GIS where have we been? Where are we going?

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Sydney Coastal Councils Group & Surveying and Spatial Sciences Institute

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University of Wollongong

GeoQuEST Research Centre

Talk Outline

- Coastal Awareness
- Sea-level rise- a GIS problem?
- Linear Mapping of the coast

  - DINAS-Coast- DIVA

  -Coastal Vulnerability Index

  - Geomorphic Stability Mapping- Smartline
- ‘Non-linear’ mapping of the coast

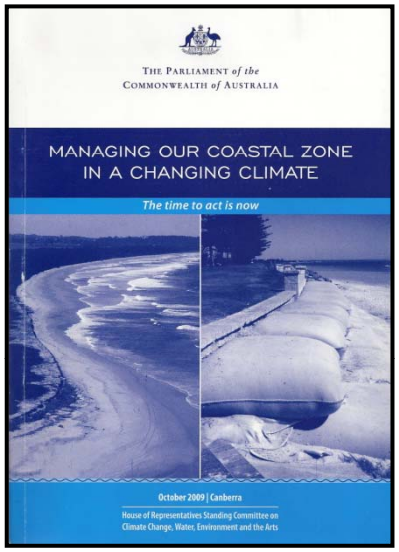
  - CVAT-NOAA’s risk analysis approach

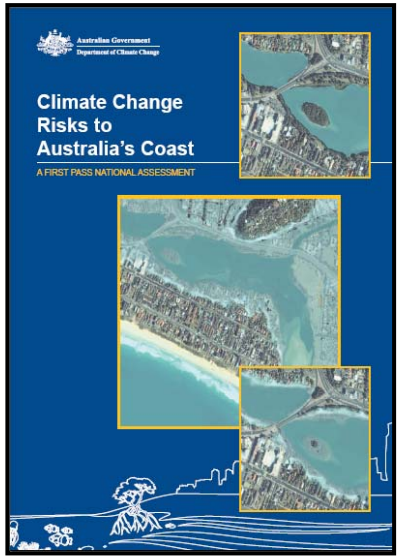
  - mapping exposure, sensitivity and adaptive capacity

  - DTMs and the mapping of potential inundation
- Conclusion

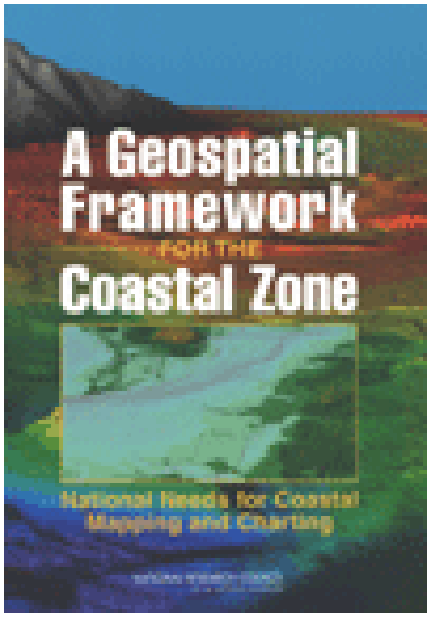
Coastal awareness ~ climate change

- NSW Draft sea-level policy – and associated guidelines
- Managing our coastal zone in a changing climate
  - Parliamentary inquiry
- Climate Change risks to Australia's coast
  - Dept of Climate Change





Increased awareness and geospatial tools



‘This convergence of technology and scientific awareness heralds a new era of geospatial data handling and products that, for the first time, may allow us to address some of the key challenges faced by those charged with understanding and managing the coastal zone’

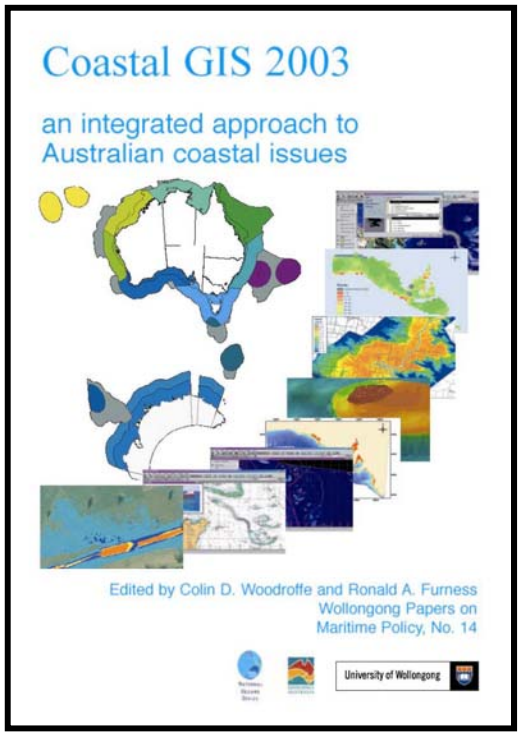
National Research Council, Washington, DC, 2004

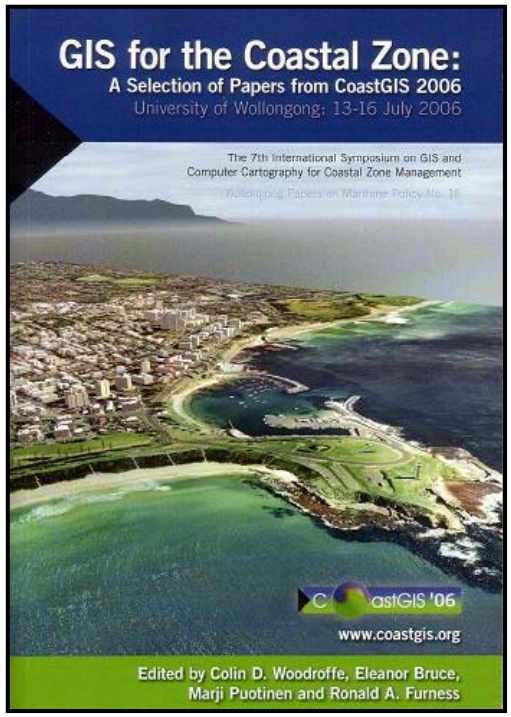
A Geospatial Framework for the Coastal Zone p. ix

In NSW – the Comprehensive Coastal Assessment report by Department of Planning, geospatial datasets – and toolkit

Coastal GIS Conferences

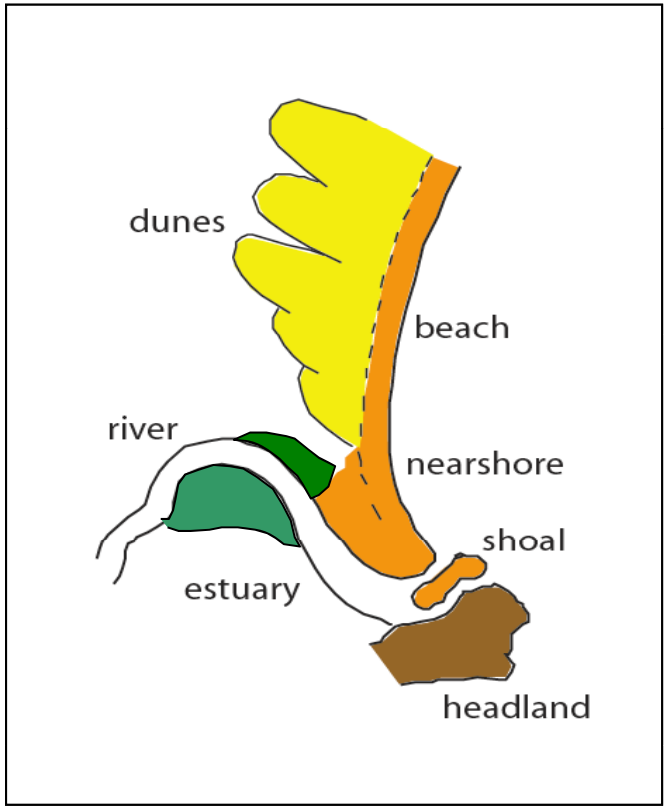
- 2003 – Coastal GIS – Australia-New Zealand – Workshop at University of Wollongong
- 2006 – CoastGIS International conference at University of Wollongong

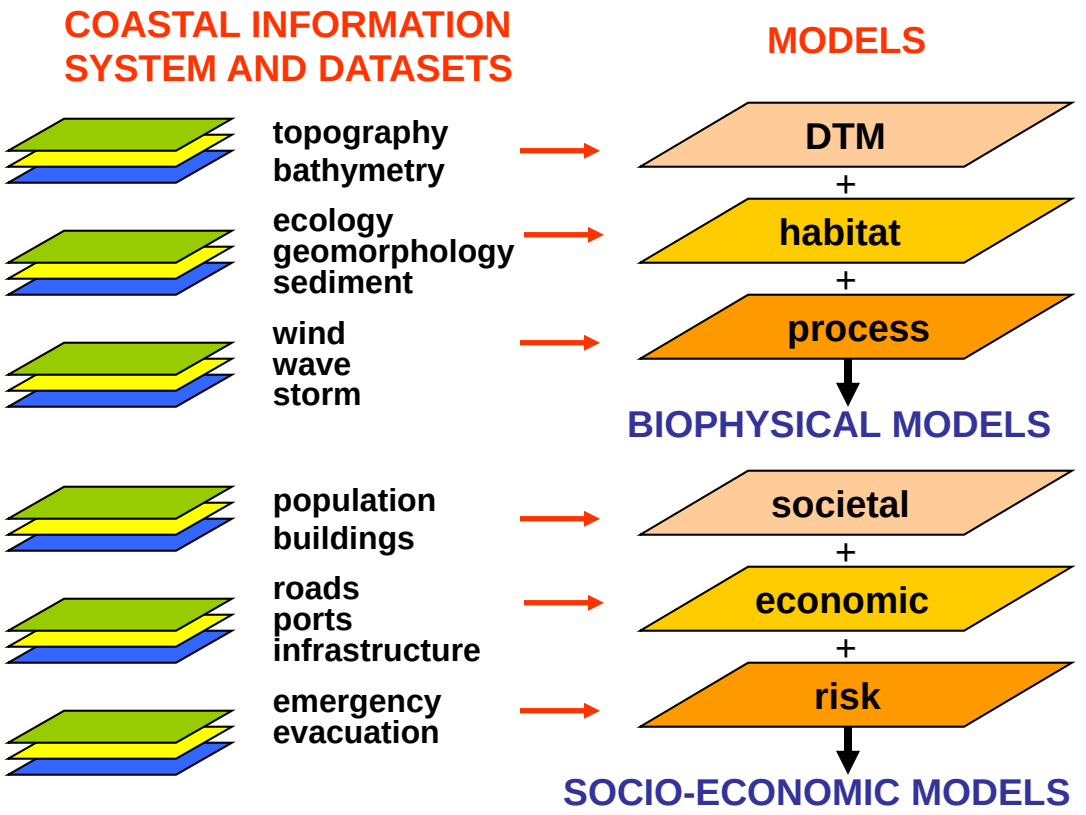




The potential

- GIS offers a means of storing and integrating a wide range of geospatial data

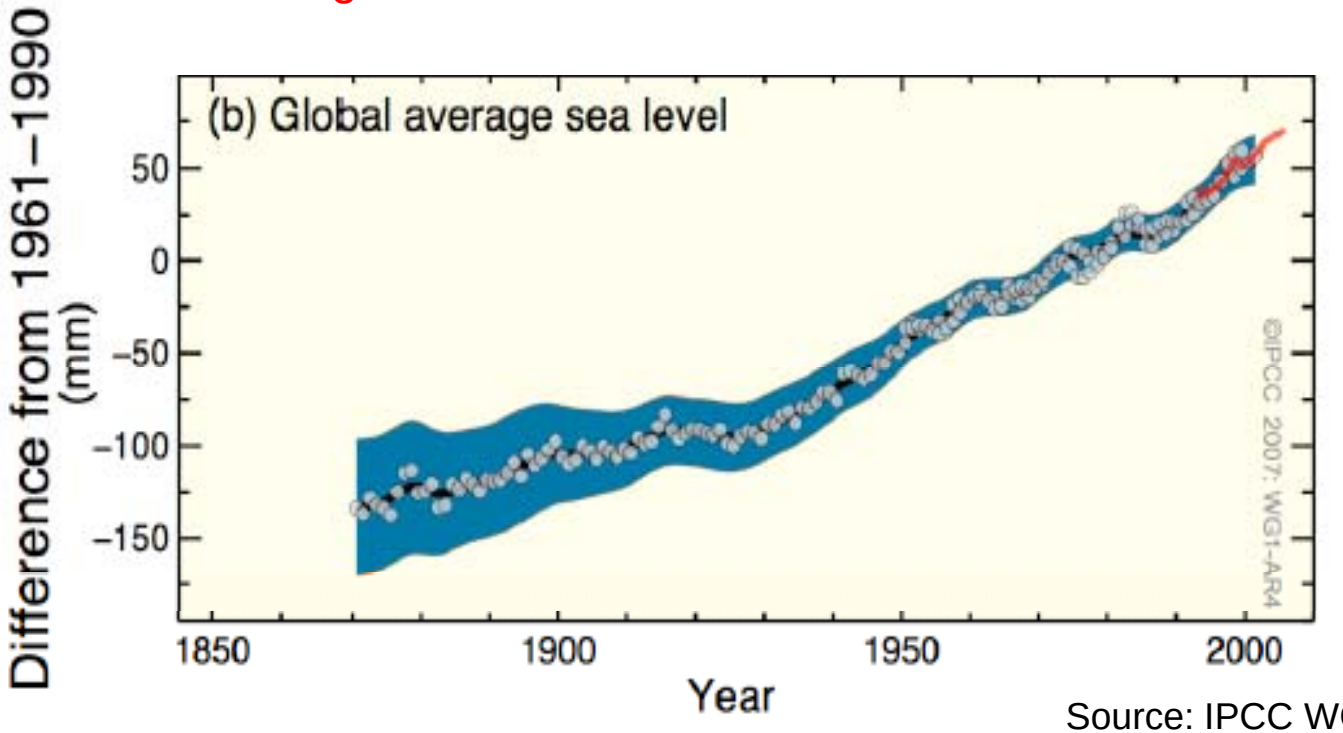




Sea-level rise ~ a GIS problem?

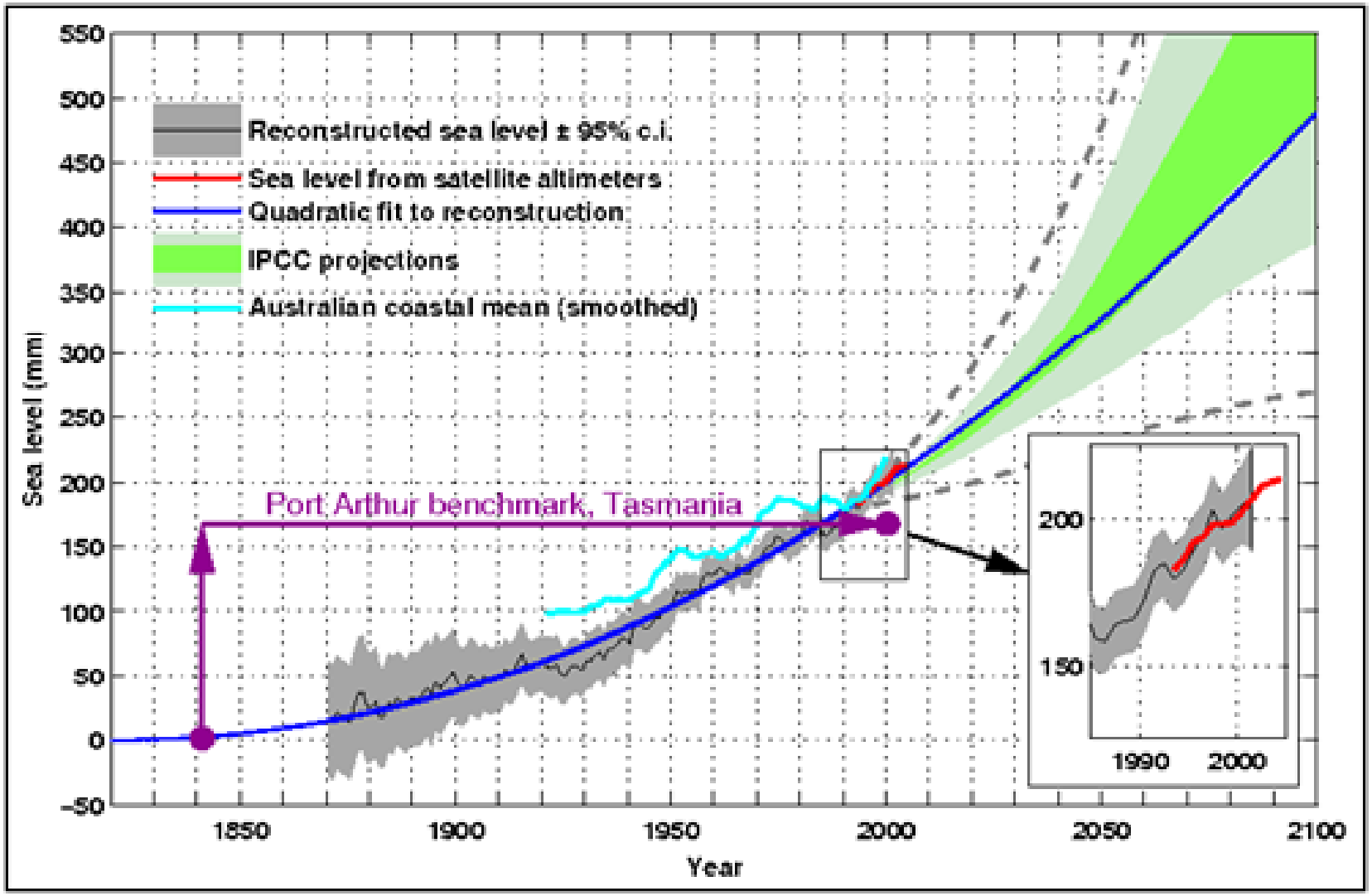
- Sea level:
  - Global average rate of rise 1961-2003 – 1.8 mm/yr
  - Global average rate of rise 1993-2003 – 3.1 mm/yr
  - Projected rise by 2100 – 0.18–0.59 m, continuing beyond 2100

