly change incl. MHWS – updates more crucial
- **Consistent methodology and measurements:**
  - tide levels e.g. MHWS; need for high-tide data in estuaries, creeks
  - vertical datum (new national vertical datum later in 2016),
- **Accurate asset/location data (infrastructure) with vulnerability attributes**