Coastal Development in South Africa

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our future through science

Geographic focus

Coastal resilience – An African context

Common threads

- Coasts provide EGS
- Disproportionate contribution to national economies
- Population densities are concentrated on coasts

More (?) pertinent in Africa

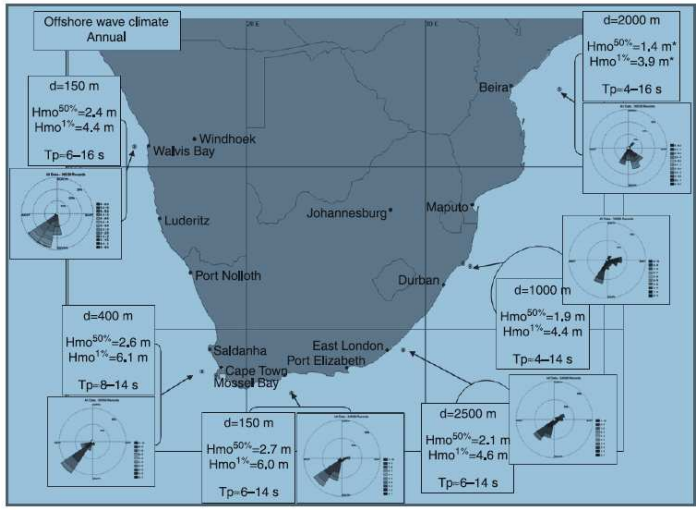
- A strong development imperative
- People strongly and often very directly reliant on provisioning EGS (subsistence)
- People are vulnerable when regulating EGS are impacted

Ecosystem Goods and Services		
Provisioning	**Regulating**	**Cultural**
• Food: fish • Timber and fuel • Building materials • Minerals • Curios • Fibre • Medicines	• Atmosphere and climate regulating • Hydrological balance • Disease control • Waste assimilation • Erosion control • Storm and flood protection	• Recreational • Spiritual and religion • Aesthetic • Inspirational • Educational • Heritage
Supporting		
• Nutrient cycling • Primary production	• Provisioning of habitat • Supporting life cycles	

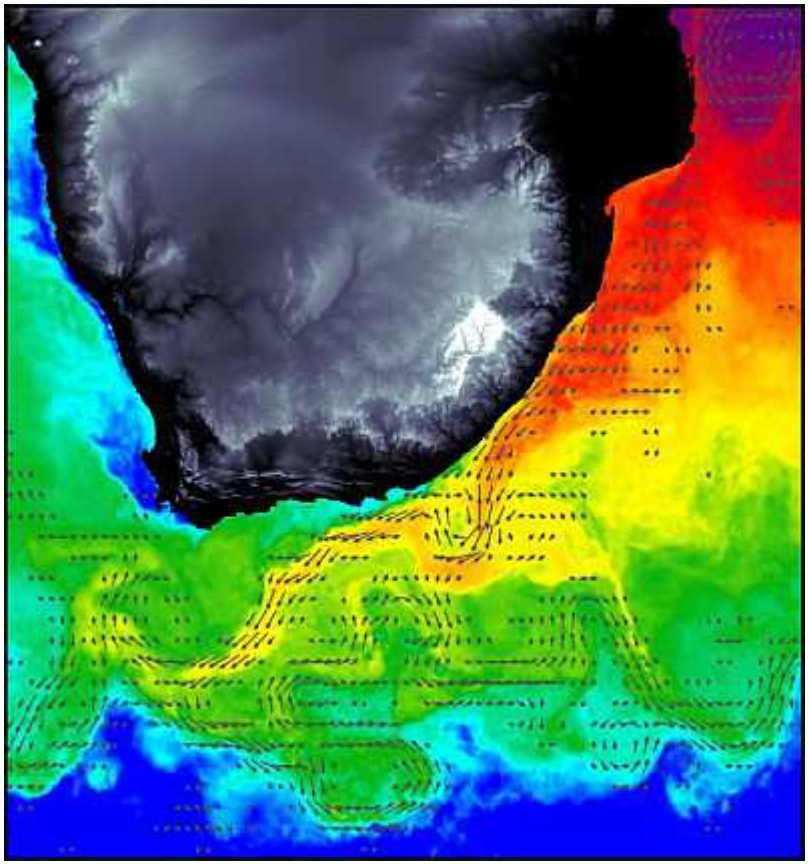
From Goble et al. (2014)

Current coastal conditions

- Strong oceanic forcings
- Role of winds in upwellings
- Tides < 2 m
- Wave dominated
- Sediment transport by long shore drift



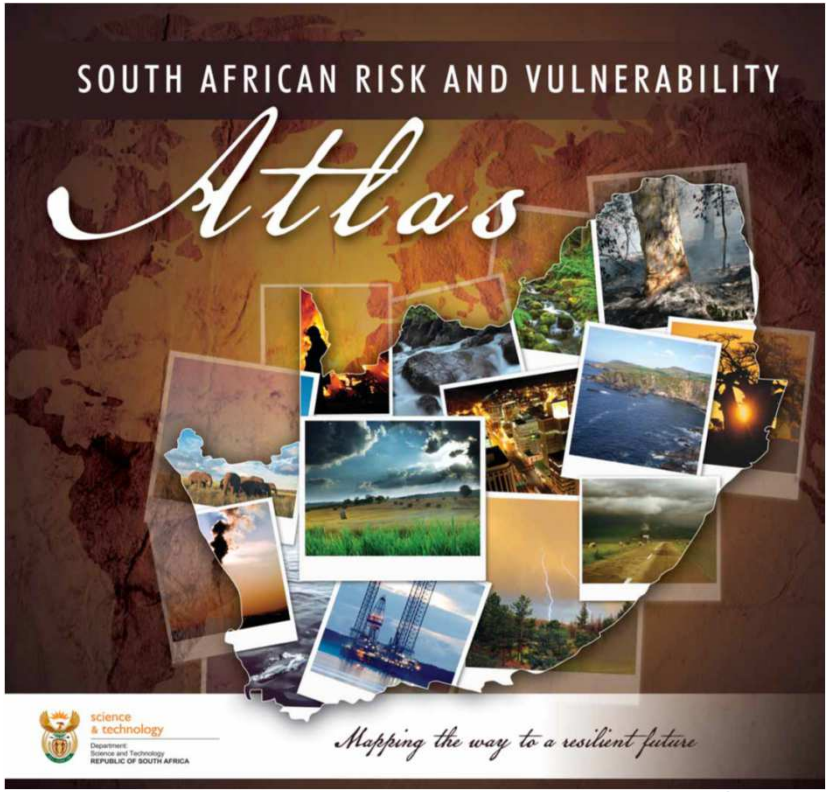
From Rossouw, Theron (2012)