Even if global emissions stabilised – sea level will continue to rise



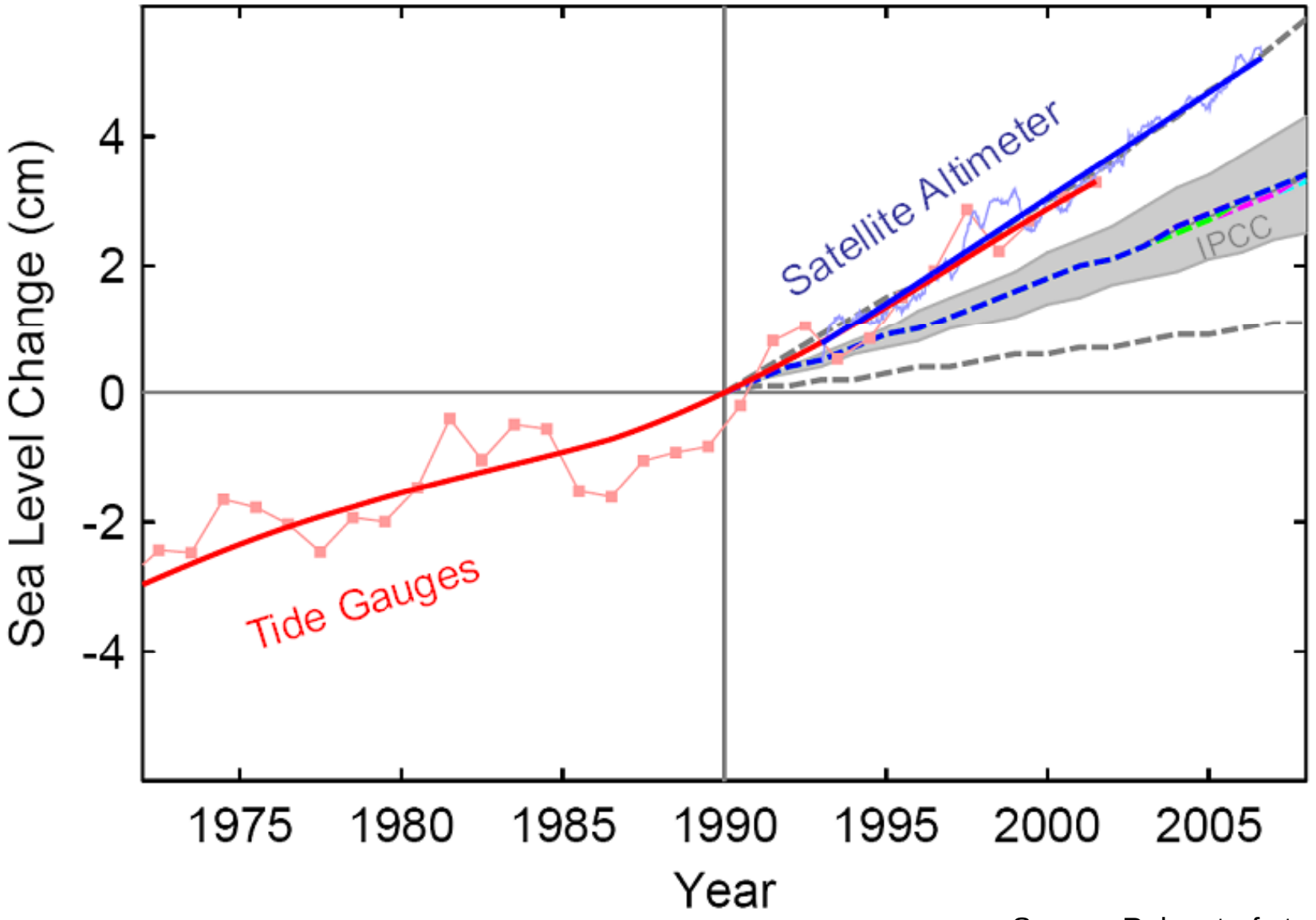
Source: IPCC WGI, SPM, April 2007

Sea-level rise ~ Australia



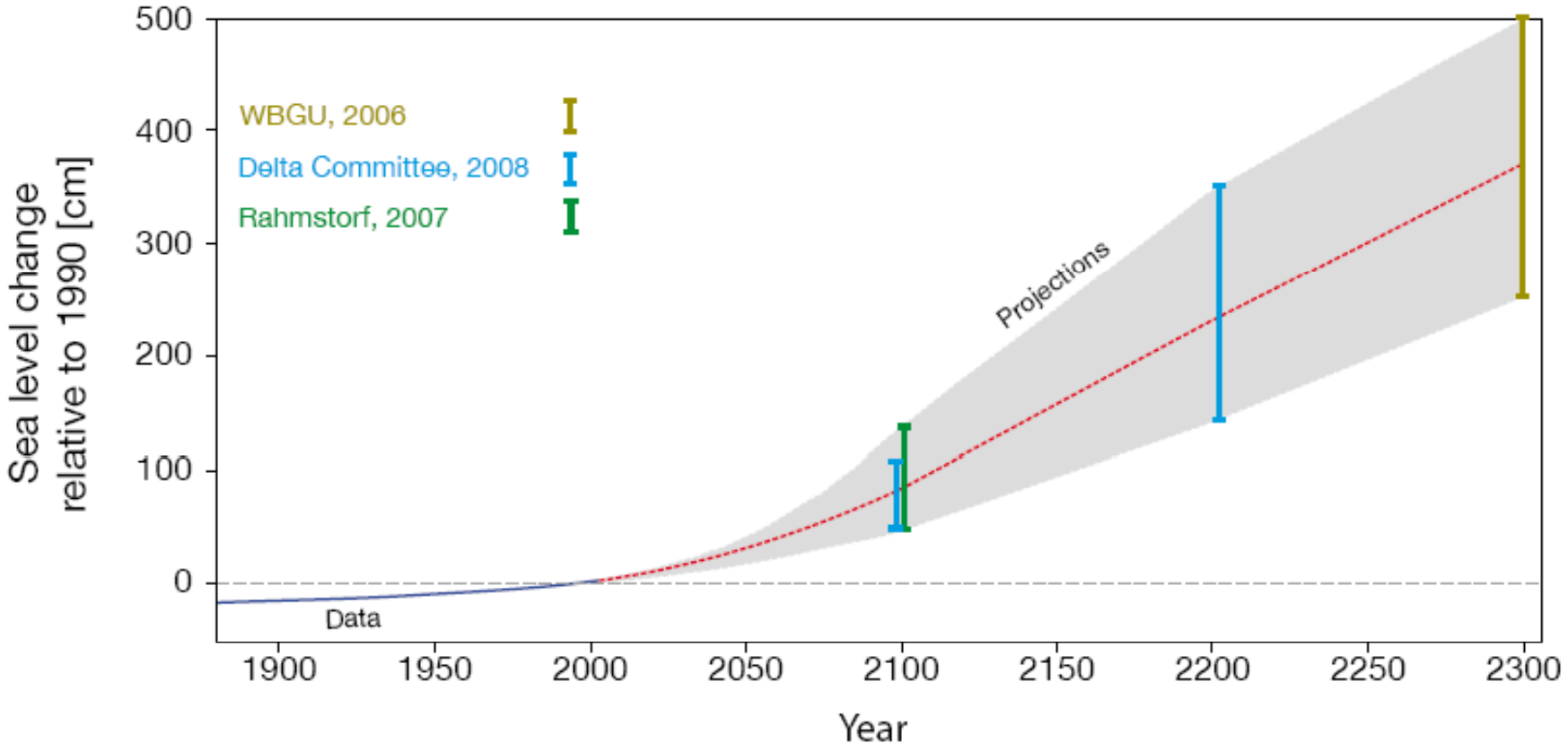
Source: John Hunter, 2007

Observed sea-level rise ~ upper IPCC



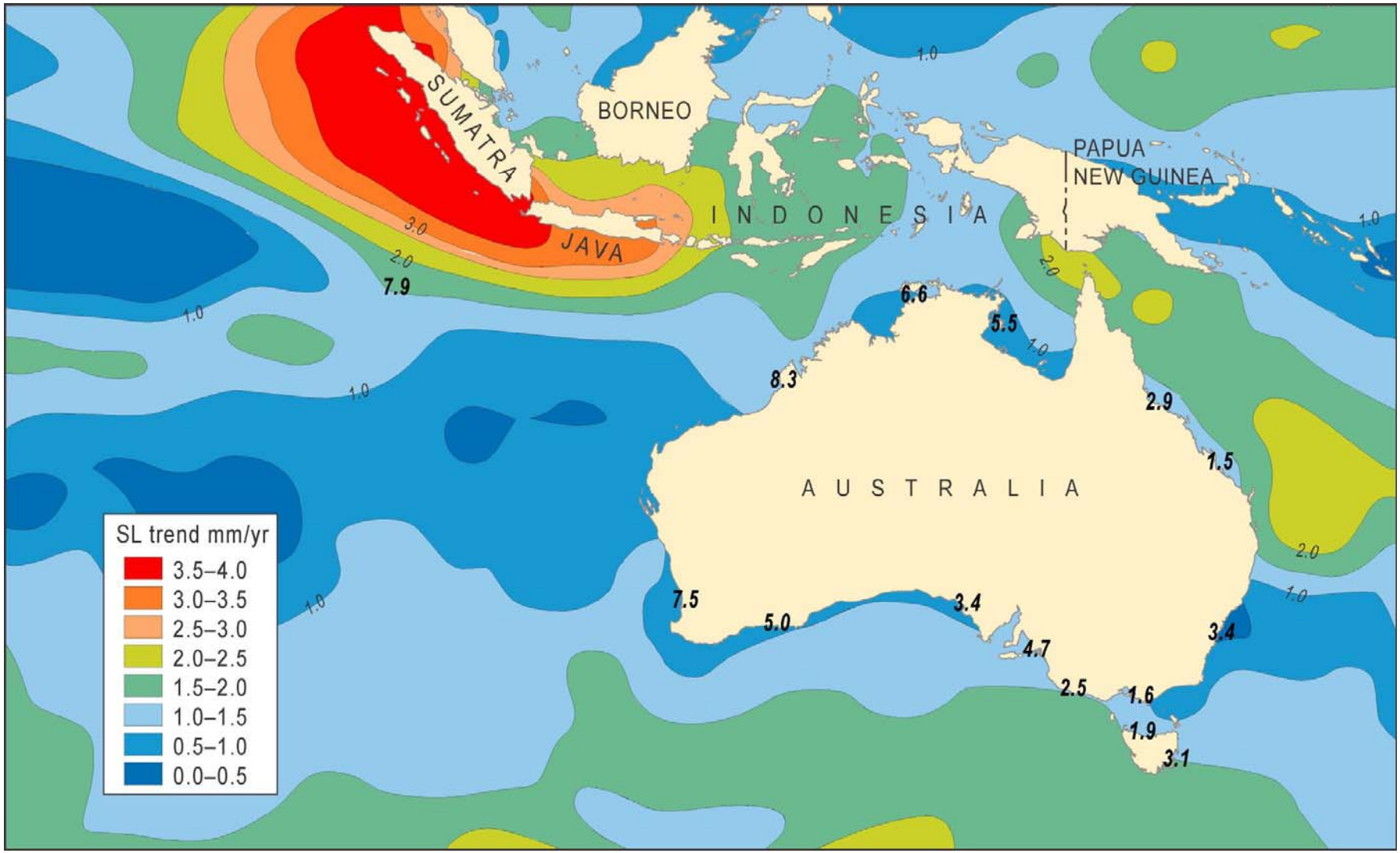
Source: Rahmstorf et al., 2007

Recent sea-level rise estimates



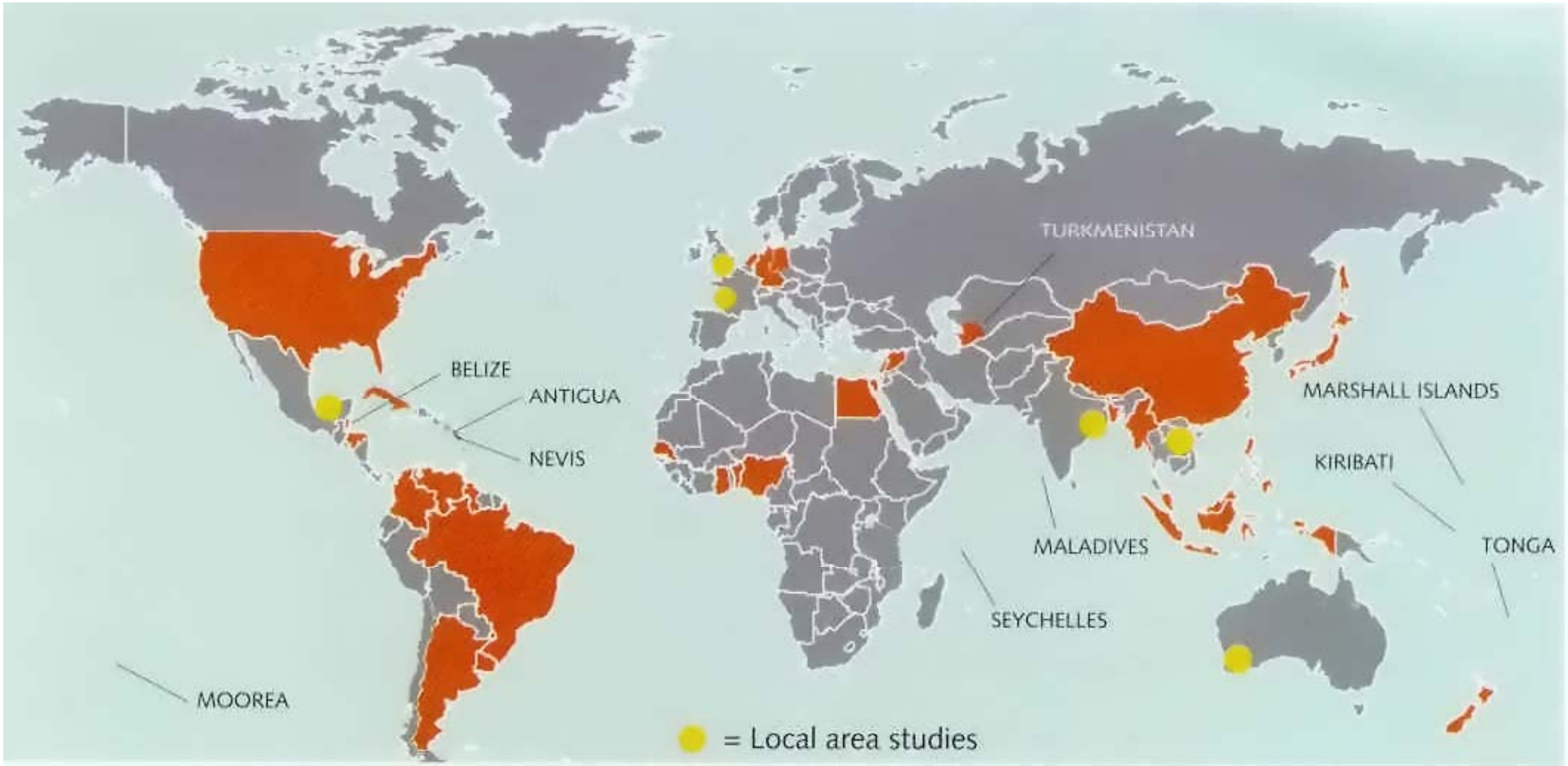
Source: Copenhagen Diagnosis, November 2009

Sea-level rise ~ Australia



Source: 50-year sea-level trend, Church et al., 2006; SEAFRAME gauges BoM Tidal Centre, July 2007; Short and Woodroffe, 2009

