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Vulnerability of the the Australian Coast to climate change: an international perspective

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IPCC Fourth Assessment report – WG2, Chapter 6: Coastal Systems and Low-lying Areas

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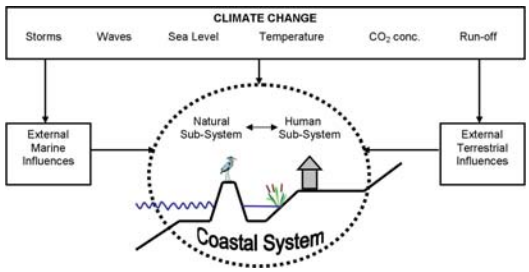
The coastal system



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Source: IPCC WGII, SPM, April 2007

Six main conclusions

- Coasts are experiencing the adverse consequences of hazards related to climate and sea level.
- Coasts will be exposed to increasing risks over coming decades due to many compounding climate-change factors.
- The impact of climate change on coasts is exacerbated by increasing human-induced pressures.
- Adaptation for the coasts of developing countries will be more challenging than for coasts of developed countries, due to constraints on adaptive capacity.
- Adaptation costs for vulnerable coasts are much less than the costs of inaction.
- The unavoidability of sea-level rise even in the longer-term frequently conflicts with present-day human development patterns and trends.

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Source: IPCC WGII, SPM, April 2007

Climate risks will increase through the 21st Century

Climate Driver (trend)		Main Physical and Ecosystem Effects on Coastal Systems
CO_2 concentration (↑)		Increased CO_2 fertilisation; Decreased seawater pH (or 'ocean acidification') negatively impacting coral reefs and other pH sensitive organisms.
Sea surface temperature (SST) (↑, R)		Increased stratification/changed circulation; Reduced incidence of sea ice at higher latitudes; Increased coral bleaching and mortality; Poleward species migration; Increased algal blooms.
Sea level (↑, R)		Inundation, flood and storm damage; Erosion; Saltwater Intrusion; Rising water tables/ impeded drainage; Wetland loss (and change).
Storm	Intensity (↑, R)	Increased extreme water levels and wave heights; Increased episodic erosion, storm damage, risk of flooding and defence failure;
	Frequency (?, R)	Altered surges and storm waves and hence risk of storm damage and flooding.
	Track (?,R)	
Wave climate (?, R)		Altered wave conditions, including swell; Altered patterns of erosion and accretion; Re-orientation of beach planform.
Run-off (R)		Altered flood risk in coastal lowlands; Altered water quality/salinity; Altered fluvial sediment supply; Altered circulation and nutrient supply.

These phenomena will vary considerably at regional and local scales, but the impacts are virtually certain to be overwhelmingly negative.

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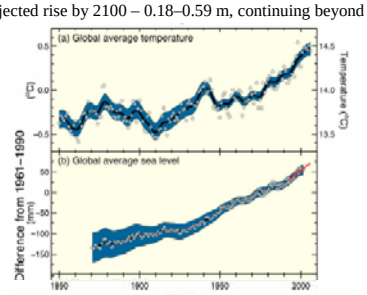
Source: IPCC WGII, SPM, April 2007

Observed sea-level rise

- 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



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Source: IPCC WGI, SPM, Feb 2007

Attribution of observed sea-level change

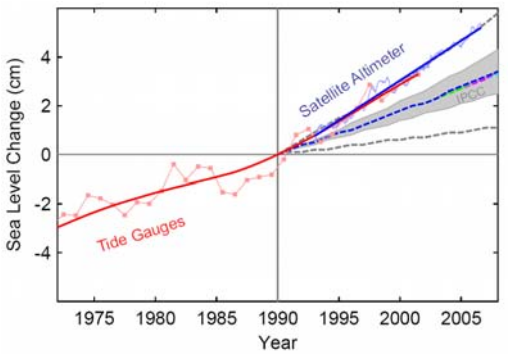
Table SPM-1. Observed rate of sea level rise and estimated contributions from different sources. [5.5, Table 5.3]

Source of sea level rise	Rate of sea level rise (mm per year)	
	1961 – 2003	1993 – 2003
Thermal expansion	0.42 ± 0.12	1.6 ± 0.5
Glaciers and ice caps	0.50 ± 0.18	0.77 ± 0.22
Greenland ice sheet	0.05 ± 0.12	0.21 ± 0.07
Antarctic ice sheet	0.14 ± 0.41	0.21 ± 0.35
Sum of individual climate contributions to sea level rise	1.1 ± 0.5	2.8 ± 0.7
Observed total sea level rise	1.8 ± 0.5[a]	3.1 ± 0.7[a]
Difference (Observed minus sum of estimated climate contributions)	0.7 ± 0.7	0.3 ± 1.0

Table note:
[a] Data prior to 1993 are from tide gauges and after 1993 are from satellite altimetry.