Future climate

South African Risk and Vulnerability Atlas:

- “downscaled climate change scenarios to support strategy development in the areas of risk and vulnerability”



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Future coastal conditions

Predicted changes in:

- Sea level
- Ocean currents
- Water temperature
- Increased storminess
- Wind and waves
- Sediment transport rate

Population
Development
Exploitation of natural capital

Not just Climate Change

Has implications for:

- The way we use the coast
- The benefits we derive from it
- Our development plans

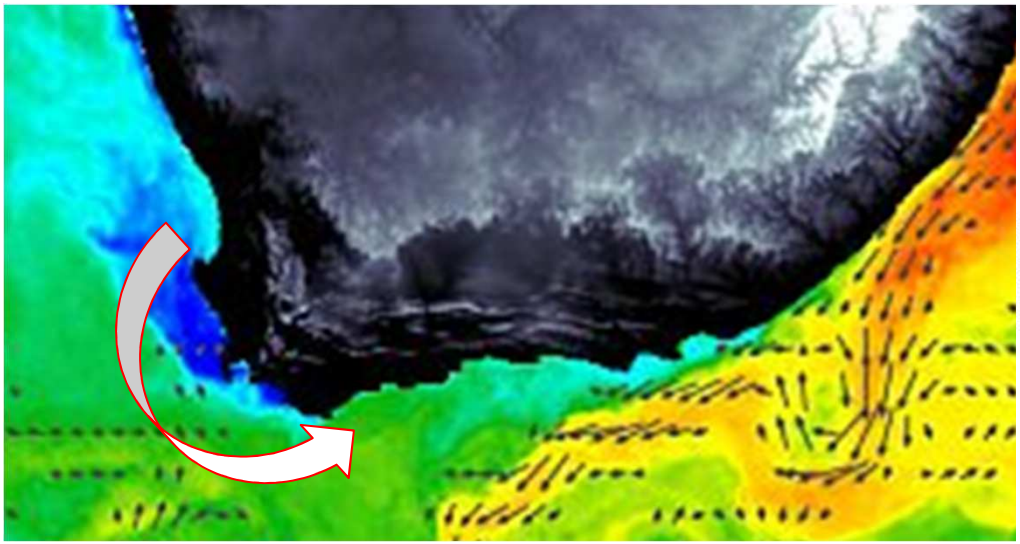
- Fisheries
- Shipping
- Coastal development

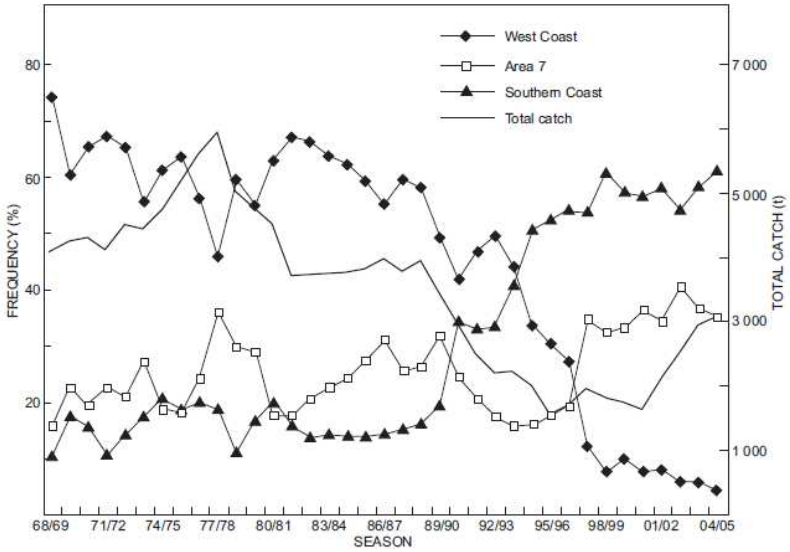
Fish stocks moving

Since ~ 1990's:

- Pilchard
- Anchovy
- West Coast Rock Lobster

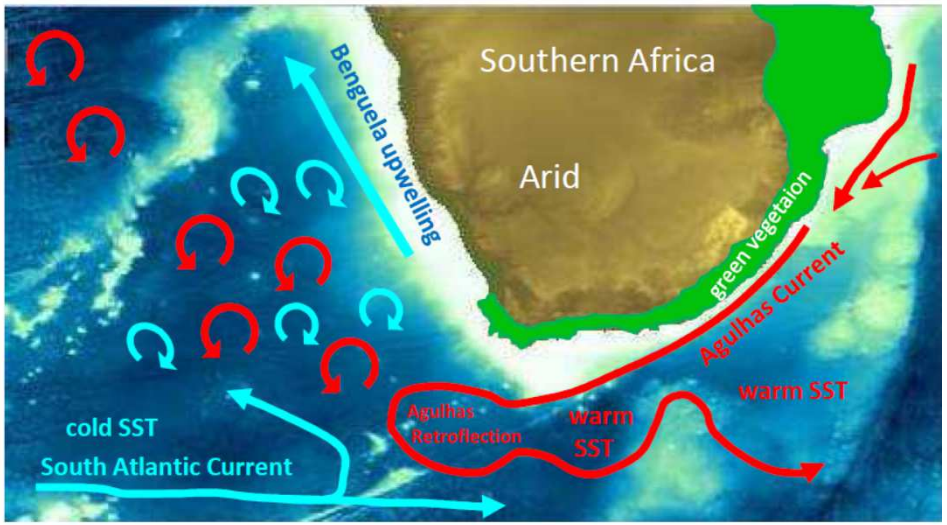
Photos: SA Dept. of Env. Affairs: Marine and Coastal Management

