CLIMATE CHANGE ADAPTATION FOR COASTAL AND SHORELINE ECOSYSTEMS

M.Lokman Husain
Aidy @ Mohamed Shawal

Climate …

is weather over the long-term

Climate Change…

is how weather changes over the long-term

…it's measured in *decades*

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What is global warming?

- Increases in global average temperature, translating into *regional climate change*
- Rising temperatures
- Changing precipitation
- Extreme weather events

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Wild weather

● 1,000 Penans stranded ● Two homes swept away in Sabah

PETALING JAYA: Bad weather continued to unleash its fury in several parts of the country.

Violent river currents from the massive Sungai Linau swept away a wooden bridge in the interiors of central Sarawak, cutting off about 1,000 Penans living near the Bakun Dam.

In Sandakan, Sabah, two houses on the Gum Gum river bank were swept away hours after the occupants moved out.

The Meteorological Department said there was heavy rainfall in East Malaysia, with Miri recording 58mm of rain on Tuesday, while Sandakan recorded 38mm on Monday.

In the peninsula, the weatherman predicts that intermittent rain could continue across Kelantan and Terengganu until Saturday.

> REPORTS ON PAGE 3

Raging river: The Lusong Laku settlement in interior central Sarawak was cut off after strong river currents swept away a wooden bridge. This picture was taken by Catholic priest Father Robert Muyang who was in the interior doing his Christmas visit with Father Damian Thomas yesterday. Inset: Heavy rain in Kuala Lumpur caused a flood in Jalan Klang Lama.

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Major environmental impacts

Changes in temperature, precipitation and sea level rise will also produce impacts in:

- **Forestry**
- **Coastal area**
- **Industry and energy**
- **Agriculture**
- **Human health**

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Potential Coastal/Marine Impacts from Global Warming

- **Higher sea levels**
- **Erosion of coastal areas**
- **Damage to estuaries**
- **Decline in water quality**
- **Decreasing yield for fisheries**
- **Decrease in marine biodiversity/ migration of species**
- **Increase in extreme weather events**

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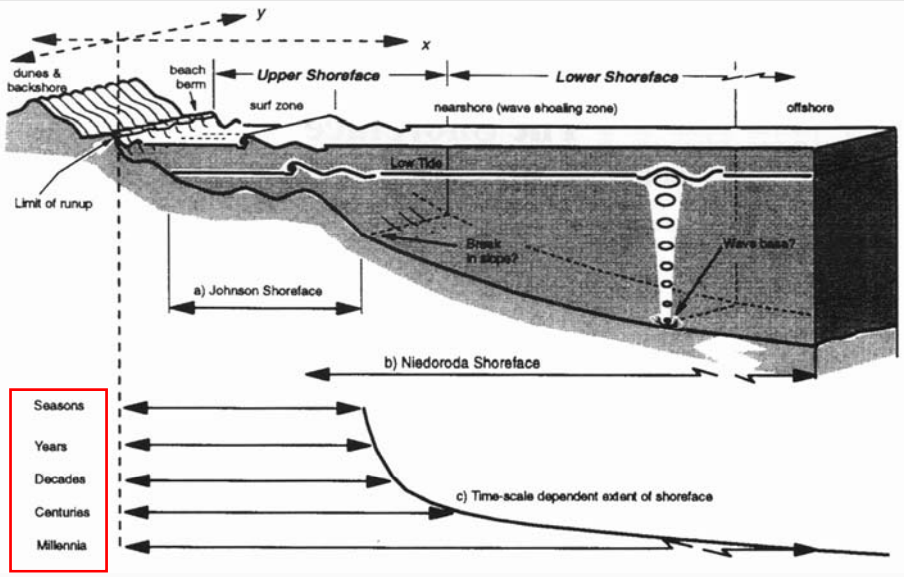
Wave dominated sandy beaches

What is the COAST ?

How can we define the spatial extension?



The shoreface as defined (a) explicitly by Johnson (1919), (b) loosely by Niederoda & Swift (1991) and (c) by Cowell et al. (1999) by extending Johnson`s definition in relation to the natural morphodynamic continuum. The curve at the bottom depicts the relationship between time scale and scale of morphological change (from Cowell et al. 1999).