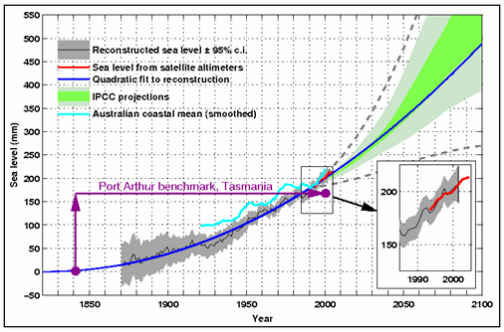
Source: IPCC WGI, SPM, Feb 2007

Sea-level change – observed vs projected



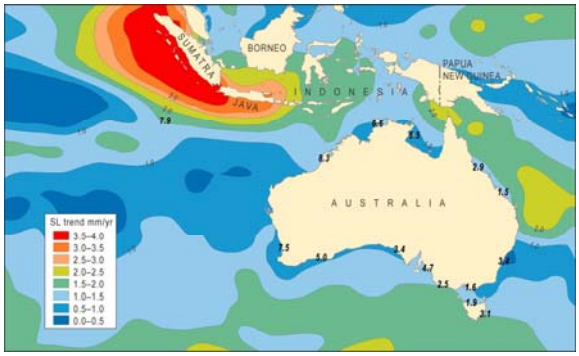
Source: Rahmstorf et al., 2007

Sea level change around Australia



Source: John Hunter, 2007

Sea-level trends around Australia



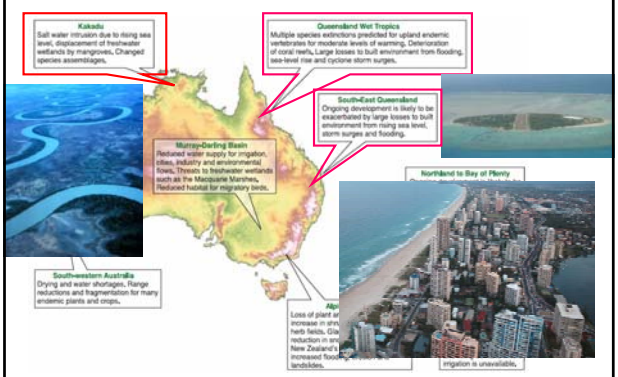
Source: John Church et al, 2006, National Tidal Centre, Dec 2007

IPCC Fourth Assessment – Summary Working Group II - Australian coasts

- Great Barrier Reef experienced 8 bleaching events since 1979 and likely to become near-annual in 21st century
- Saltwater inundation into freshwater wetlands in northern Australia
- Beaches in NSW show long-term oscillations related to storms and ENSO
- Tropical storms and associated surges likely to become more intense
- Coastal communities at greater risk of inundation, especially in Cairns and southeast Queensland regions