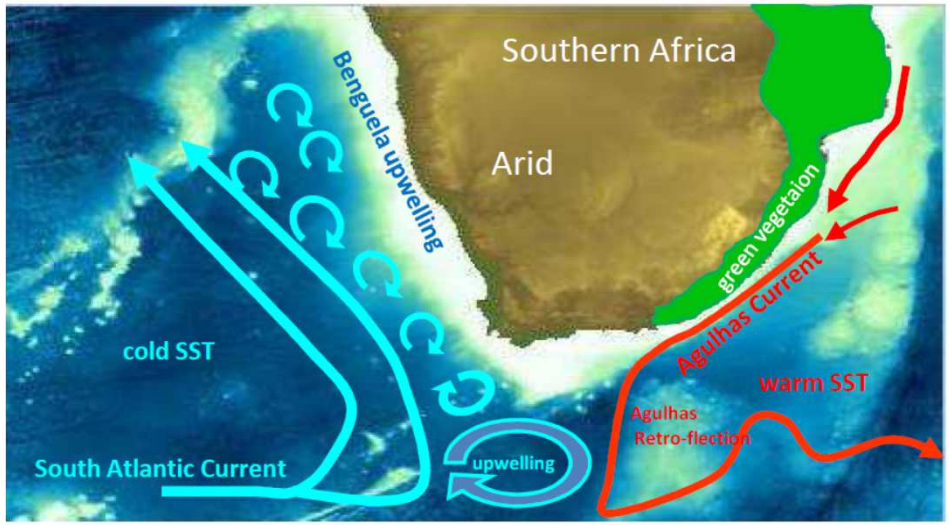




From Cockroft et al. (2008)

Fish stocks moving





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Downstream mode of Agulhas Retroflection

Upstream mode of Agulhas Retroflection

Fish stocks moving

Implications for:

- Catches (decreasing/increasing)
- Infrastructure
  - Fish processing plants
  - Supporting industries
- Permit allocations
- West coast fishing communities
  - Deep rooted culture

Shipping and maritime operations Rossouw M & Theron A (2012)

Main ports around southern Africa

Country	*Port*	*Main Functions*	*Export/import volumes p.a. (2007)*
Namibia	Walvis Bay	Containers & fishing	3.9 Mt (0.13 MTEU)
	Lüderitz	Fishing & zinc export	0.5 Mt (0.01 MTEU)
South Africa	Saldanha Bay	Iron ore export	43.7 Mt
	Cape Town	Containers, fishing & repair works	4.1 Mt (0.76 MTEU)
	Mossel Bay	Fishing & export of oil products	1.8 Mt
	Port Elizabeth	Containers, cars & fishing	5.5 Mt (0.42 MTEU)
	East London	Cars & containers	1.8 Mt (0.04 MTEU)
	Durban	Containers, oil import & food	41.9 Mt (2.48 MTEU)
	Richards Bay	Coal export	84.5 Mt
Mozambique	Maputo	Coal, containers & sugar	6.3 Mt (0.10 MTEU)
	Beira	Containers, oil import & fishing	N/A

Source: National Port Authority.

Development implications

Shipping and maritime operations Rossouw M & Theron A (2012).

Wind and waves:

- 10% increase in wind speed = 26% increase in wave height
- 10% increase in wind speed = 80% increase in wave power

Waves and current:

- Increase in Agulhas current strength = increase probability of ‘rogue’ waves



Shipping and maritime operations Rossouw M & Theron A (2012)

Storm events:

- Cold fronts
- Cut-off lows
- Tropical cyclones
- Wave data indicate increasing wave height in winter storms (0.5 m over last 14 years?)
- Storm intensity is increasing

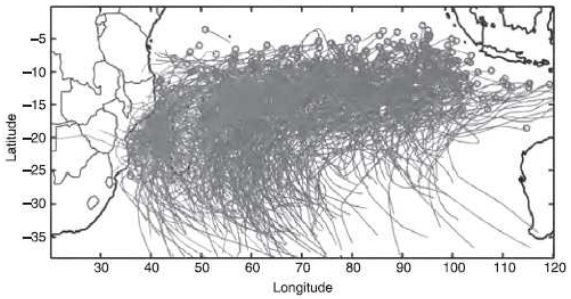


Figure 15.8 Cyclone tracks during the November to April period for the years 1952 to 2007 in south-west Indian Ocean.

Source: Mavume et al., 2009.