IPCC Common Methodology



IPCC Common Methodology ~ and beyond

CM – Definition of study area; Collection of data; Assessment of change; Response

Australian Approaches	International Approaches
ACVAP, 9 case studies	**SimClim: Bruun-based model**
Holocene geomorphology model (SA)	**LOICZ: cell-based typology**
Wetland assessment/mapping (WA/NT)	**DINAS-Coast, DIVA Model**
Bruun-based 2D beach model (Tas)	**CVI segmentation model**
Storm-tide recurrence model (QLD)	**CVAT community mapping tool**
Probabilistic/fuzzy approach (NSW)	**Flooding-Bruun based model**

Source: Abuodha and Woodroffe, 2006

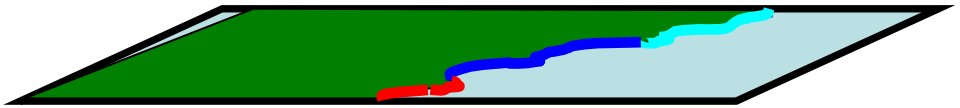
Linear vs ‘non-linear’ mapping of the coast

- Linear approaches to vulnerability analysis
  - DINAS-Coast – DIVA
  - Coastal Vulnerability Index (CVI)
  - Geomorphic Stability Mapping - Smartline

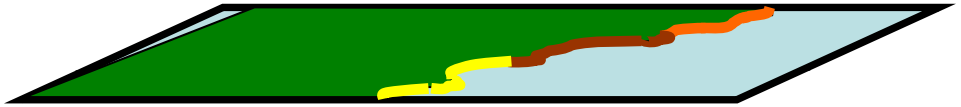
- Other approaches to vulnerability analysis
  - CVAT – NOAA’s risk analysis approach
  - Mapping exposure, sensitivity and adaptive capacity
  - DTMs and the mapping of potential inundation

The DINAS-Coast and DIVA tool

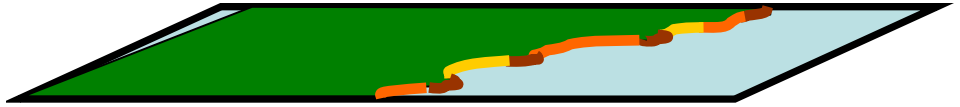
Administrative units



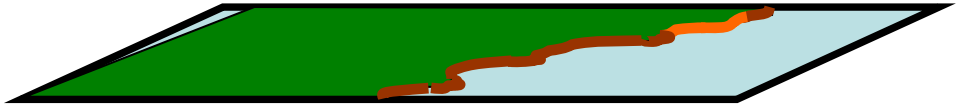
Population density



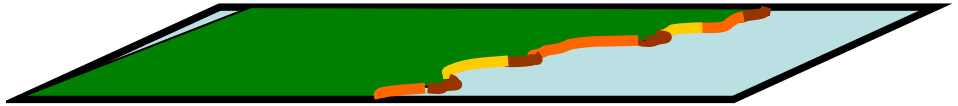
Physical environment



Landform evolution



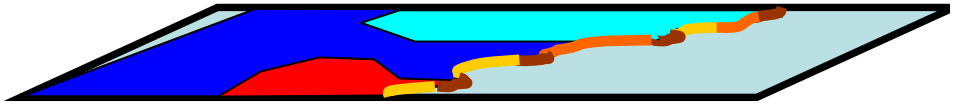
Global segmentation



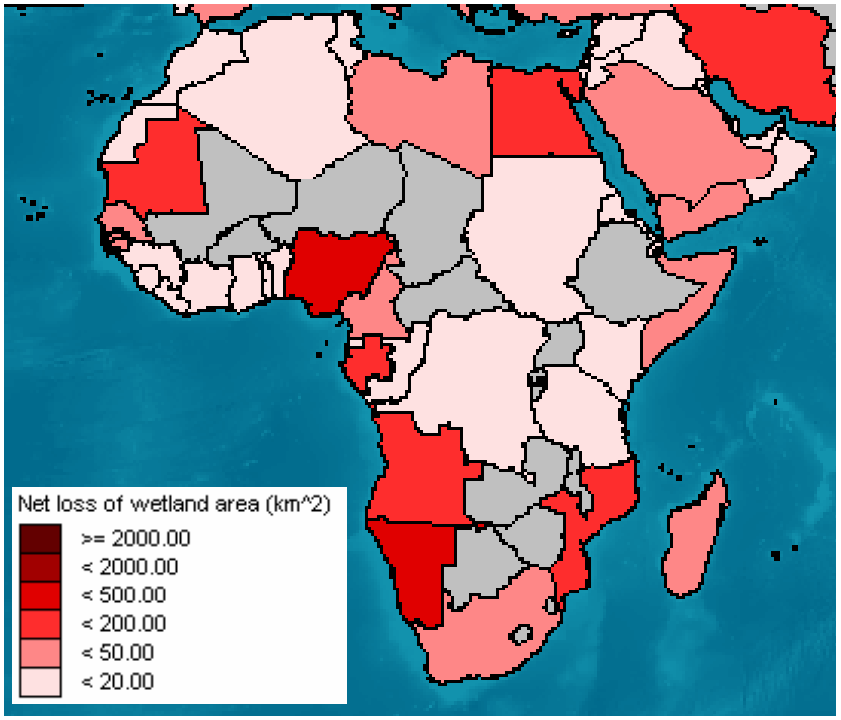
Additional attributes

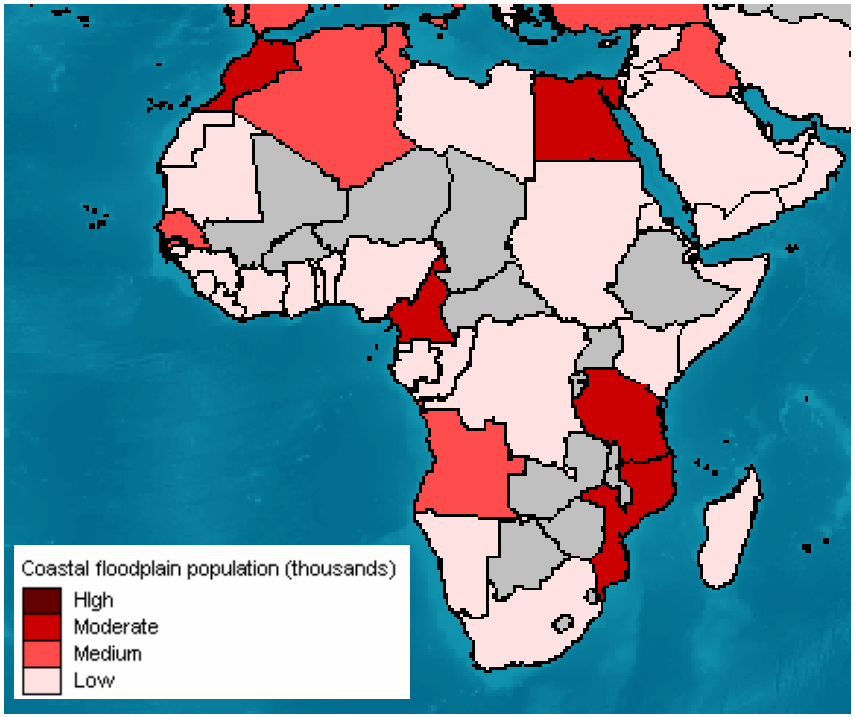
Elevation classes
Bruun factor
Adaptation strategies

DIVA vulnerability classes



DIVA segmentation of the coast



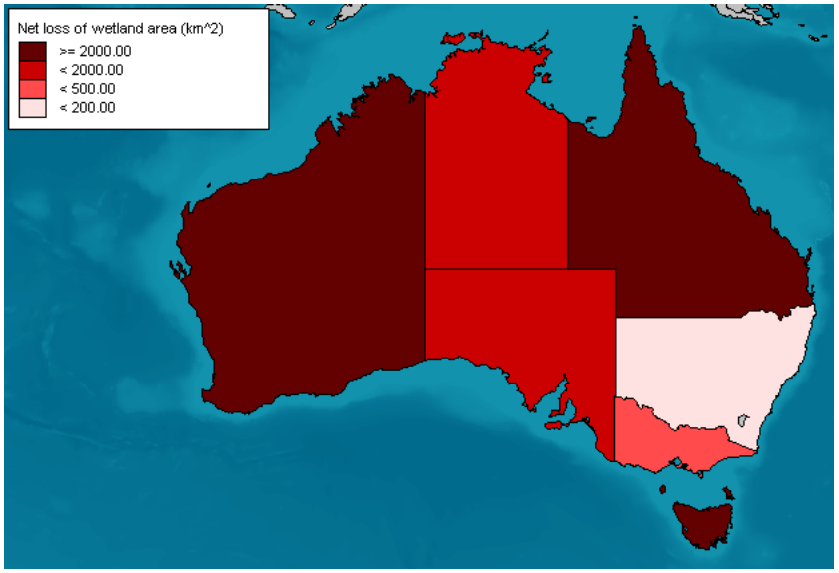


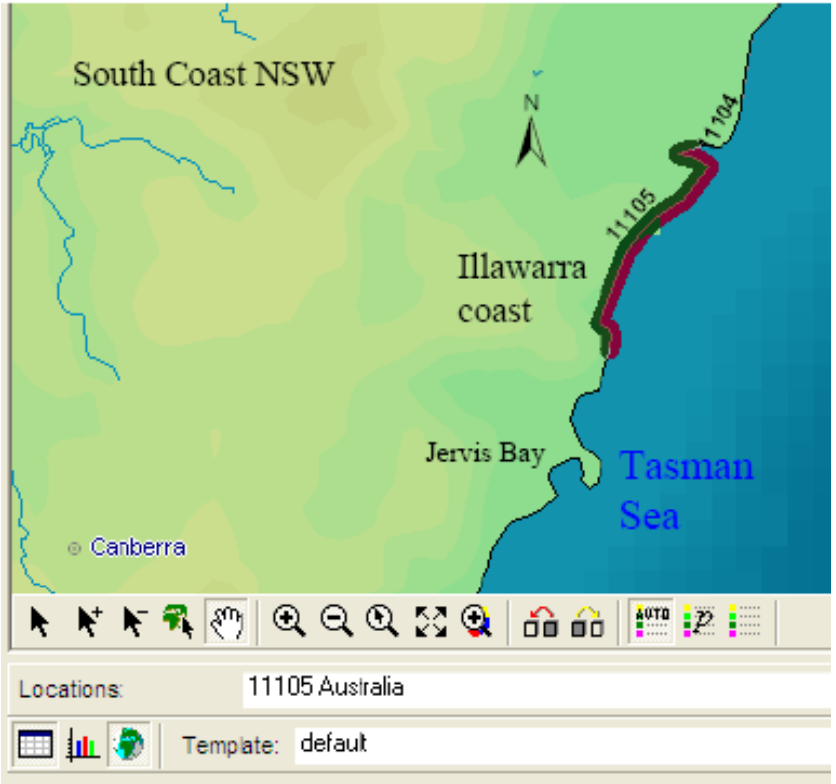
A global tool, enabling SRES scenarios and adaptation options to be selected by user

Administrative unit level – countries in case of Africa

Source: the DINAS-Coast Consortium database

DIVA Output





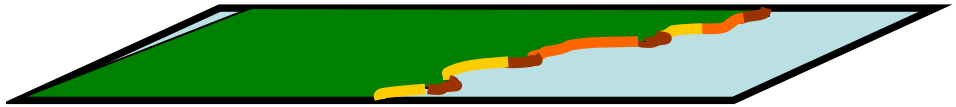
administrative unit level
– state in case of Australia

The Illawarra coast is represented by 1 segment

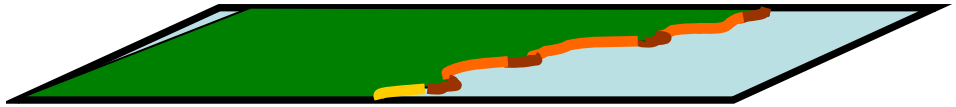
Source: the DINAS-Coast Consortium database