Source: IPCC WGII, SPM, April 2007

IPCC - Working Group II - Hotspots

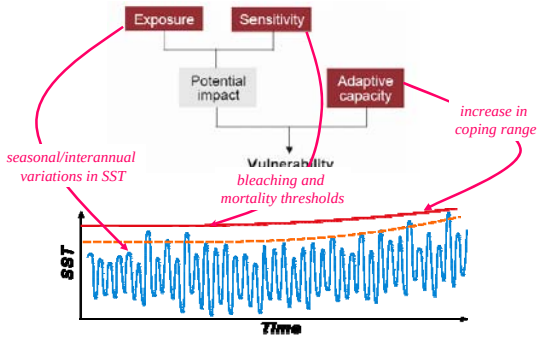


Source: IPCC WGII, SPM, April 2007

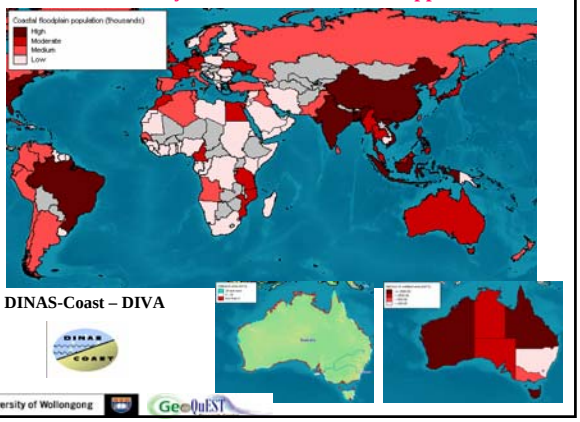
Climate change in the coastal zone is an additional stress

- Human utilisation of the coast increased dramatically during the 20th century
- This trend is virtually certain to continue through the 21st century and coastal population could grow from 1.2 billion people (in 1990) to 1.8 to 5.2 billion people by the 2080s.
- Increasing numbers of people and assets at risk at the coast are subject to additional stresses by land-use and hydrological changes in catchments, including dams that reduce sediment supply to the coast.

Exposure sensitivity, adaptive capacity

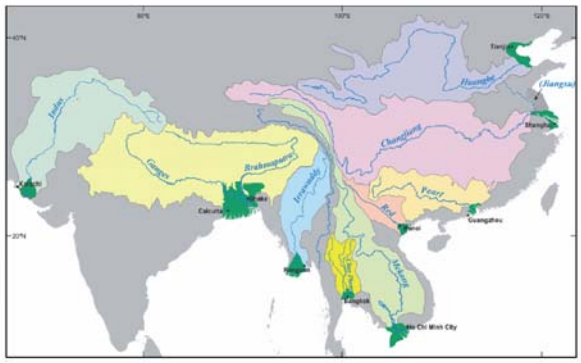


Vulnerability assessment – alternative approaches



- **DINAS-Coast – DIVA**

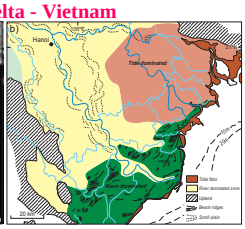
Asian MegaDeltas



Source: Woodroffe et al., 2006

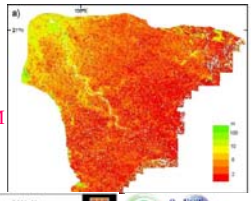
Red River Delta - Vietnam

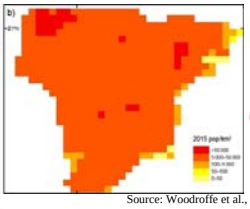
JERS



Zones

SRTM

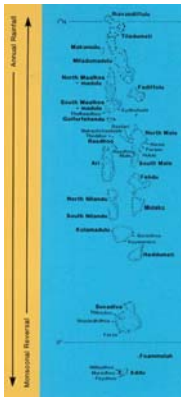


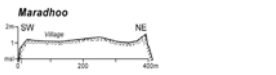


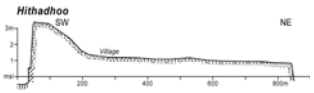
GWP

Source: Woodroffe et al., 2006

Maldives

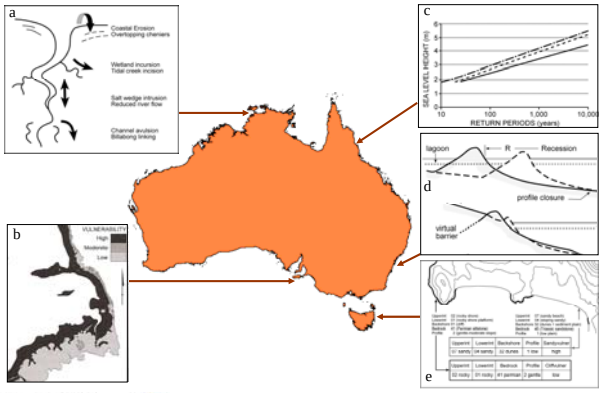






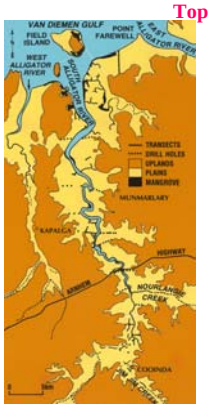
Source: Woodroffe, 2008

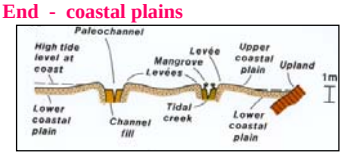
Australian approaches to vulnerability assessment