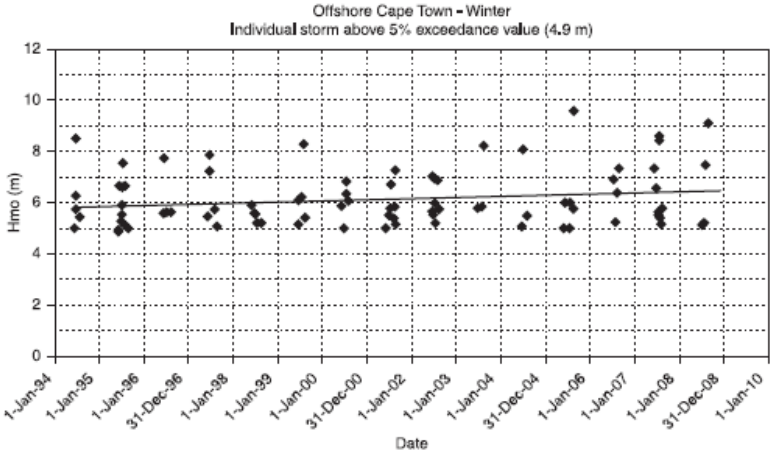


Figure 15.5 Peaks of individual storms over 14-year period – offshore Cape Town.

Source: Based on recordings by CSIR from 1994 to 2009.

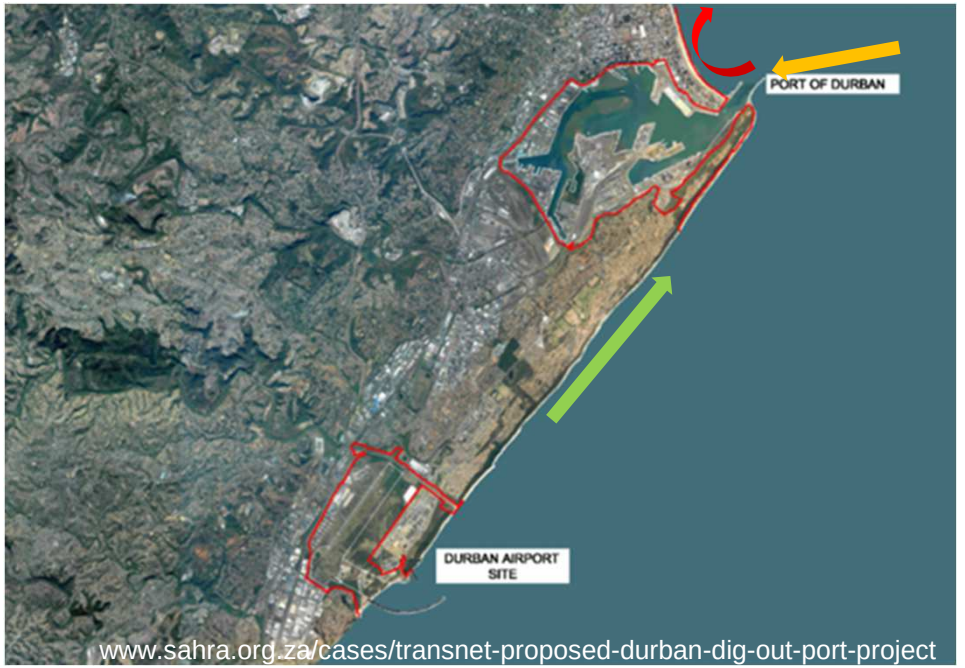
Shipping and maritime operations Rossouw M & Theron A (2012)

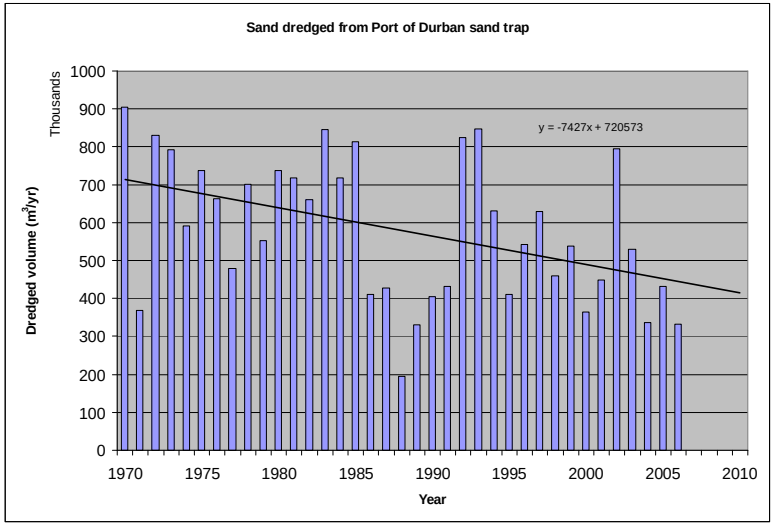
Vulnerability to marine weather conditions:

- Shipping
  - Predominantly (but not only) smaller vessels vulnerable
- Port operations and transport infrastructure
  - Increased frequency and duration of port “closure”
  - Wave height, SLR and aging infrastructure (e.g. Maputo, Beira)
  - Finger jetties and transhipment operations (Mozambique)
- Impact of port development and operations on the coastline
  - Sediment dynamics and coastal erosion

Coastal erosion (eThekwini municipality)