A Coastal Vulnerability Index

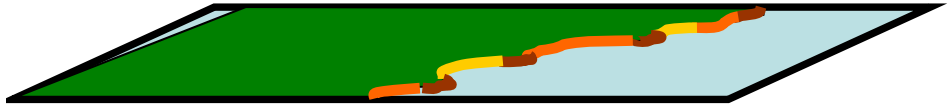
Geomorphology



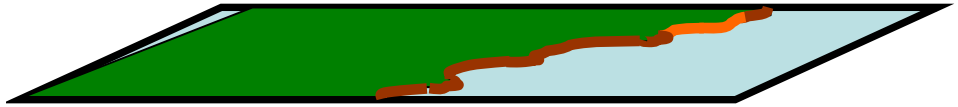
Shoreline change



Slope



Relative sea-level rise

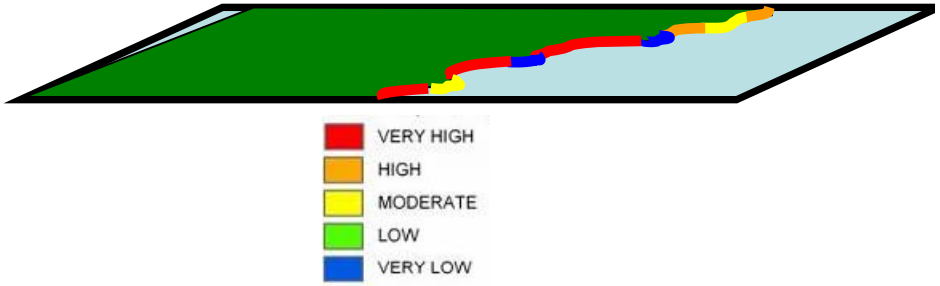


Wave height

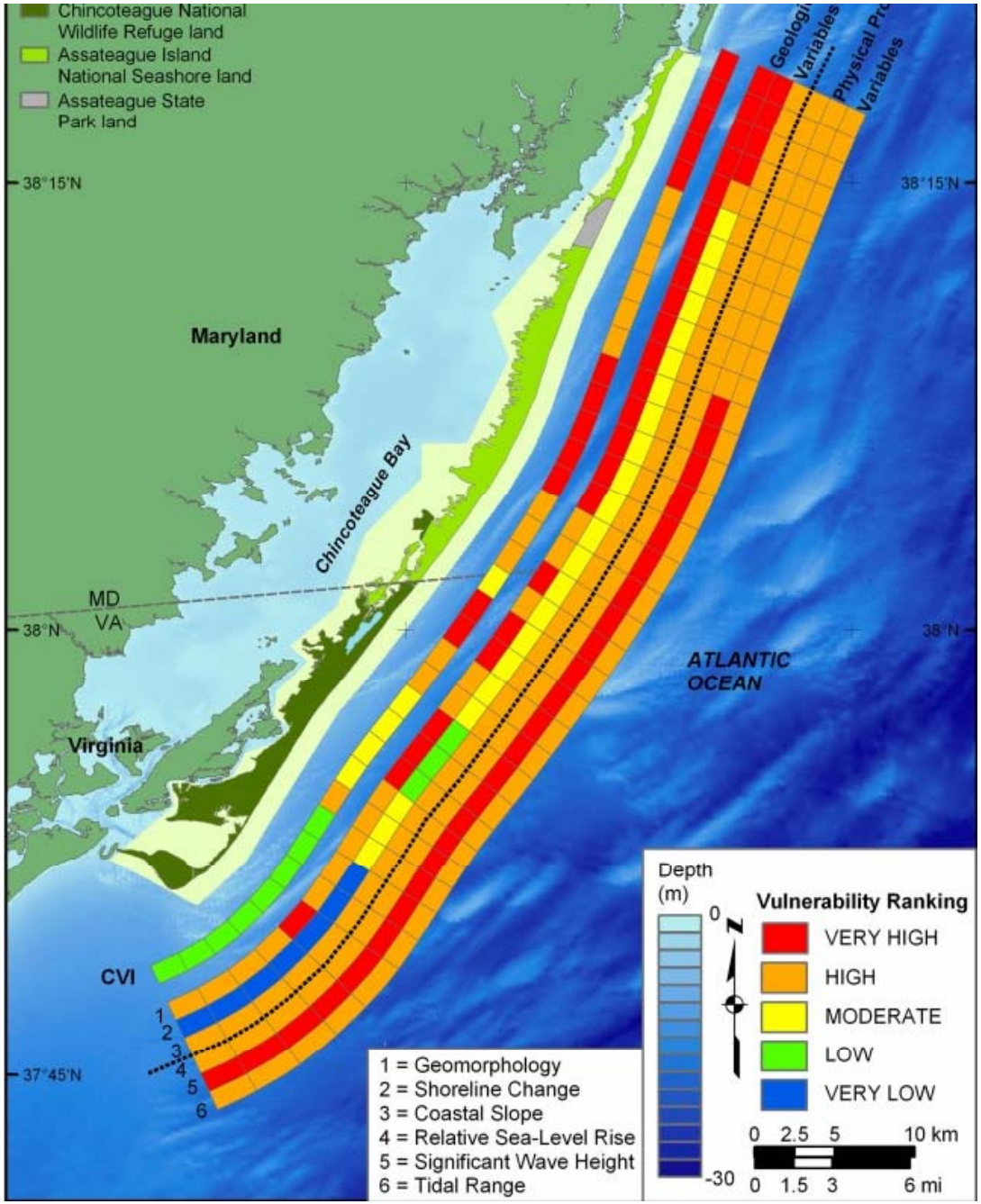
Tidal range

$$CVI = \sqrt{\frac{(a*b*c*d*e*f)}{6}}$$

Coastal Vulnerability Index



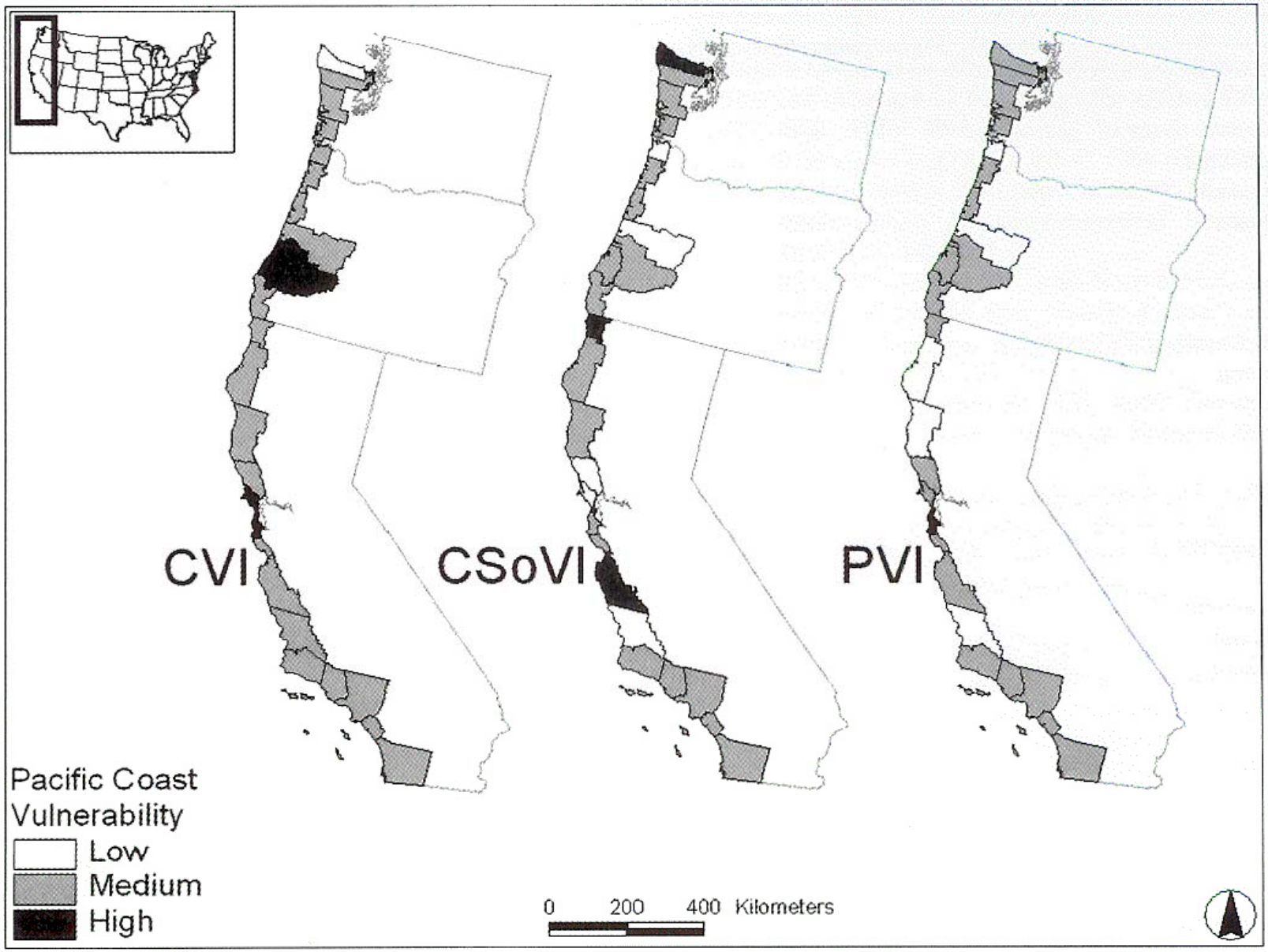
USGS CVI



$$CVI = \sqrt{\frac{(a * b * c * d * e * f)}{6}}$$

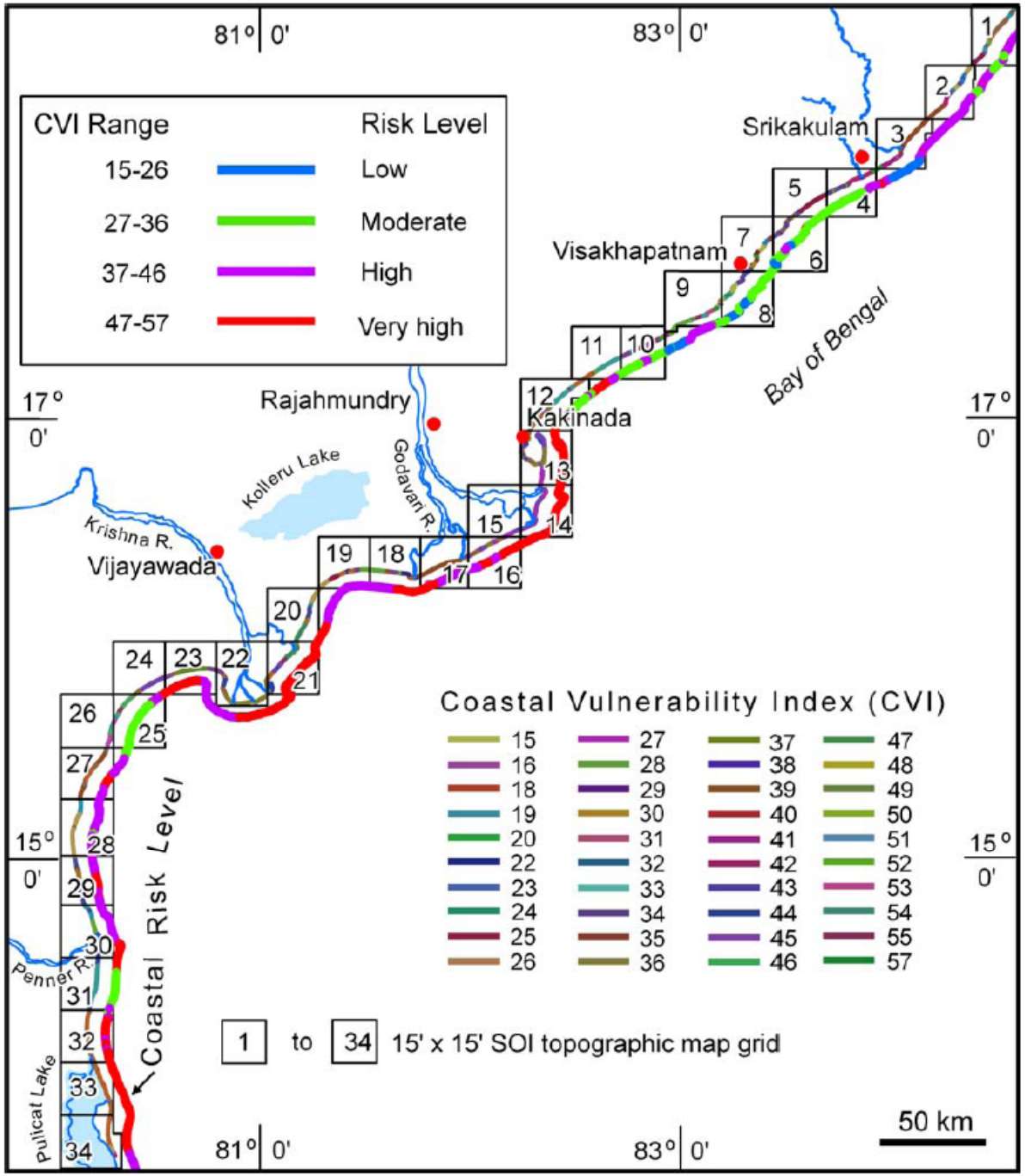
Source: USGS Open-File Report 2004-1020

CVI ~ socio-economic



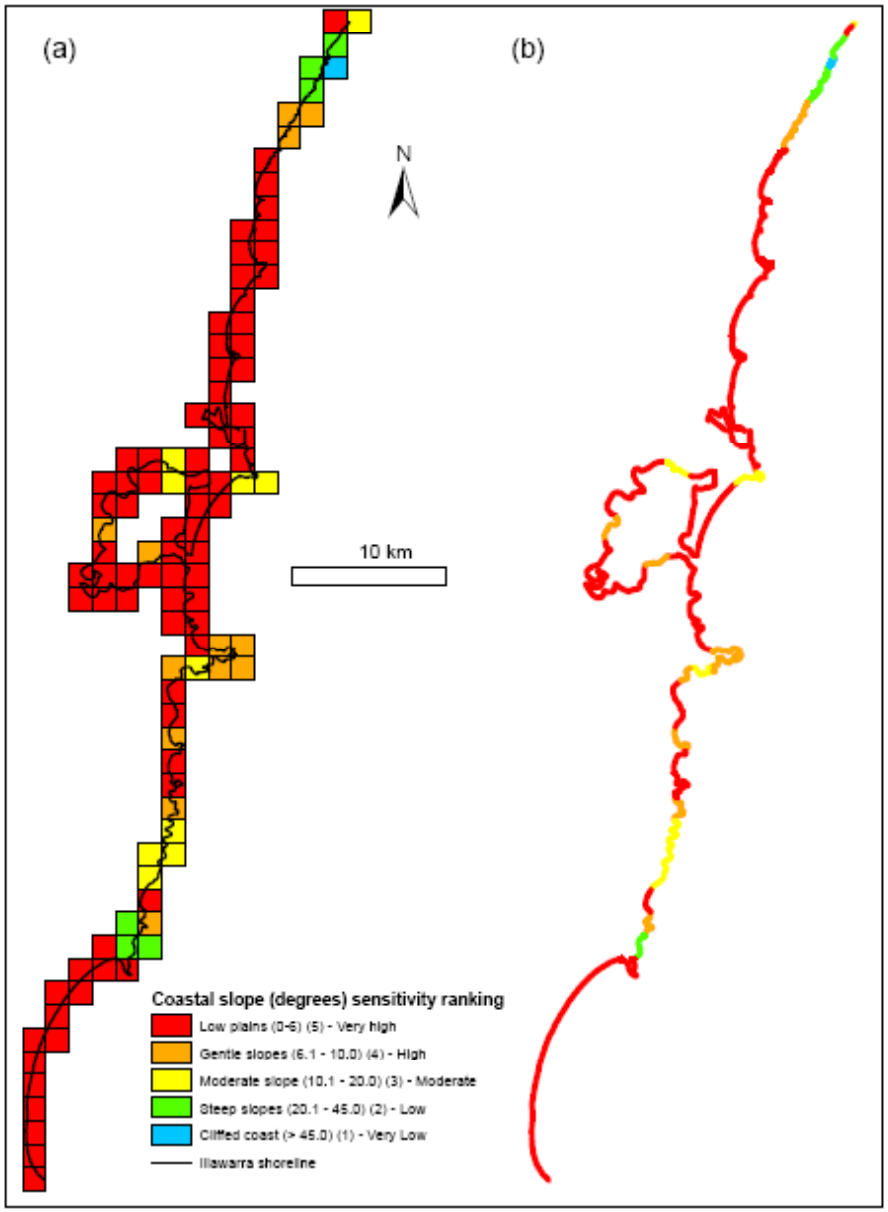
Source: Boruff et al., 2005

CVI in India



Source: Rao et al., 2008

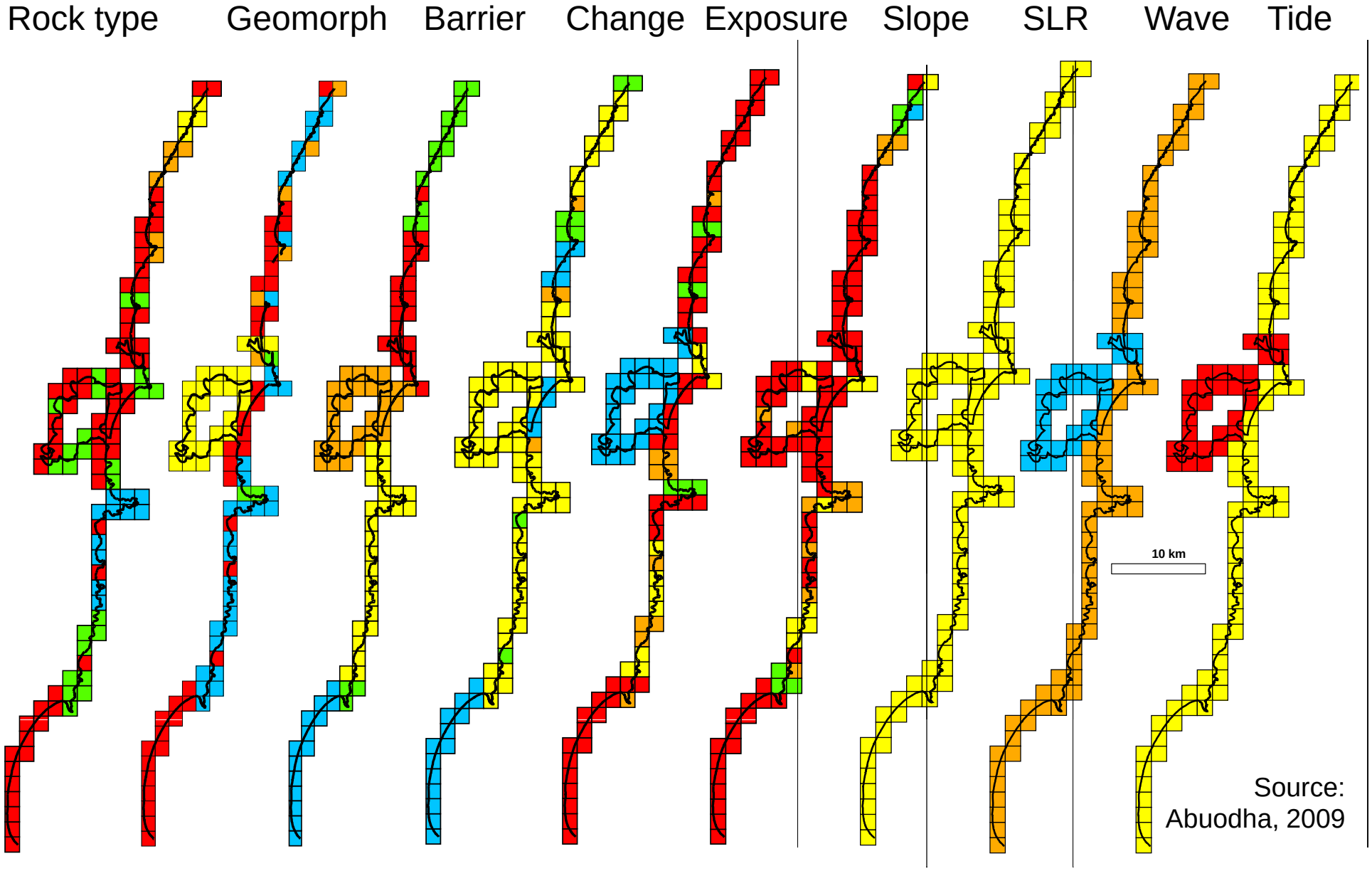