Source: Harvey and Woodroffe, 2008

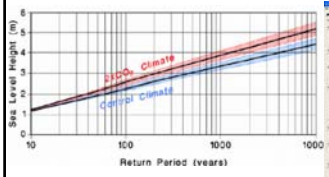
Top End - coastal plains





Extreme sea-level simulations including mean sea-level rise and storms

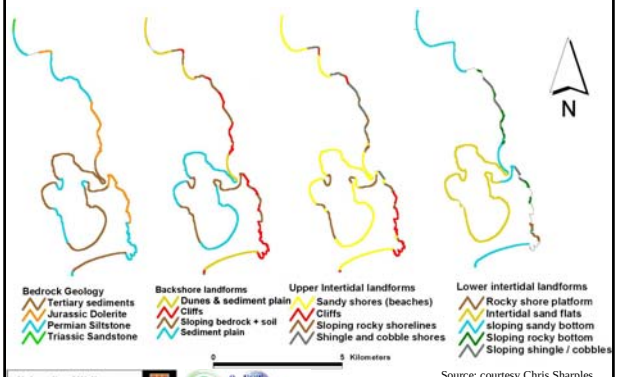
Cairns, Australia



Source: courtesy Peter Todd, USC

Mackay – floods, Feb 2008

Tasmanian coastal geomorphic mapping - Smartline



Source: courtesy Chris Sharples

Climate driver template – Engineers Australia

	Mean Sea Level K1	Ocean Currents & Temperature K2	Wind Climate K3	Wave Climate K4	Rainfall / Runoff K5	Air Temperature K6
Local Sea Level S1						
Local Currents S2						
Local Winds S3						
Local Waves S4						
Effects on Structures S5						
Groundwater S6						
Coastal Flooding S7						
Beach Response S8						
Foreshore Stability S9						
Sediment Transport S10						
Hydraulics of Estuaries S11						
Quality of Coastal Waters S12						
Ecology S13						

Source: NCCOE, 2004

Many adaptation options are available

Coastal Adaptation (IPCC CZMS, 1990)	*Adaptation Objectives (Klein and Tol, 1997)*	*Adaptation Responses (after Cooper et al., 2002; DEFRA, 2001)*	*Examples*
		Advance the line	Land claim; polders
Protect	Increased robustness	Hold the line	Dyke; beach nourishment
Accommodate	Increased flexibility		'Flood proof' buildings Floating agricultural systems
Retreat	Enhanced adaptability	Retreat the line	Managed realignment
		Limited intervention	Ad hoc seawall
		No intervention	Monitoring only
	Reversing maladaptive trends	Sustainable adaptation	Wetland restoration
	Improved awareness and preparedness	Community-focussed adaptation	Flood hazard mapping; flood warnings

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Source: IPCC WGII, April 2007

Floodplain adaptation to climate change

Coasts have some natural capacity to adjust to change

There are a range of adaptations that can be planned

Engineering solutions are costly and require ongoing maintenance

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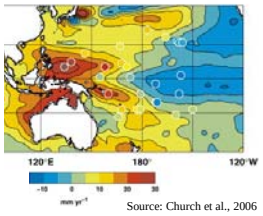
Source: DECC Floodplain management guidelines, 2007

Summary -sea-level rise and consequent impacts

- Tide gauge records indicate rise around Australia, with higher rates in the north
- IPCC maximum rate of sea-level of 59 cm by 2100 is conservative
- Regional variation in sea-level trends to be expected
- Rise will continue beyond 2100



Source: Church et al., 2006

- Need to further evaluate the threat of coastal erosion vs the Venice effect
- Intensification of tropical storms and increased surge levels likely to result in greater flooding

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