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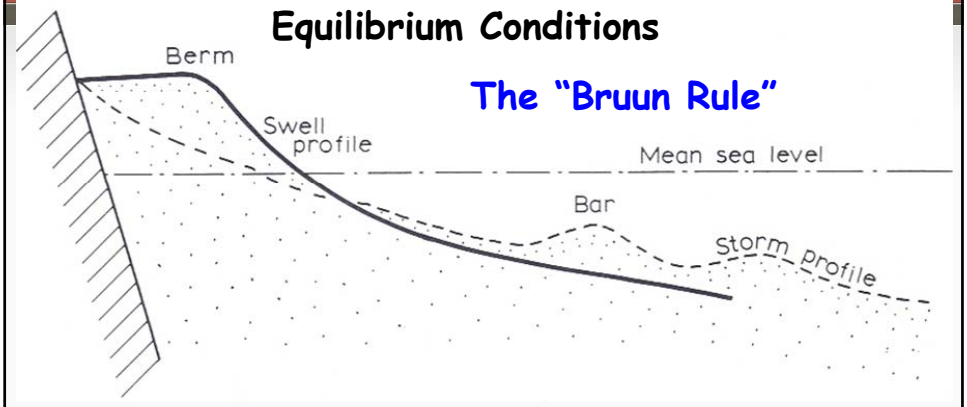
Equilibrium Conditions

The "Bruun Rule"



The steep beach profile characteristic of swell waves contrasted with the shallow profile of storm waves.

Note the position of the berm and bar on these profiles (only simple 2-dimensional approach).

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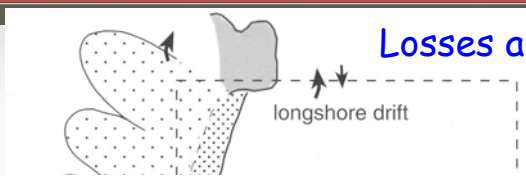
Losses and gains



Geomorphological units longshore and cross-shore have to be considered.

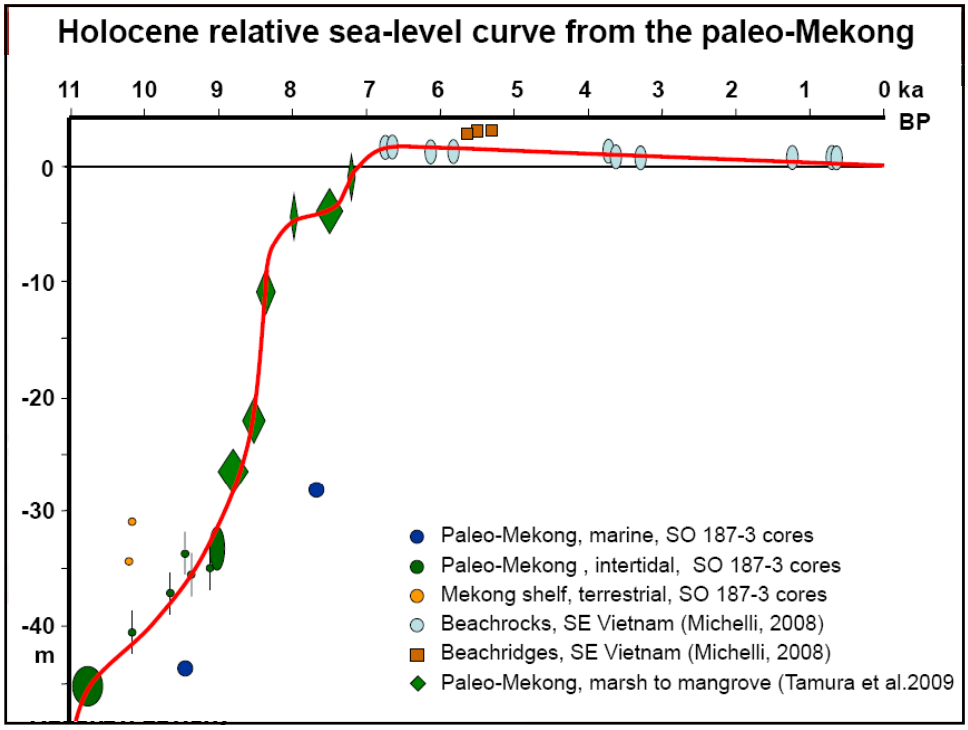
Boundaries in the coastal system are natural and not given by jurisdiction or site specific problems. Geomorphological units exist due to sediment transport processes and geological prerequisites

Woodroffe, C., 2003

The coast is always striving for an equilibrium

but

How does the coast react to sea level rise ?