Coastal slope ~ Illawarra



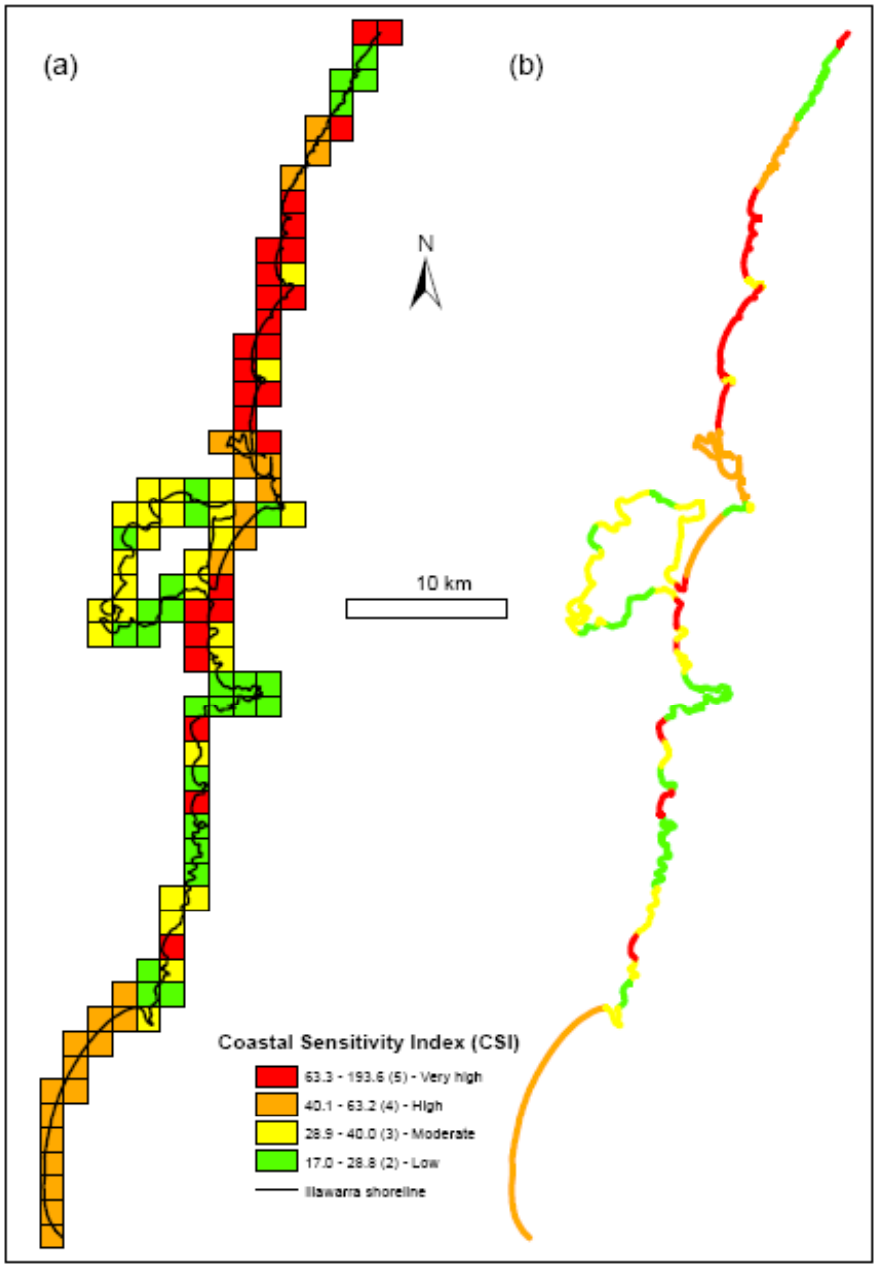
Profile (Coastal slope) (degrees)	Length (%)	Sensitivity ranking
Low plains (0.0-6.0)	71.3	**Very high**
Gentle slopes (6.1 – 10.0)	14.3	**High**
Moderate slopes (10.1 - 20.0	8.6	**Moderate**
Steep slopes (20.1 - 45)	5.1	**Low**
Cliffed coast (> 45)	0.7	**Very low**
Total = 167 km	**100.0**	**-**

Source: Abuodha, 2009

Illawarra ~ CSI vulnerability



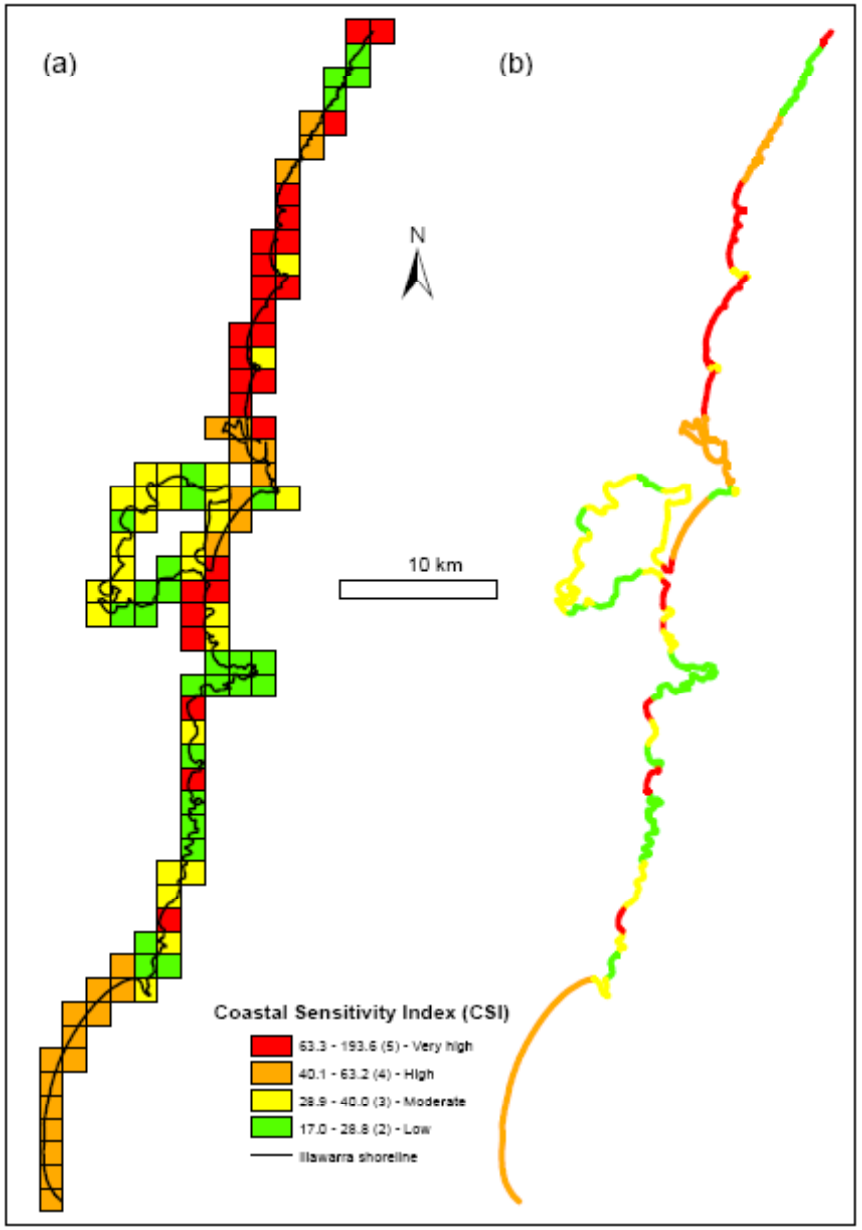
Coastal sensitivity index



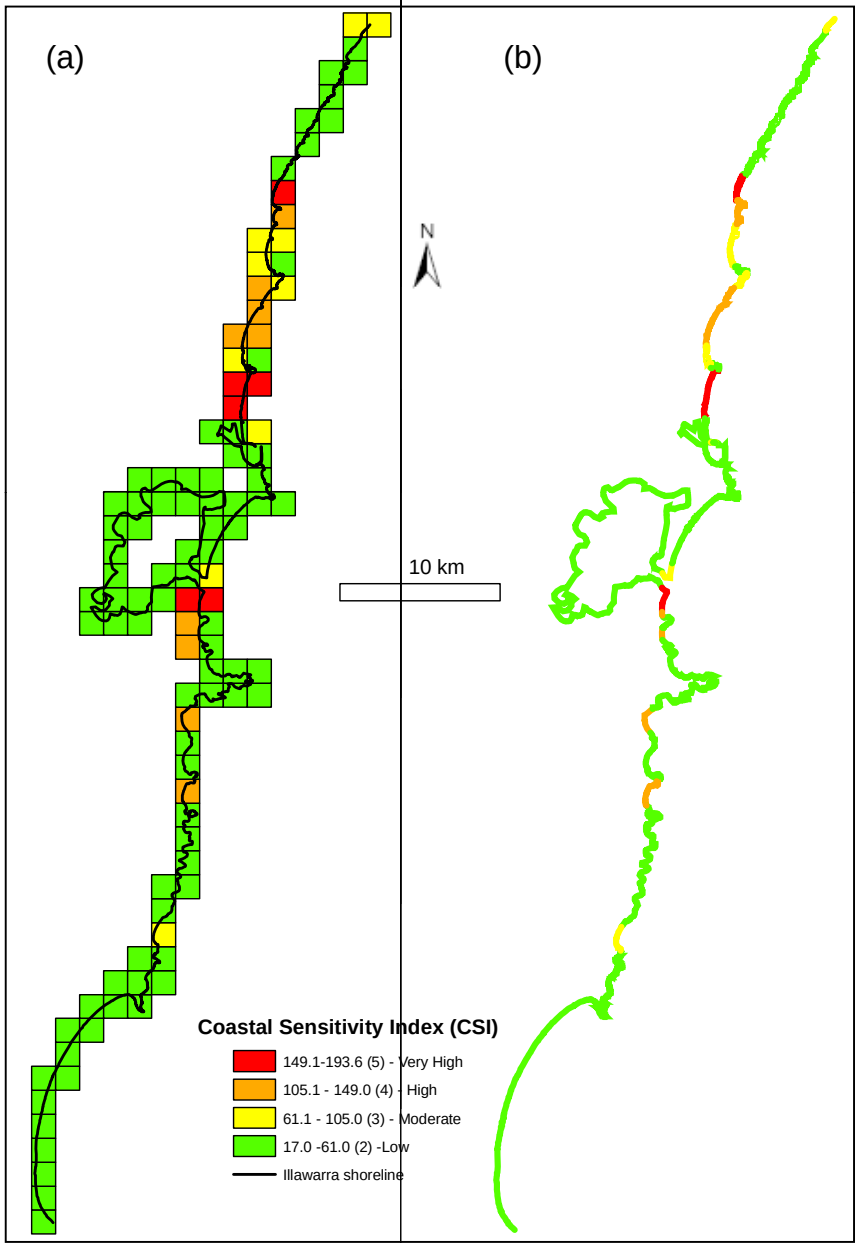
Coastal sensitivity index	Length (%)	Sensitivity ranking
63.3 – 193.6	17.6	**Very high**
40.1 – 63.2	26.5	**High**
28.9 – 40.0	28.7	**Moderate**
17.0 – 28.8	27.2	**Low**
Total = 167 km	**100.0**	**-**