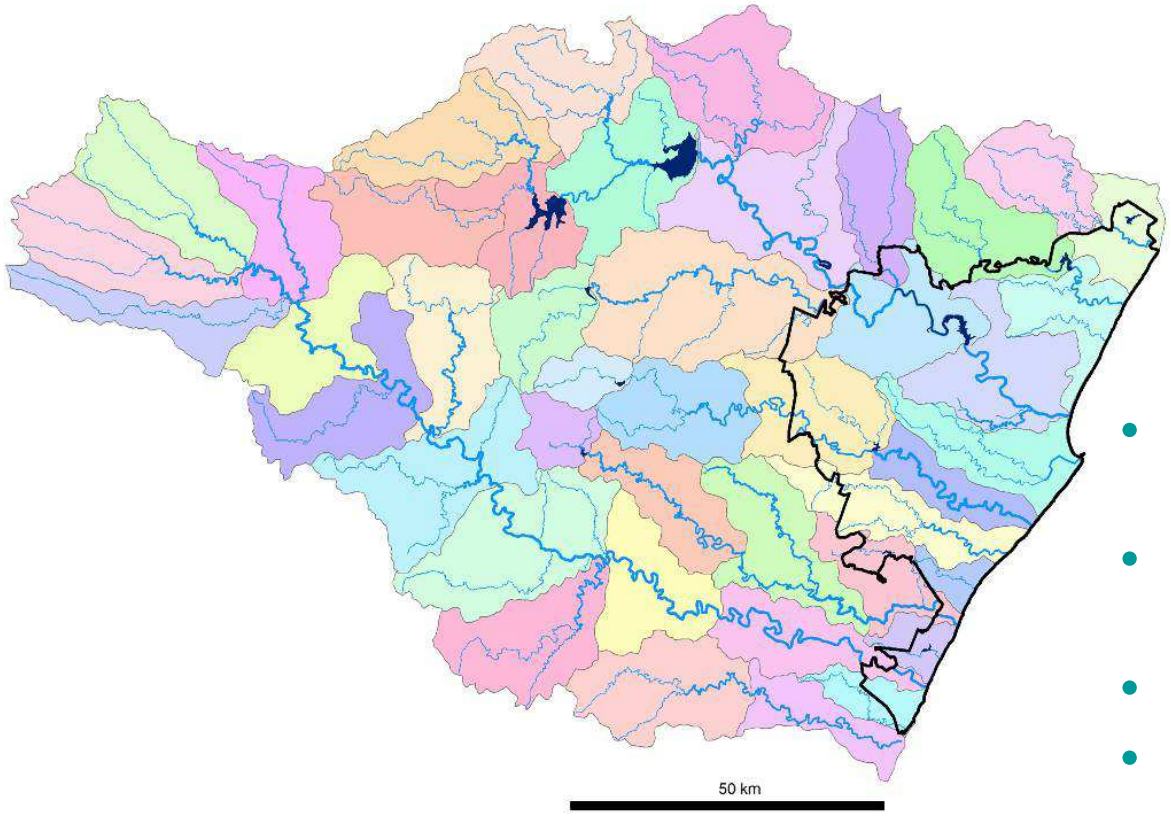
- Many environmental constraints to port operation and development
- Disruptions to sediment movement is a major one
- Sediment by-pass systems needed to maintain entrance canal
- Not particularly successful





Sediment budgets on the eThekwini coastline

Andre Theron, CSIR



- Soil erosion models and input data, e.g. landcover, slopes, erodibilty…
- 19 rivers sediment yield modelling
- Field measurements in 4 rivers
- Verification of sediment yields

Sedimentary Inputs From Fluvial Sources

Andre Theron

eThekwini Municipality

Dams:

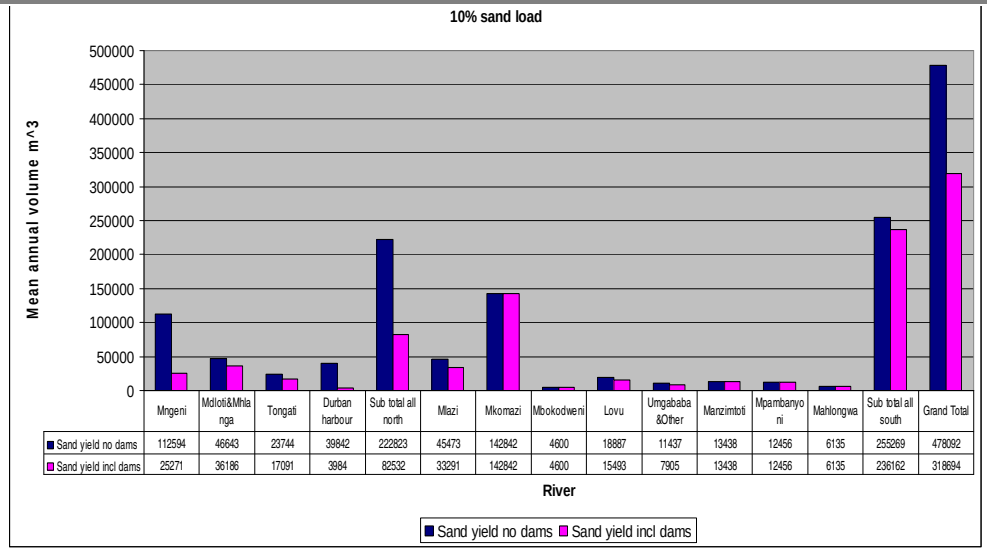
- 12 large dams with high sand trapping efficiencies high
- Reduce sand yield to coast by ~ 1/3

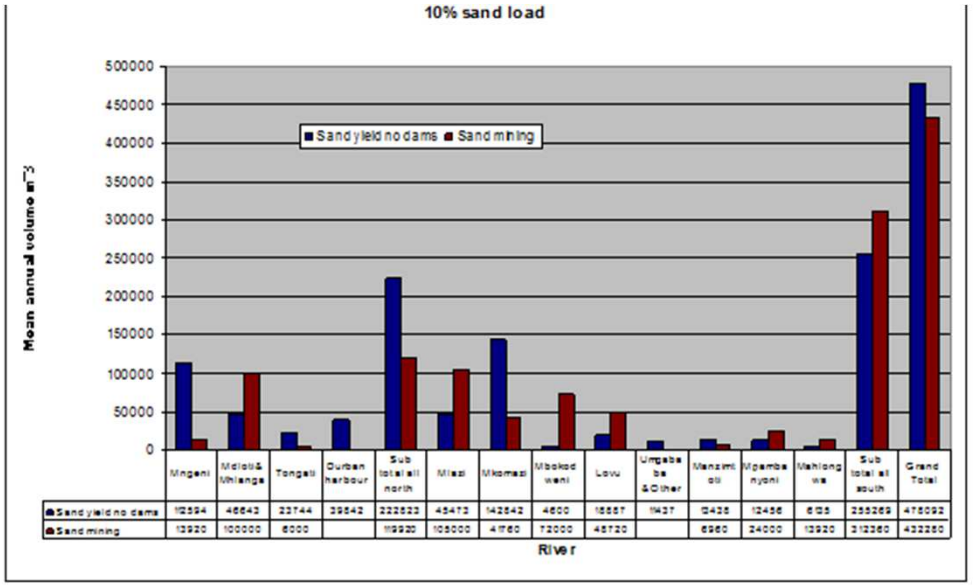
Sand mining:

- 31 operations on 18 rivers
- Reduce sand yield to coast by ~ 1/3

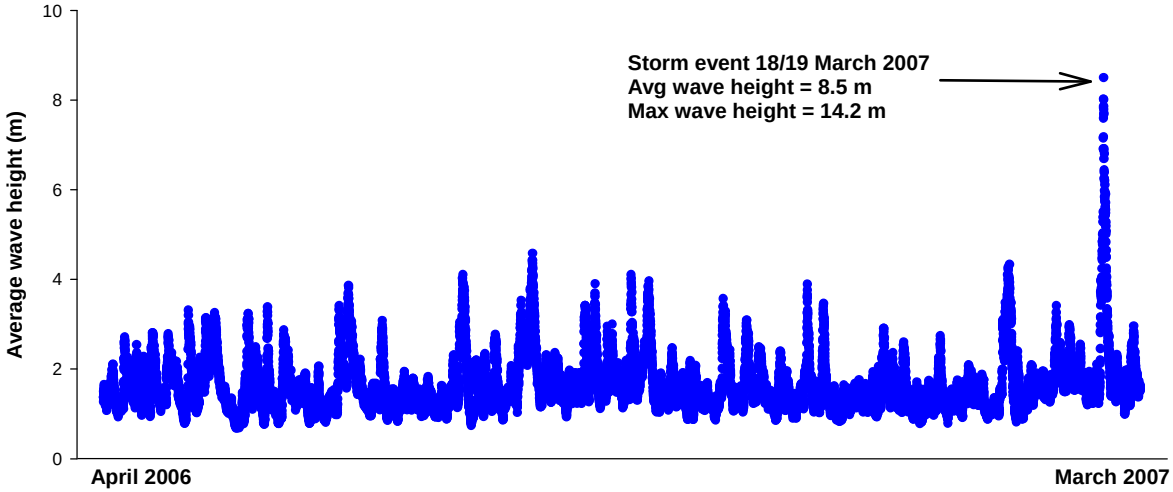
Combined impacts:

- Remaining sand yield to coast only 140000 - 240000 m^3/yr
- ~ 1/3 “natural” budget





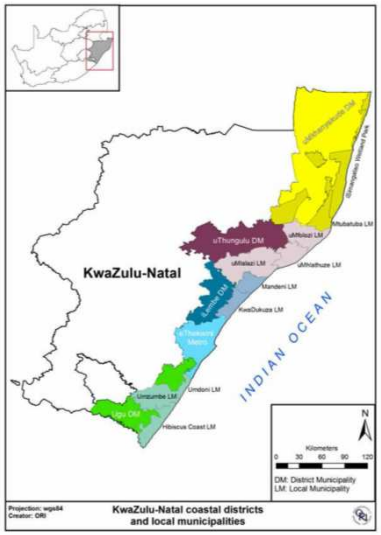
A coastal storm – March 2007

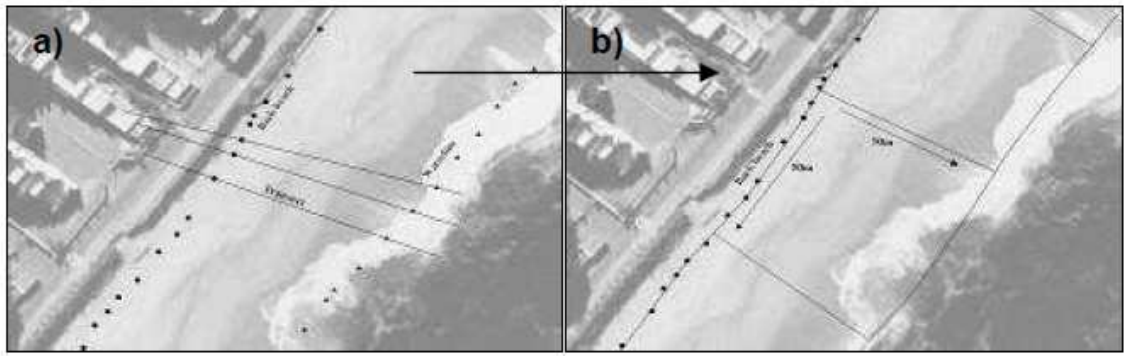


Coastal Vulnerability Index Palmer et al. (2011)

A relative index of vulnerability (KwaZulu-Natal coast) based on:

- Beach width - The wider the beach the more wave energy dissipates
- Dune width - Dune width gives an indication as to the sediment available which will buffer against erosion
- Distance to the 20m isobath - The greater the offshore distance to the 20m isobath the greater the dissipation of wave energy
- Percentage rocky outcrop - The higher the percentage the lower the erosion rate
- Width of vegetation behind the back beach - The more the vegetation, the greater the buffer against erosion





Coastal Vulnerability Index Palmer et al. (2011)

Table 1: Rating of physical parameters

Physical Parameter	Extremely Low (1)	Low (2)	Moderate (3)	High (4)
Beach width	> 150m	100 – 150m	50 – 100m	< 50m
Dune width	> 150m	50 – 150m	25 – 50m	< 25m
Distance to 20m isobath	> 4km	2 – 4km	1 – 2km	< 1km
Distance of vegetation behind the back beach	> 600m	200 – 600m	100 – 200m	< 100m
Percentage outcrop	> 50%	20 – 50%	10 – 20%	< 10%

$$\textit{Relative CVI} = a + b + c + d + e + f + g$$

Where a = beach width vulnerability score, b = dune width vulnerability score, c = distance to 20m isobath vulnerability score, d = percentage outcrop vulnerability score, e = distance of vegetation behind the back beach vulnerability score, f = additional weighting of highly vulnerable sites (if a, b and c = 4), g = additional weighting if the cell intersects an estuarine area.