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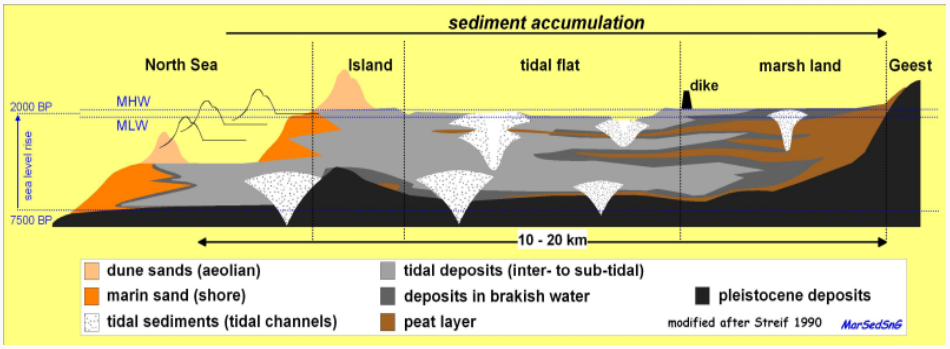
Adaptation of barrier islands, tidal flats, salt-marshes / mangroves to sea level fluctuations



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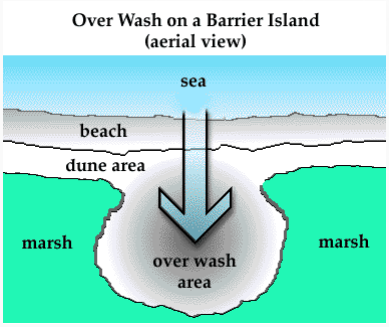
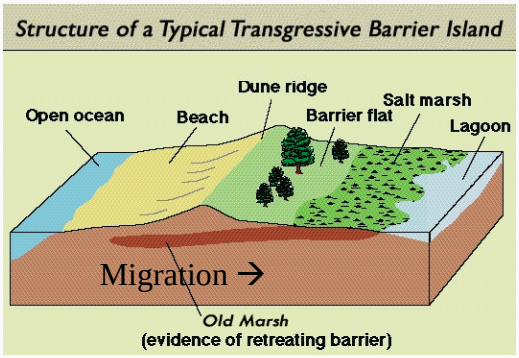
Barrier islands and a rising sea level

Under a rising sea level barrier islands tend to migrate towards the mainland





Migration, how?

- **Washover**
- **Eolian sand transport**
- **Hooked spits**

The Coastal System

Sea-level rise:
lateral erosion (retreat) is approximately 1 : 100

1 m sea level rise will result in 100 m coastal retreat

ADAPTION BY MIGRATION

- 20% of the worlds coastline are sandy coasts.
- 70% of these coasts have been under erosion during the last century

(Bird, 1993), Leatherman (2001) argued that 80 – 90 % are under erosion.

- 20 – 30% are stable and only 10 % are advancing

Need To Redefine / Reclassify Shoreline In Context Of Sea Level Rise Taking Into Account Buffer Zones For Coastal Migration

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What makes erosion so negative?

Tok Jembal, K.
Terengganu
December 2009

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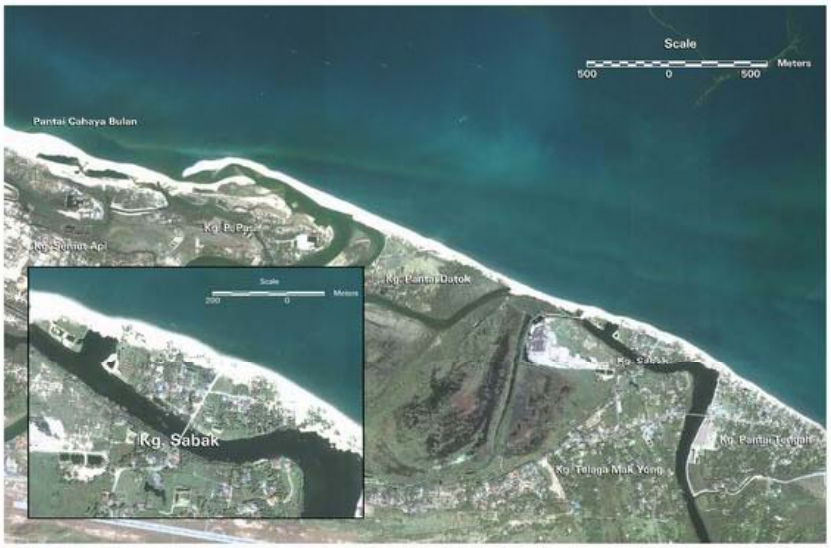
Coast of Kota Bharu and Bachok- 21 April 2001