Source: Abuodha, 2009

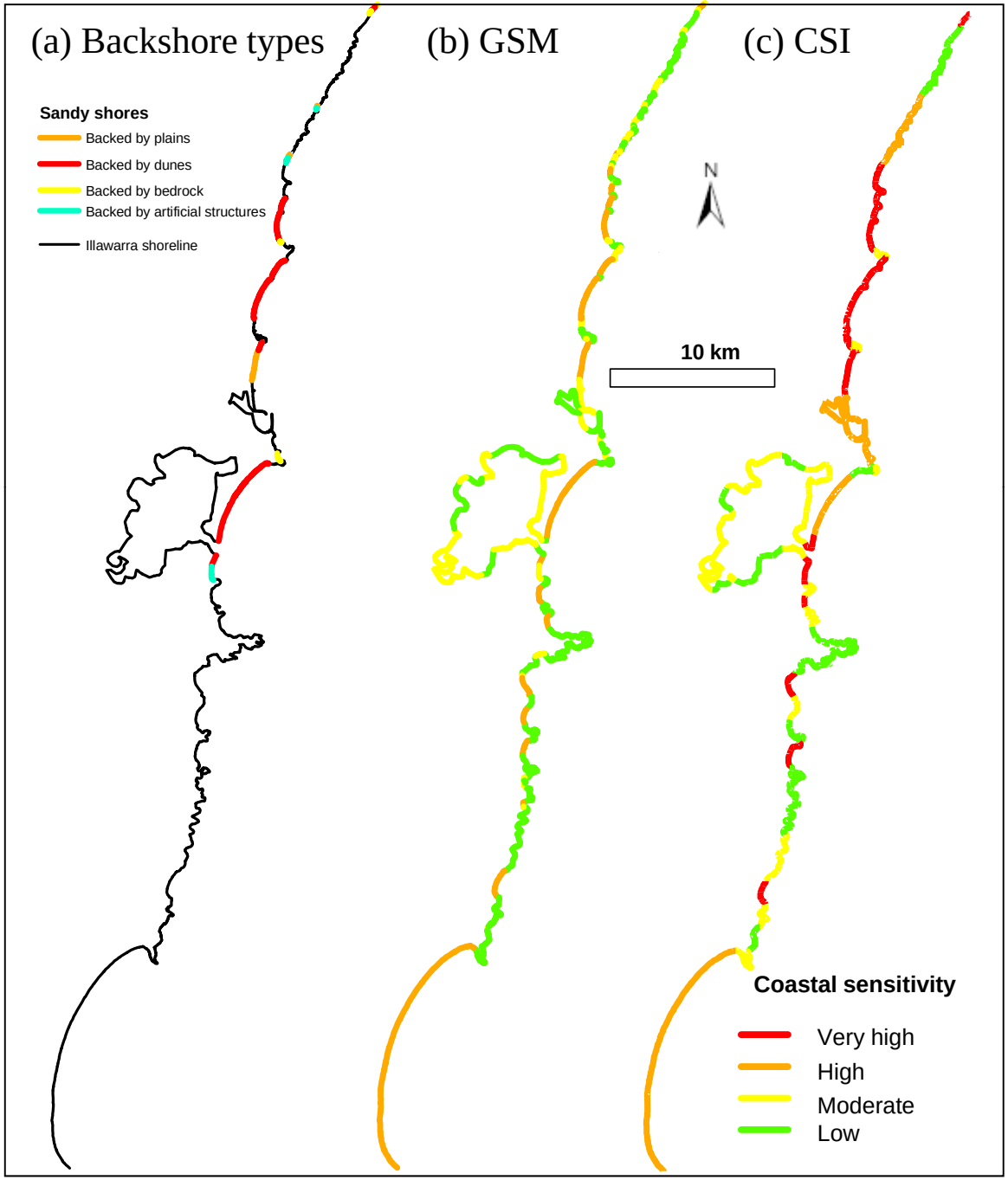
Percentiles



Quartiles



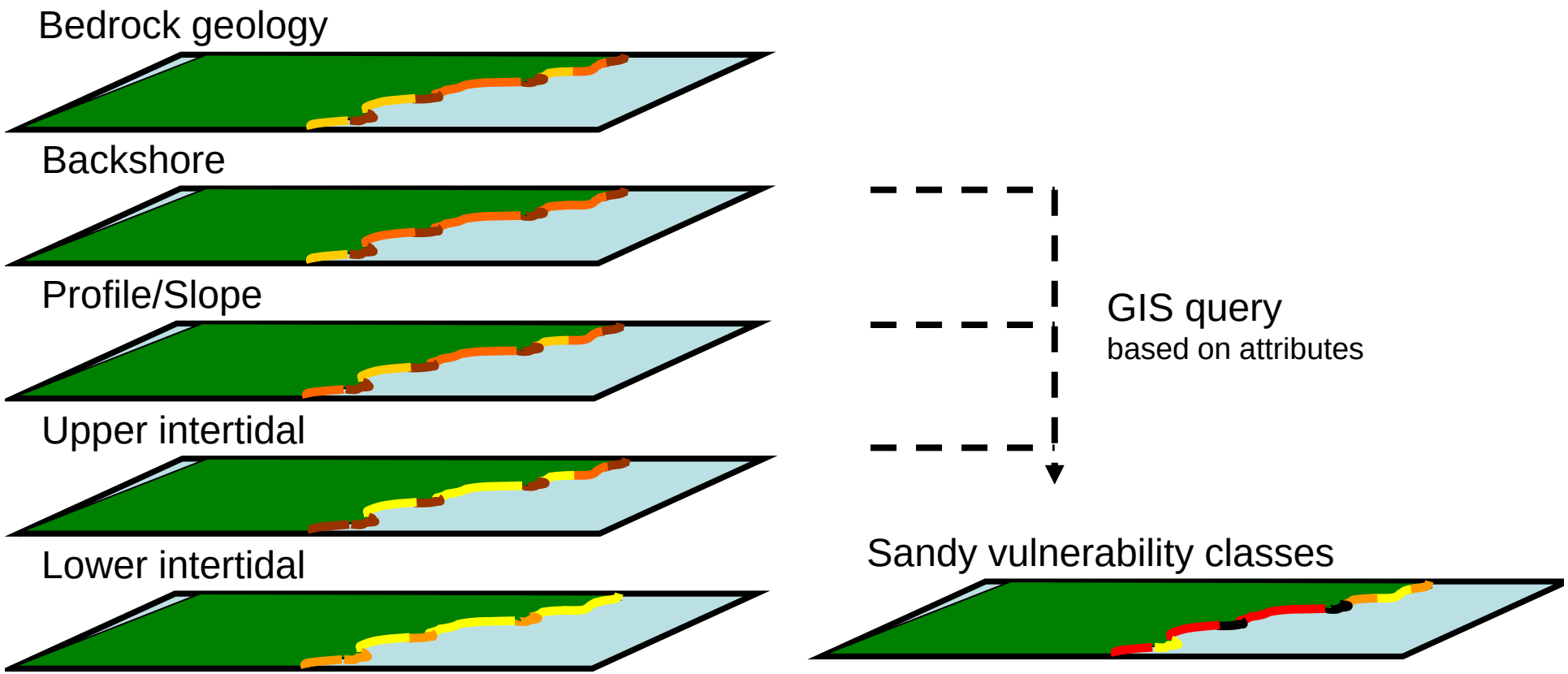
Source: Abuodha, 2009



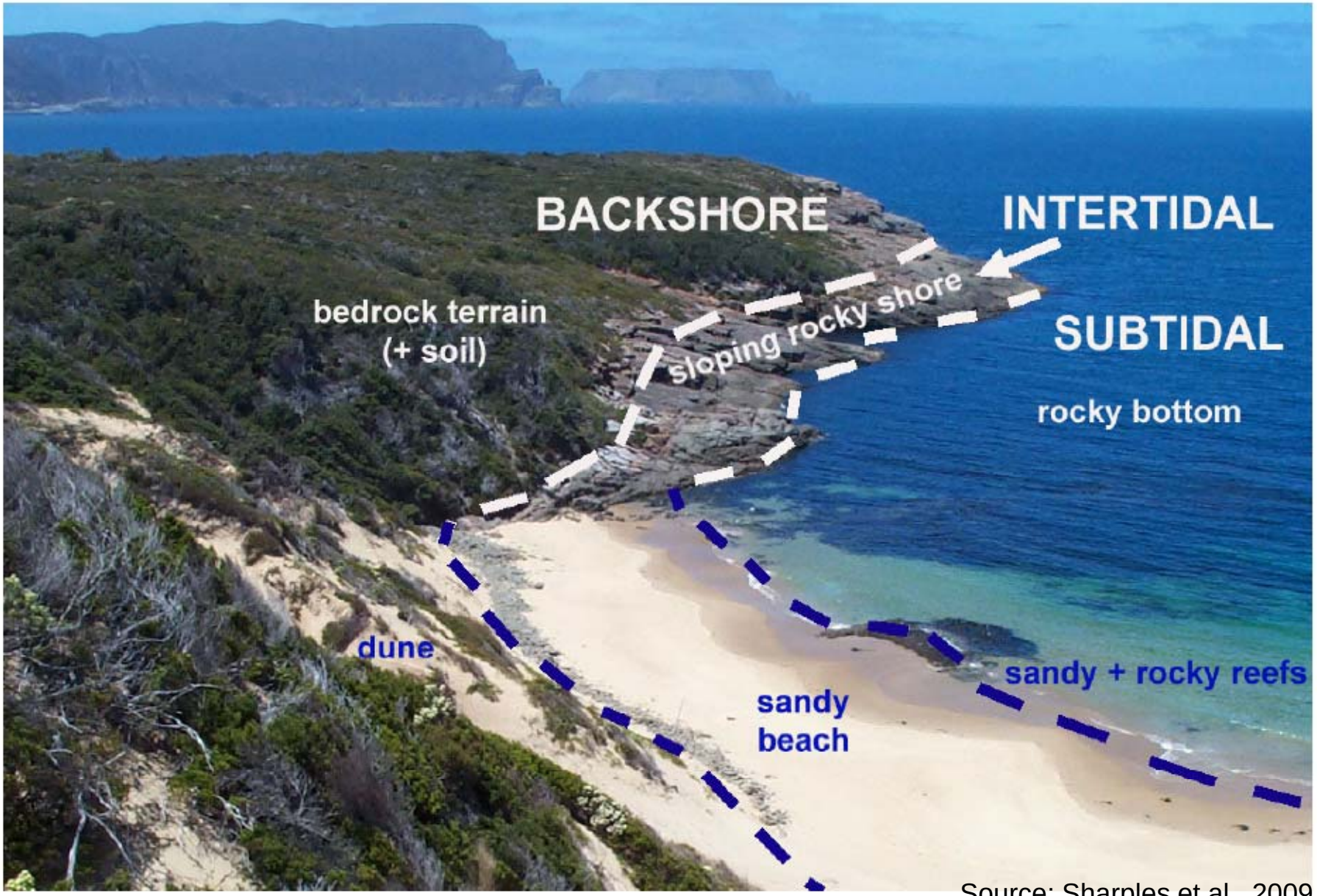
Comparison of the GSM and the CSI

Source: Abuodha, 2009

Smartline mapping of the coast

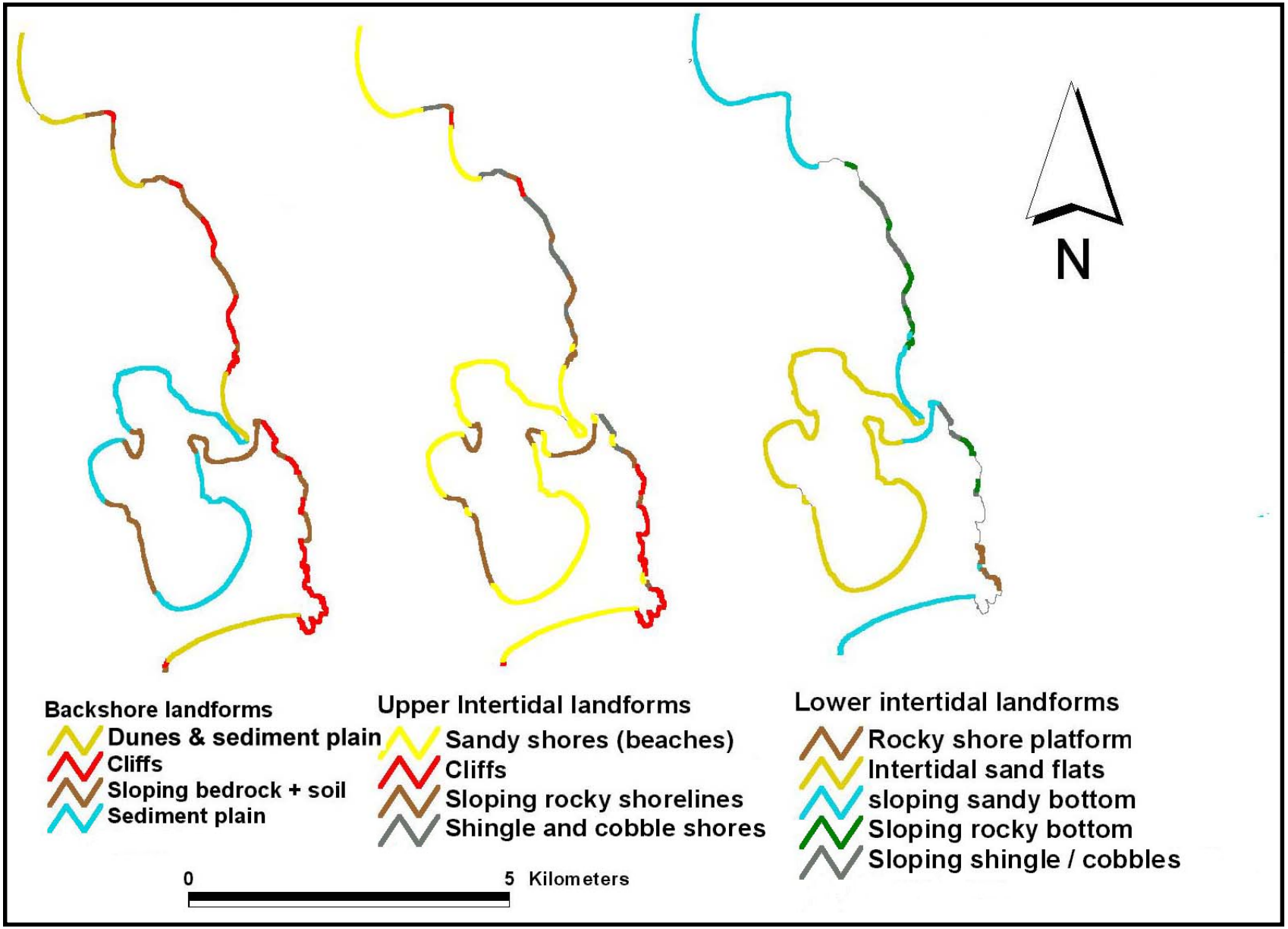


Smartline



Source: Sharples et al., 2009

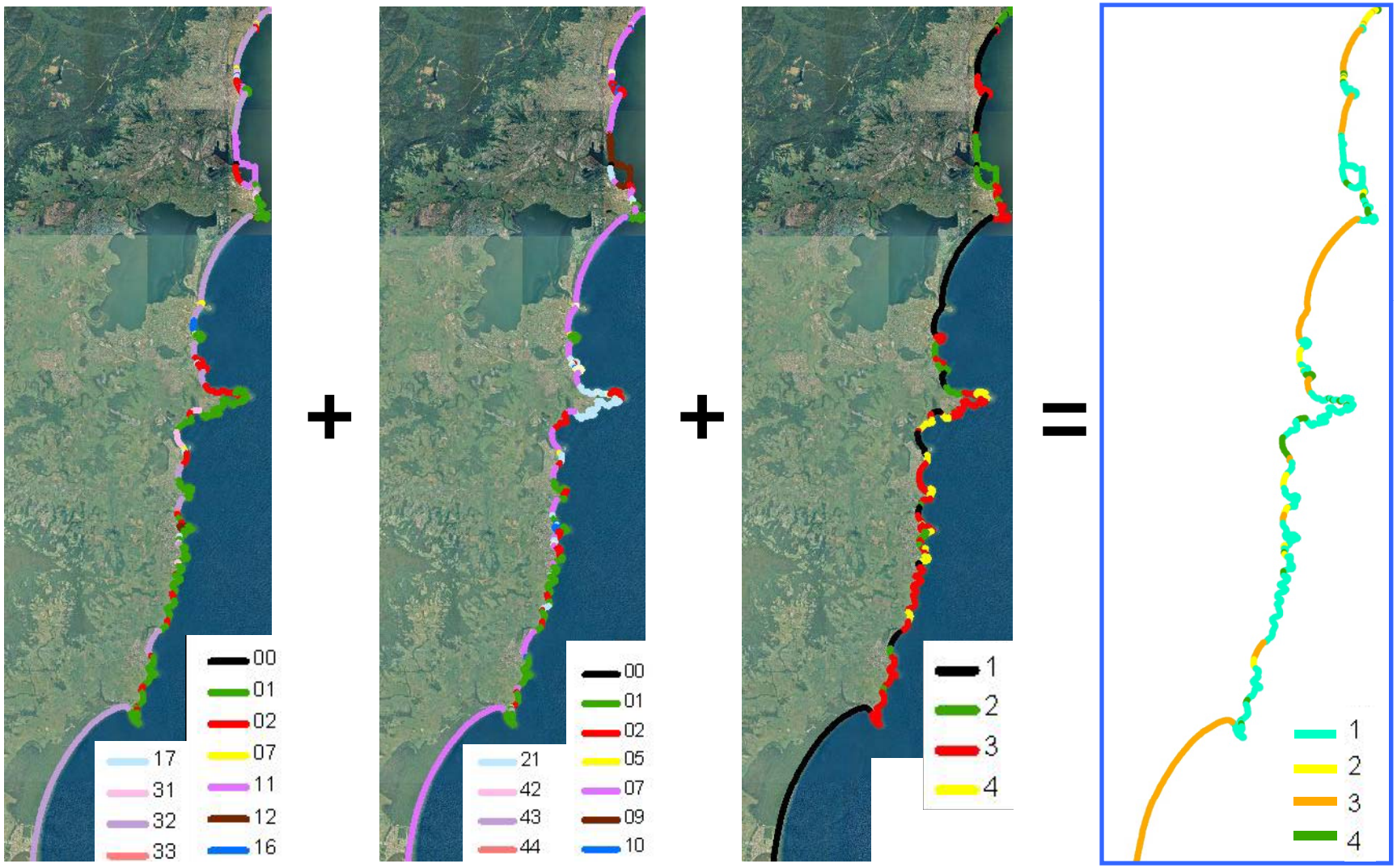
Smartline - geomorphic stability mapping