Coastal Vulnerability Index Palmer et al. (2011)

Table 2: The grouping at which social, economic and ecological assets were assessed

Economic & commercial activities	Strategic infrastructure	Recreational areas	Subsistence sites	Ecological important areas	Residential properties
Dune mining	Piers#	Boat launch sites#	Subsistence fishing sites#	Marine Protected Areas#	Residential erven
Forest plantation	Roads	Fishing hot spots#	Subsistence harvesting sites#	Bird sanctuary sites#	
Sugar cane	Railway lines	Swimming beaches#	Subsistence farming areas	Turtle nesting sites#	
Commercial & industrial buildings	Lighthouses	Sports facilities		Estuary mouths#	
Commercial farms		Coastal Public Property[4]		Protected areas (terrestrial)	

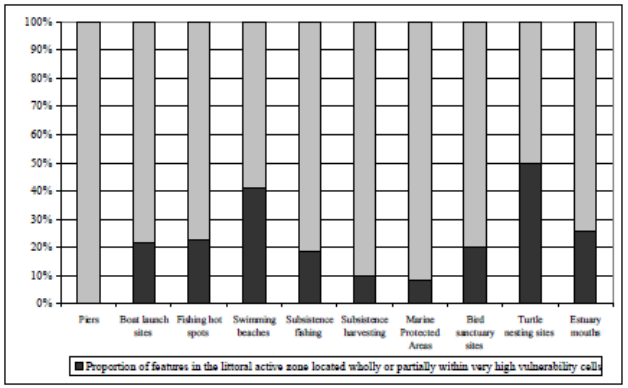


Figure 4: Proportion of features in the littoral active zone located wholly or partially within very high vulnerability cells

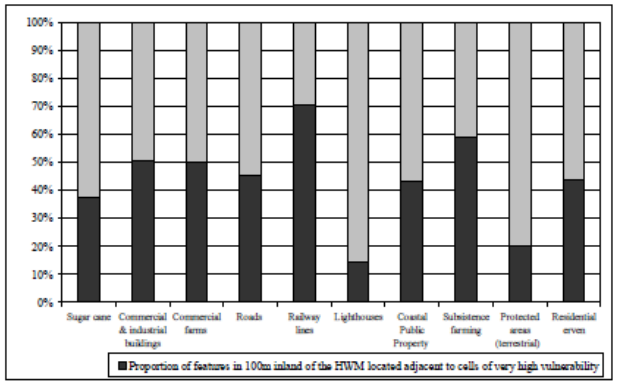


Figure 5: Proportion of features within 100m inland of th HWM and located adjacent to cells of very high CVI

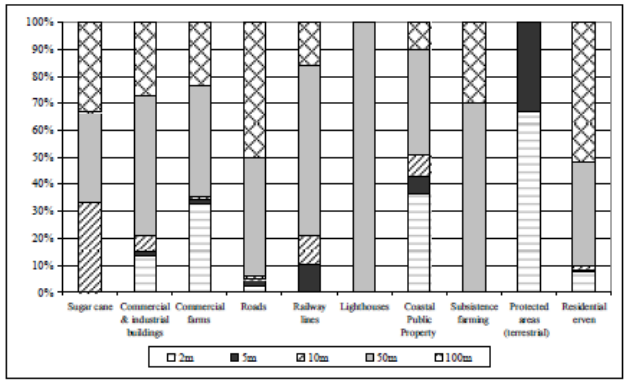


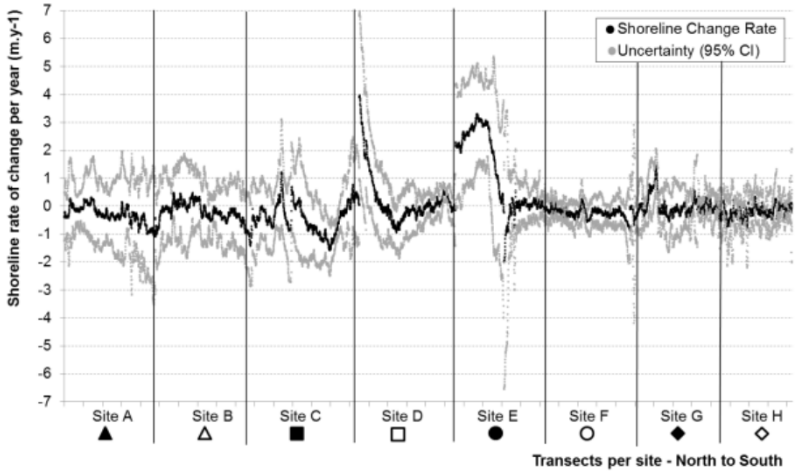
Figure 6: Features within varying distances of the HWM of very high CVI cells

Risk set-back lines Goble & MacKay (2013)

Set-back lines ~ “seawards of which development can be prohibited or controlled” (Integrated Coastal Management Act)