Tide level 0.68 m (11.36 am)



IKONOS Pan-Sharpen satellite sensor image

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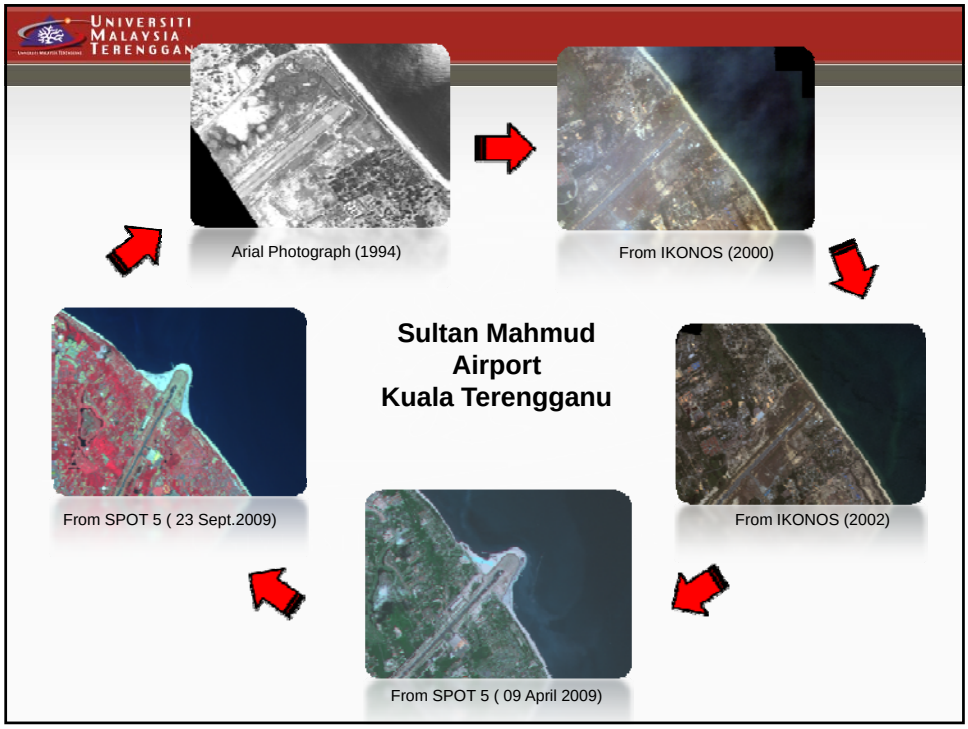
Coast of Kota Bharu and Bachok- 8 September 2004

Tide level 1.34m (11.29 am)

SPOT XS 123 Pan-Sharpen
The red line depicts the shoreline position in 2004 while the yellow depict the position in 2001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Arial Photograph (1994)
From IKONOS (2000)
Sultan Mahmud Airport Kuala Terengganu
From SPOT 5 (23 Sept.2009)
From IKONOS (2002)
From SPOT 5 (09 April 2009)