Source: Sharples, 2004

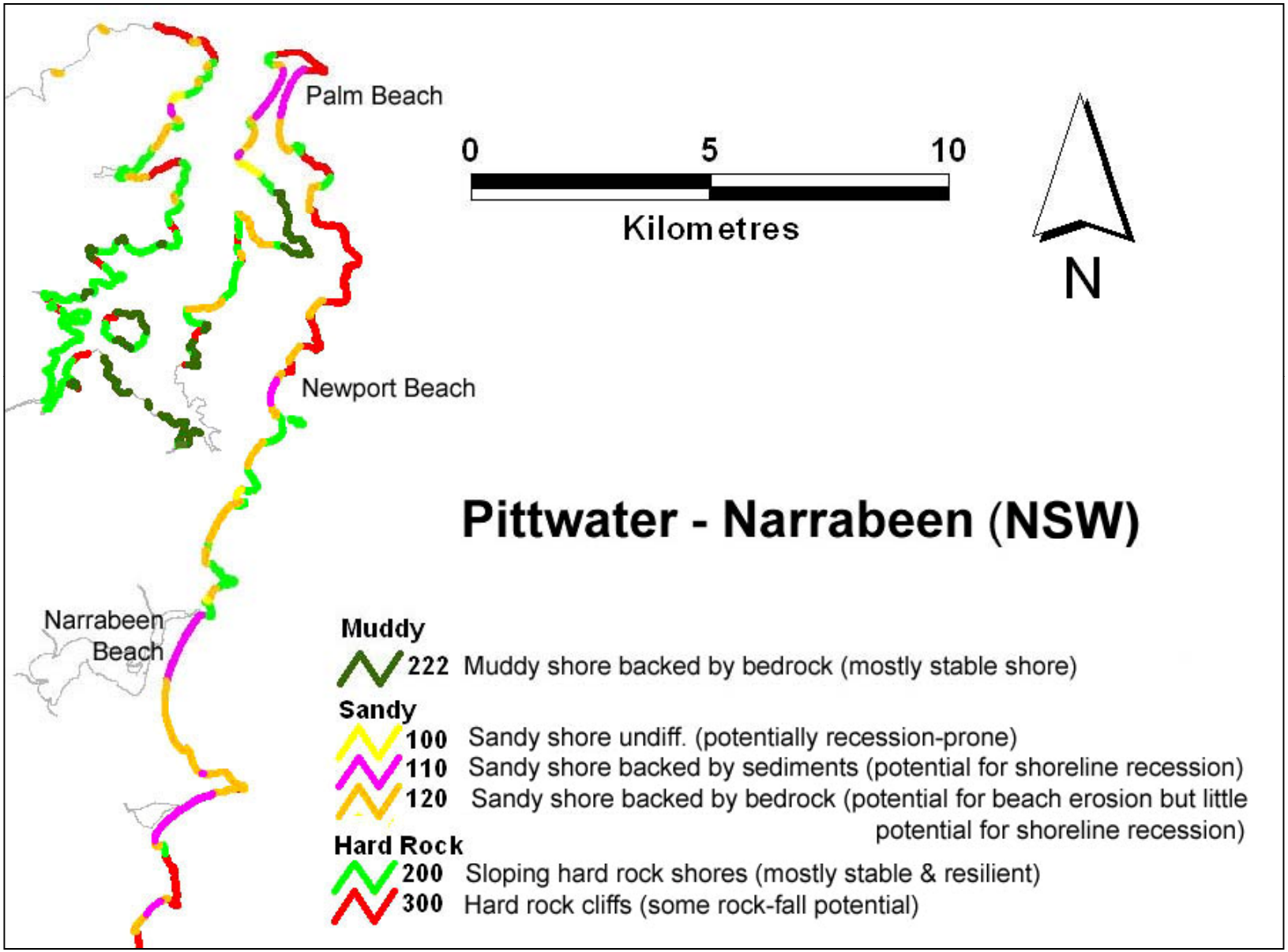
Illawarra ~ vulnerability

Backshore | Upper intertidal | Profile | Vulnerability



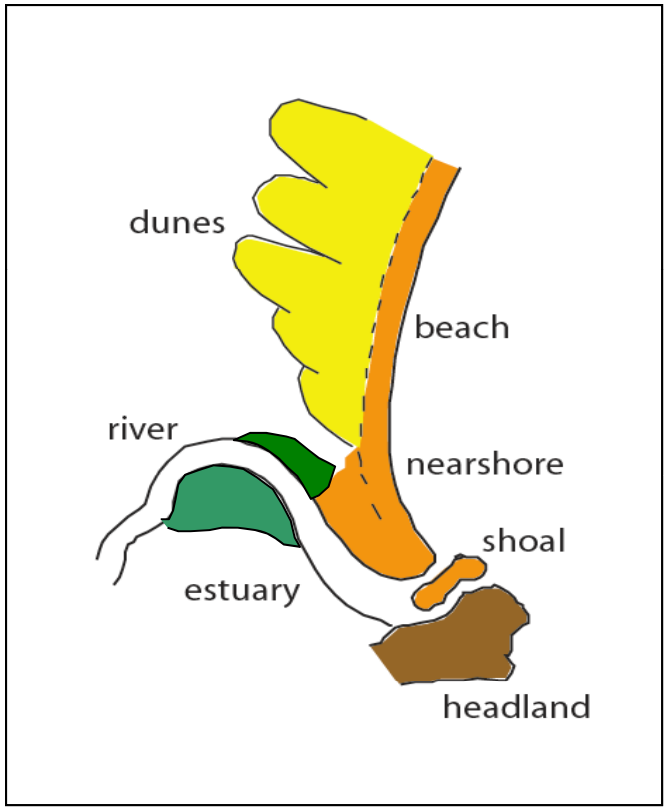
Source: PhD research – Pam Abuodha

Potential for recession



Source: Sharples et al., 2009

Assessment so far



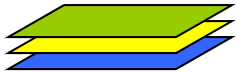
COASTAL INFORMATION SYSTEM AND DATASETS


topography
bathymetry


ecology
geomorphology
sediment


wind
wave
storm


population
buildings


roads
ports
infrastructure


emergency
evacuation

Many approaches use elevation data

Some use other physical parameters

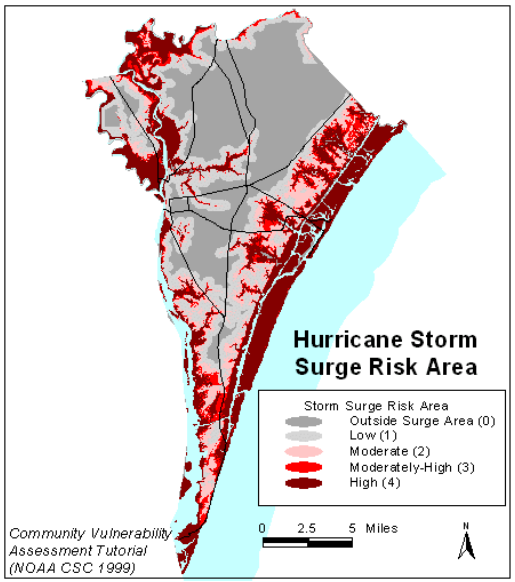
Few incorporate socio-economic data

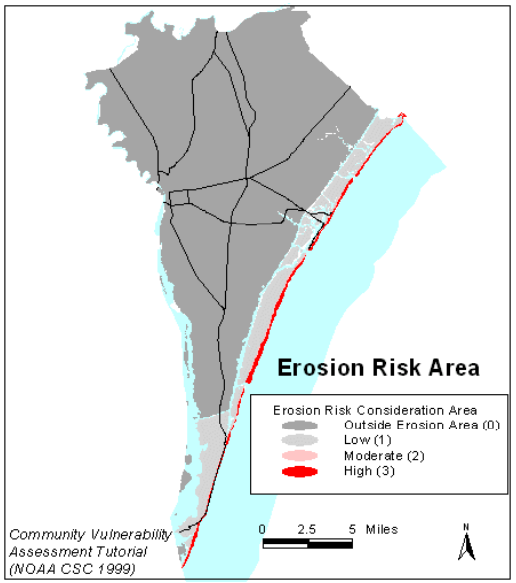
Vulnerability ought to consider adaptive capacity

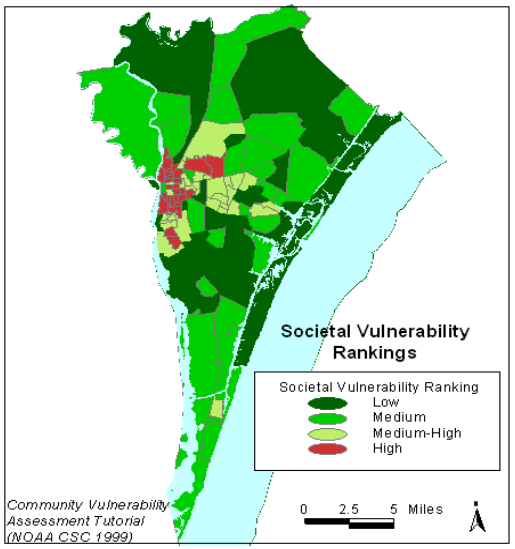
Community Vulnerability Assessment Tool CVAT

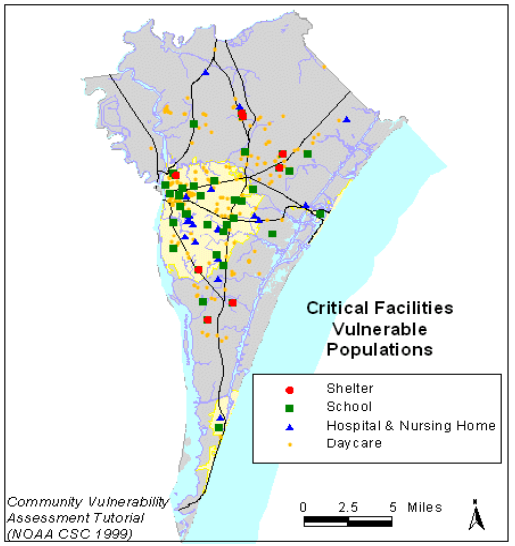
NOAA – 7 step procedure

1. Hazard identification
2. Hazard analysis
3. Critical facilities analysis
4. Societal analysis
5. Economic analysis
6. Environmental analysis
7. Mitigation opportunities analysis



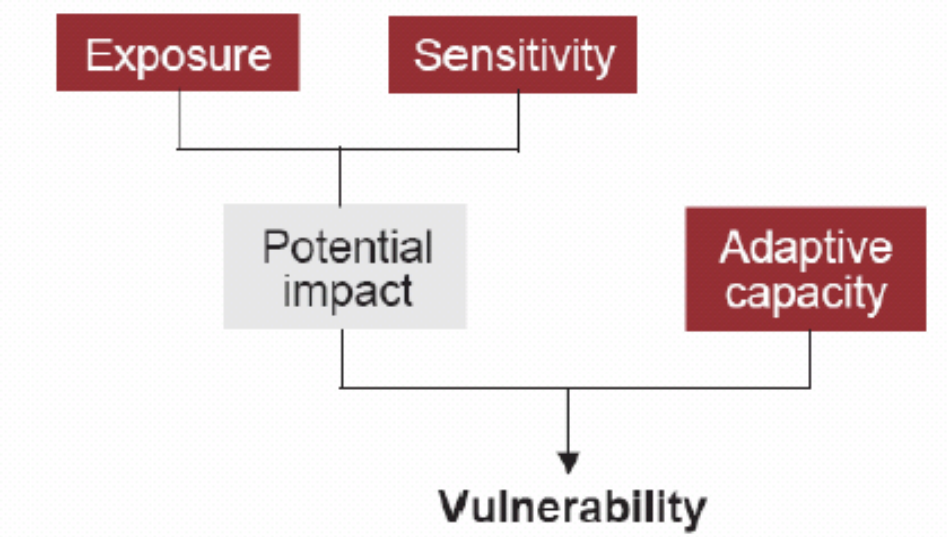


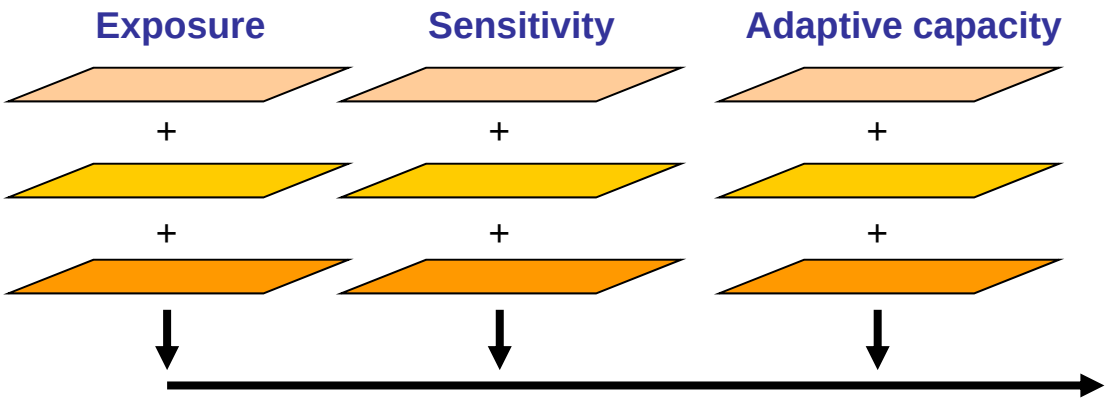


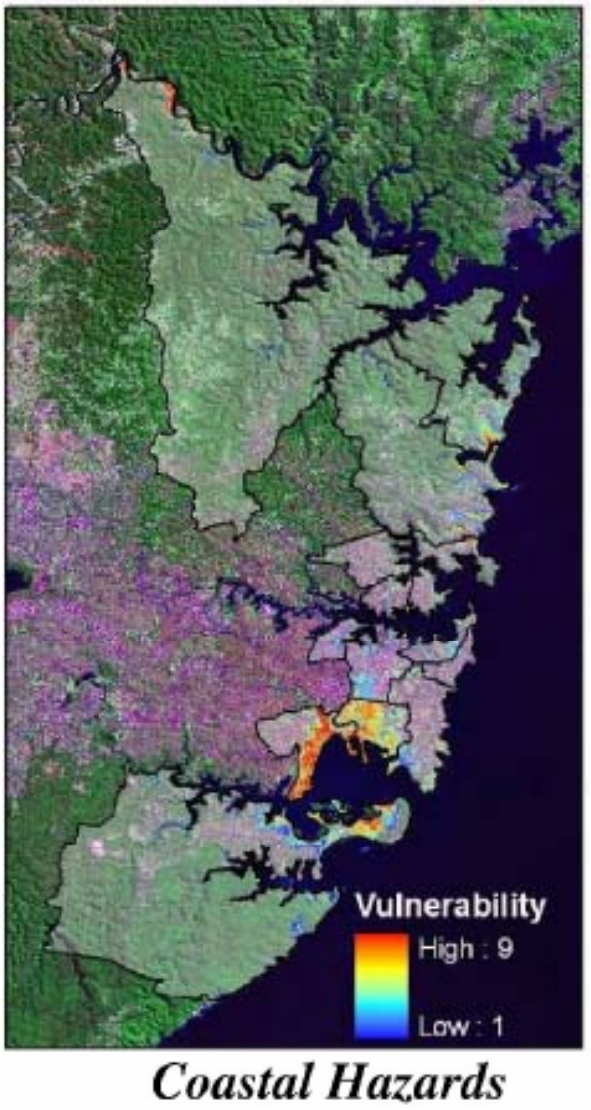


Source: NOAA Coastal Services Centre, 1999

Assessment for SCCG

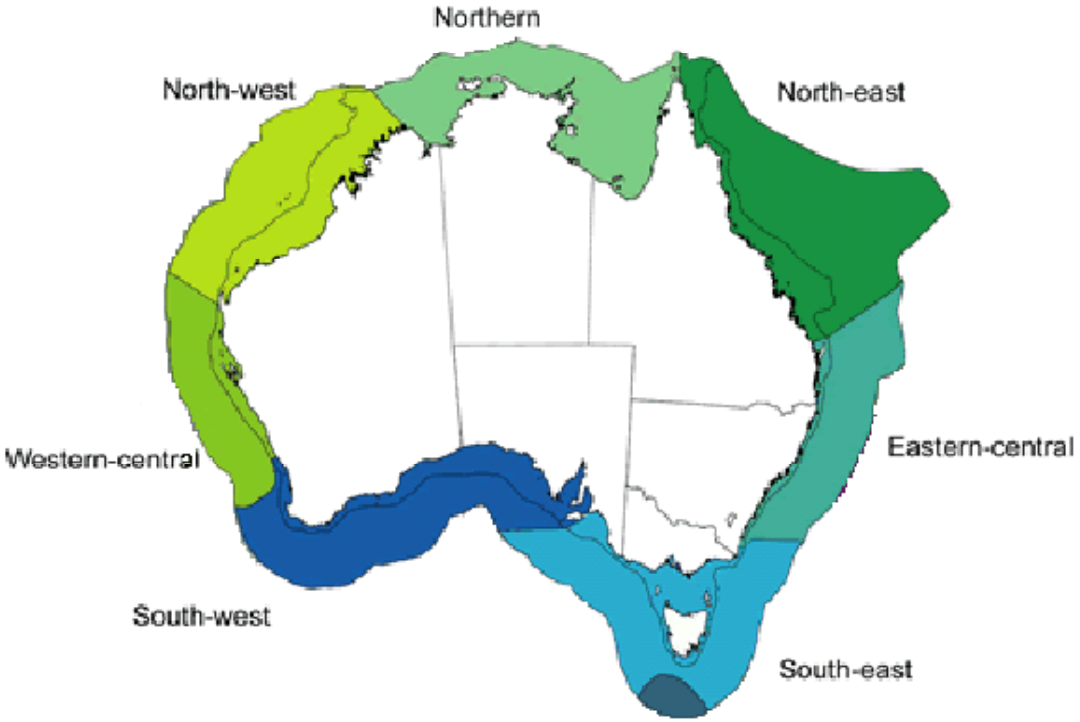


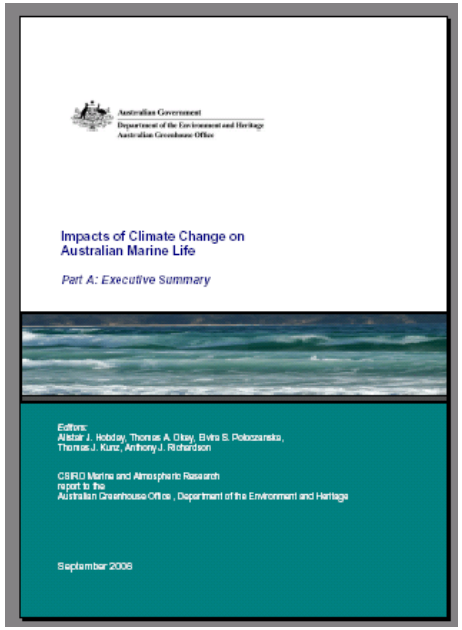




Source: Preston et al., 2008

Relative vulnerability of large marine domains

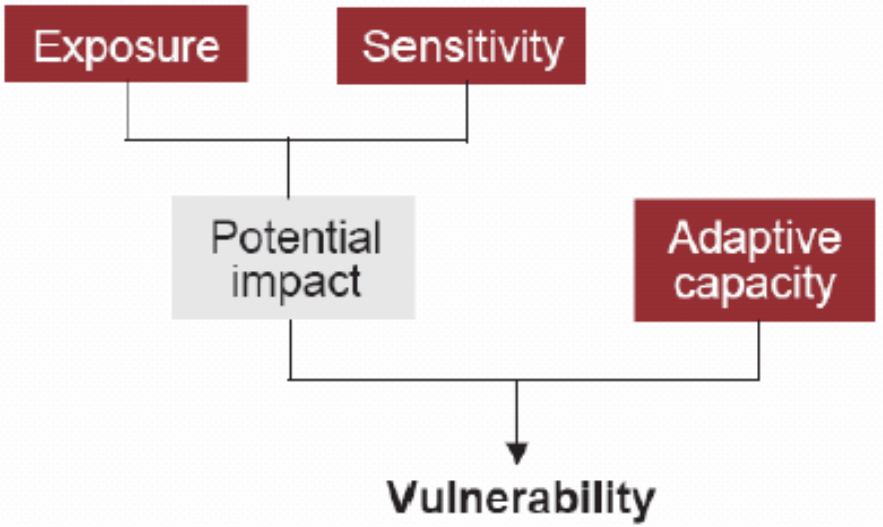




Vulnerability Dimension	Northern	North-east	North-west	Western-central	Eastern-central	South-west	South-east
Biological	1.25	2.75	2.75	3.25	3.75	2.00	2.00
Regional	3.00	1.00	2.00	2.00	1.67	2.67	2.33
Climate Change	3.45	3.89	3.48	2.76	4.35	1.65	3.31
Fishing	3.39	1.57	1.01	1.32	3.17	2.04	3.84
Other Anthropogenic	2.38	2.50	3.75	2.63	3.13	2.75	3.88
Overall Vulnerability	2.68	2.33	2.60	2.43	3.21	2.28	3.07
Ranked Vulnerability	**3**	**6**	**4**	**5**	**1**	**7**	**2**