Input factors

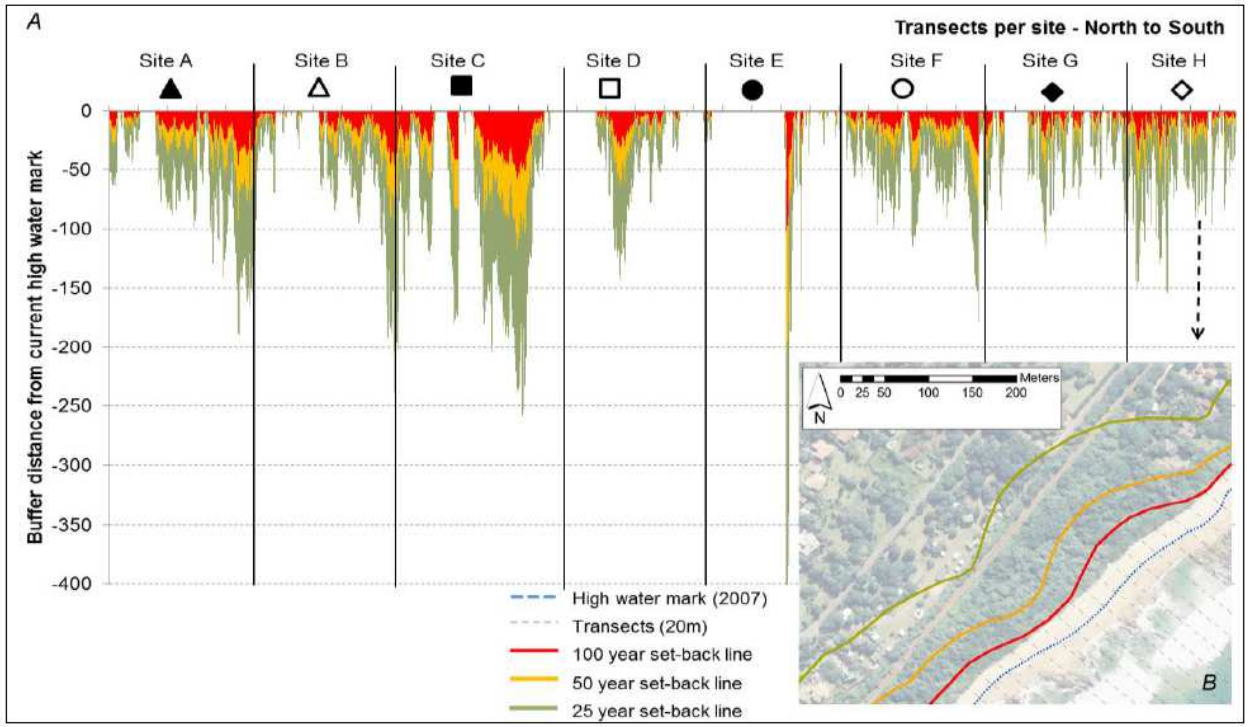
- Long-term shoreline change
  - Aerial photography
  - 1937 – 2007
  - -1.97 m/yr to +3.96 m/yr



- Sea level rise
  - 3.55 mm/yr (Mather et al. 2009)

- CVI

Risk set-back lines Goble & MacKay (2013)



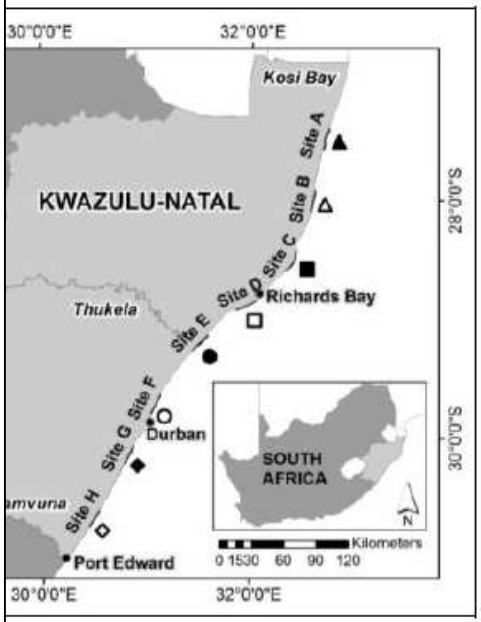


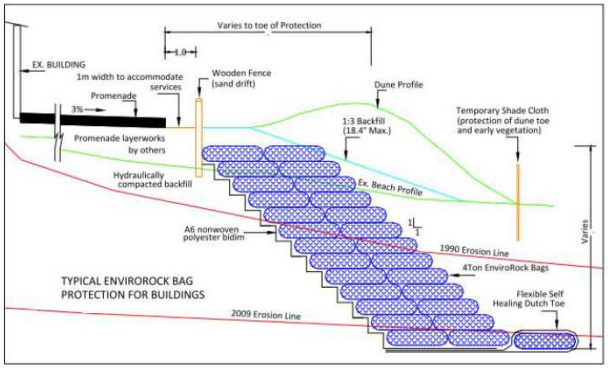
Figure 6. Proposed set-back buffer distances for each transect per scenario. A) shows the distance per transect for each set-back line scenario, while B) provides a spatial representation of this. Sections that appear to show no change are primarily accreting sections of coast that have a high natural buffer.

Soft engineering on Durban's Central Beachfront

Breetzke & Mather (2013)

Post the March 2007 storm event:

- Geotextile bags used to facilitate the development of vegetated dunes along most of Durban's beachfront as part of a development project
- Learning-by-doing and adaptive management adopted
- Smart and ecologically sound:
  - reduces strain on city maintenance requirements and service delivery needs
  - reduces risk to infrastructure by creating a sustainable buffer against dynamic coastal processes
  - an innovative and proactive response to disaster management requirements
  - can be considered to be a financially and environmentally sustainable investment
  - created both short term and long employment
  - proactively addresses waste, security and crime issues
  - beautifies the city landscape / coastal zone
  - improves public amenity and access to the coastal zone
  - adopts an innovative and best practice



Soft engineering on Durban's Central Beachfront

Acknowledgments

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- Fiona MacKay (Oceanographic Research Institute)

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