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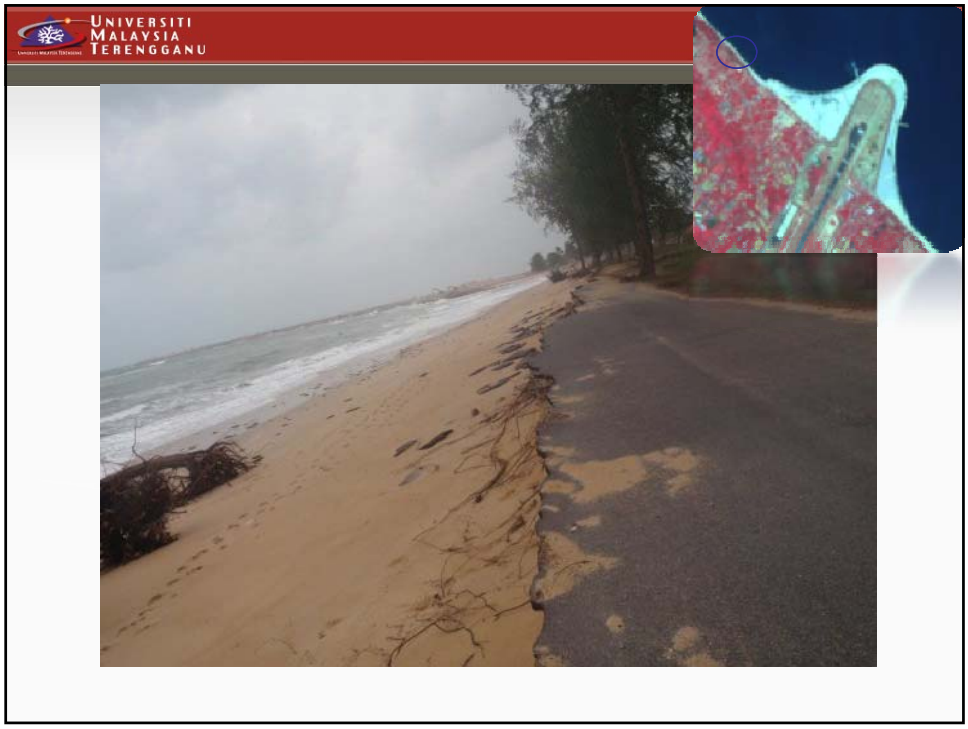
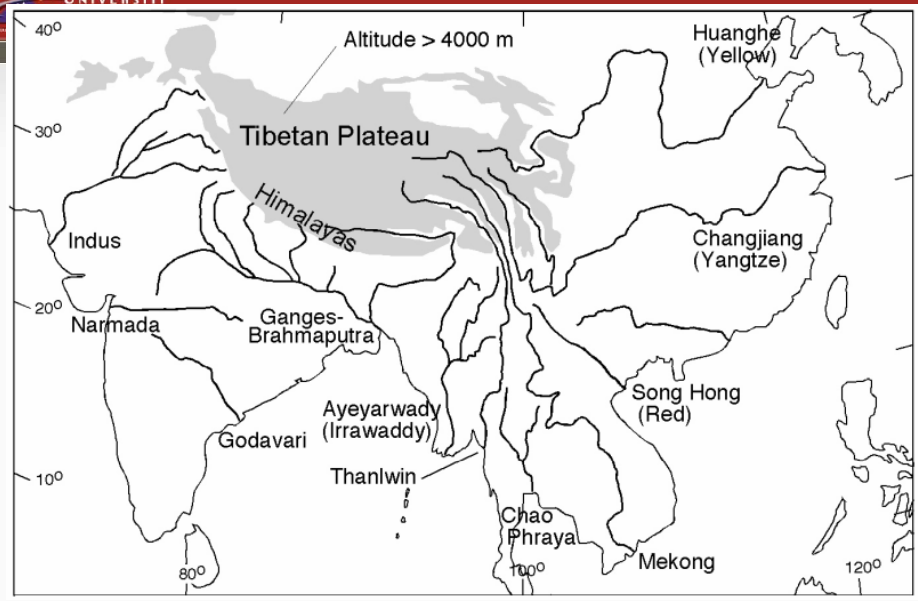
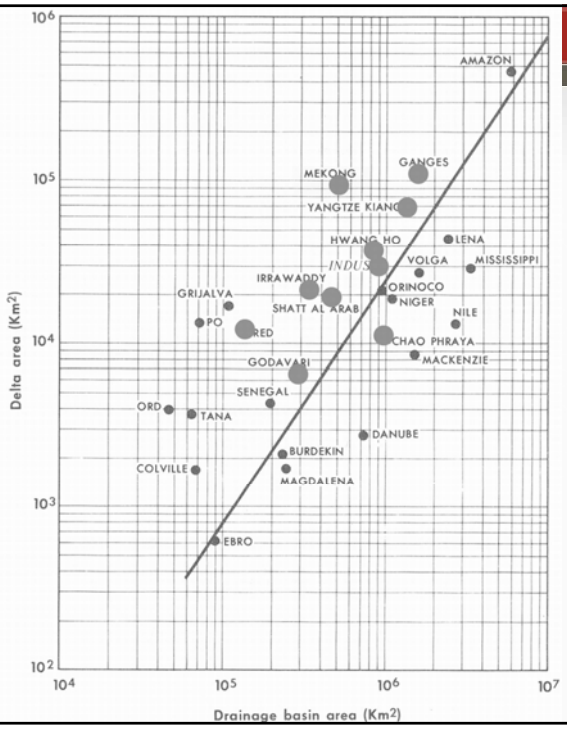