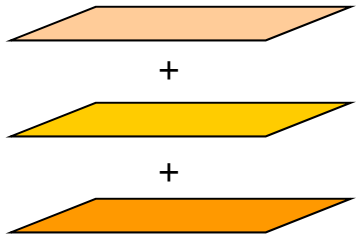
Source: CSIRO, September 2006

Smartline ~ moving beyond the 1st pass

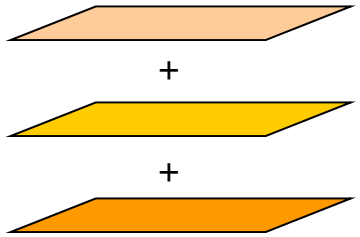


Sensitivity

Form



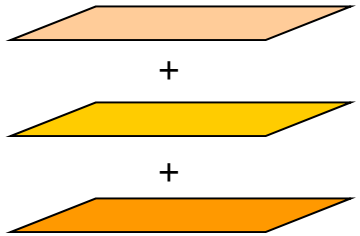
Fabric



\+

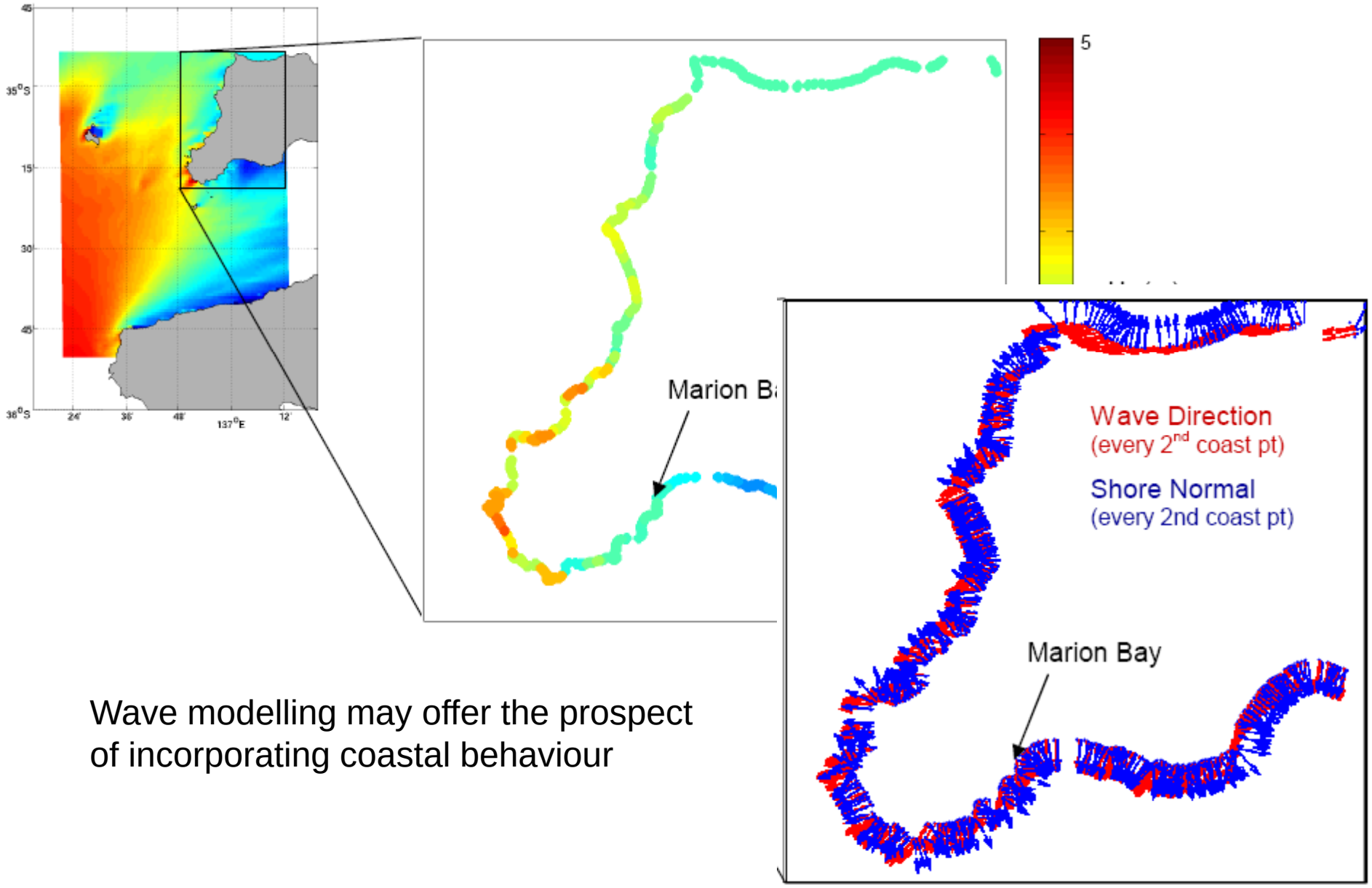
Exposure

Wave energy



Source: Sharples, pers comm.

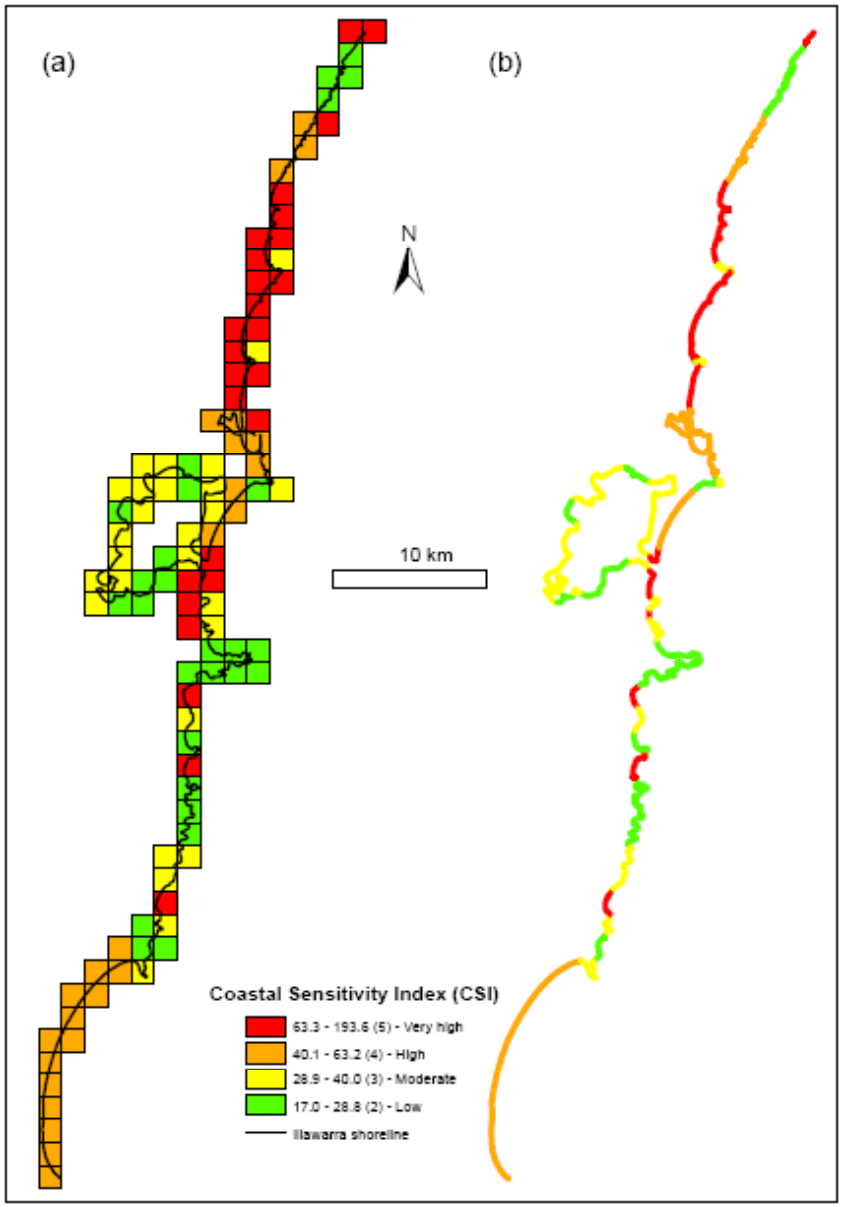
Smartline ~ incorporating 2nd pass processes

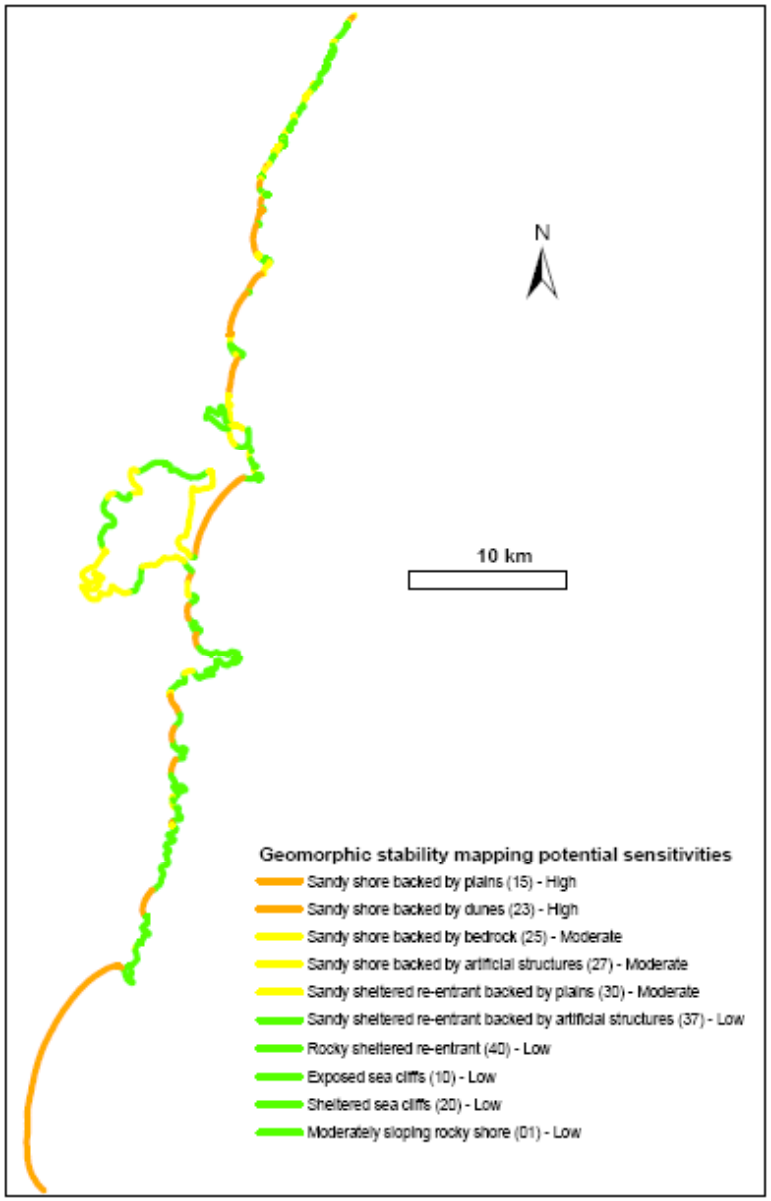


Wave modelling may offer the prospect of incorporating coastal behaviour

Source: Hemer et al., 2008

Smartline ~ moving towards 2nd pass processes





Source: Abuodha, 2009

Detailed elevation ~ and simulating inundation

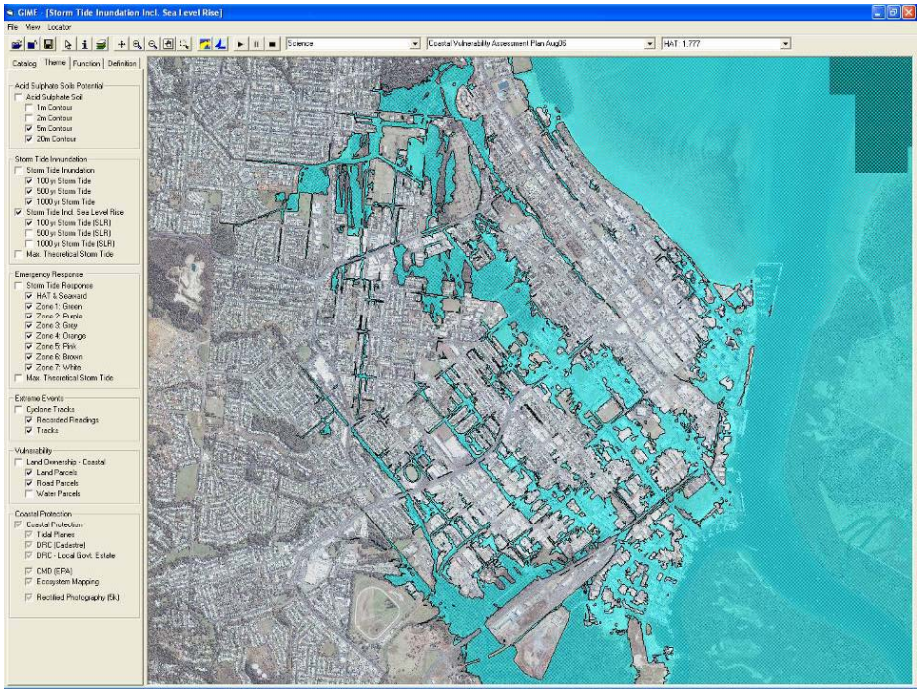
Photogrammetry

Lakes Entrance

Source: courtesy Peter Wheeler, Monash

Lidar

Cairns



Source: courtesy Peter Todd, USC

Simulated inundation

Narrabeen

1.1m SLR + 1 in 100 storm tide

Tweed Heads

Source: DCC, 2009

Inundation of the creek systems

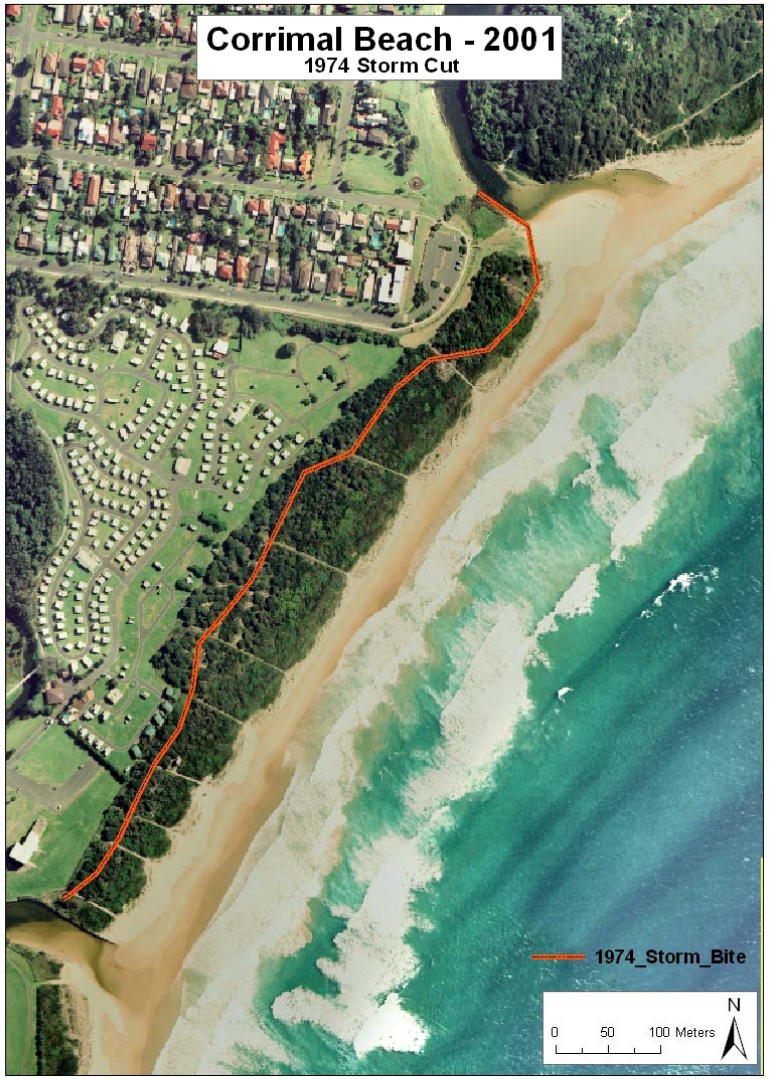
Source: Noakes, 2008

Inundation and the Venice effect

- Procedures known to be simplistic
  - Bruun rule
  - Bucket fill
- Need to incorporate hydrodynamics and coastal behaviour
- Rarely take past behaviour of coast into consideration

Photo credit ©iStockphoto.com/Patrick Oberem

Shoreline change



Hazelwood, 2007

Conclusions

- GIS provides a very VISUAL means of indicating vulnerability
- Different approaches are appropriate at different scales
  - DIVA – global; CVI and Smartline regional
- Most GIS has concentrated on physical variables
  - First pass analysis of form and fabric; some processes
  - Few extend far in terms of socio-economic factors
- Need to study vulnerability of estuaries and Venice effect
  - Sub-segment variability of coast
- Predictive capability still limited
  - Need to incorporate coastal behaviour
  - Scope to make better use of past changes

Thank You

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