Coastal equilibrium

- Supply and demand
  - Sediment movement
- Current movement
  - Seasonal changes



Megadeltas in SE-Asia, Hori et al., 2005



The relationship between delta area and drainage basin area.

Large closed circles show Asian deltas, which are plotted above the average line, means that Asian deltas have a relatively large delta area. (Saito, 2004).

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The Asian Megadeltas

RIVER	SEDIMENT DISCHARGE t / YEAR DURING	SEDIMENT DISCHARGE SINCE	SEDIMENT DISCHARGE t / YEAR	GROWTH RATE OF DELTA PLAIN M²/YEAR
				After 1969: 1,5 km² in 25 years
Irrawaddy River (Myanmar)	No data			

All deltas show a tremendous decrease in sediment discharge;

Most of the changes in discharge are due to river damming and sand and gravel extraction in the river systems.

diminished to < 10 % since 1999 when the Xiaolangzi dam came in operation.

Data based on Saito et al., 2007

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What can be done?

A variety of solutions exist.

Do nothing option;

Maintain (mainly "hard solutions")

Control (mainly "soft solutions")

- Breakwaters at Sungai Marang rivermouth, Terengganu

SAUH Revetment, Haji Sirat, Selangor.

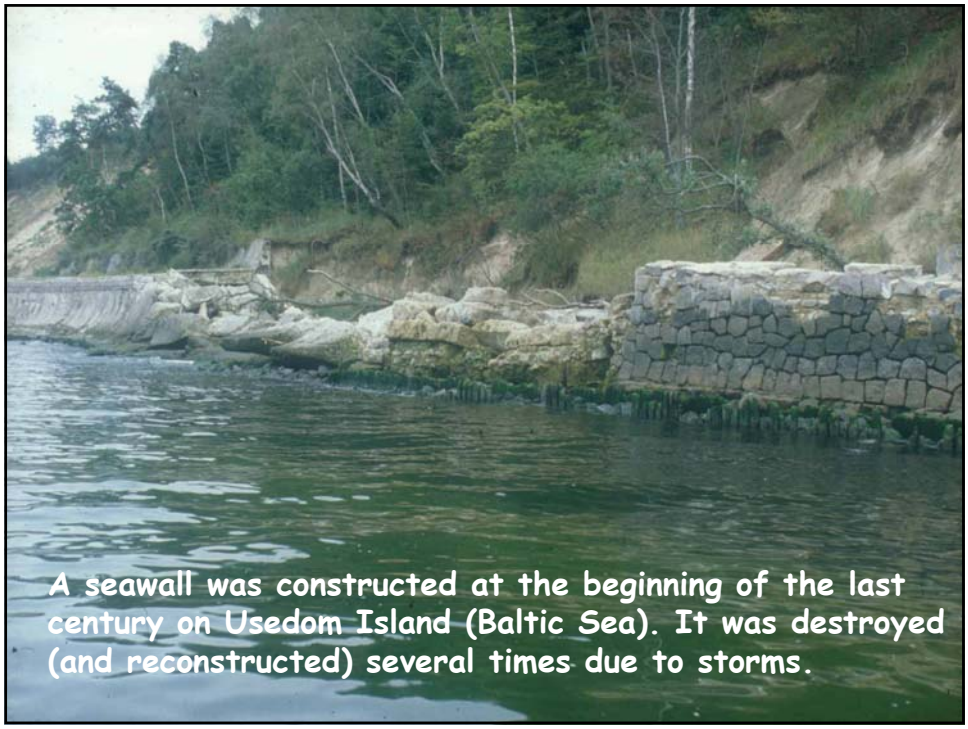
Basalton Revetment, Pulau Besar, Melaka

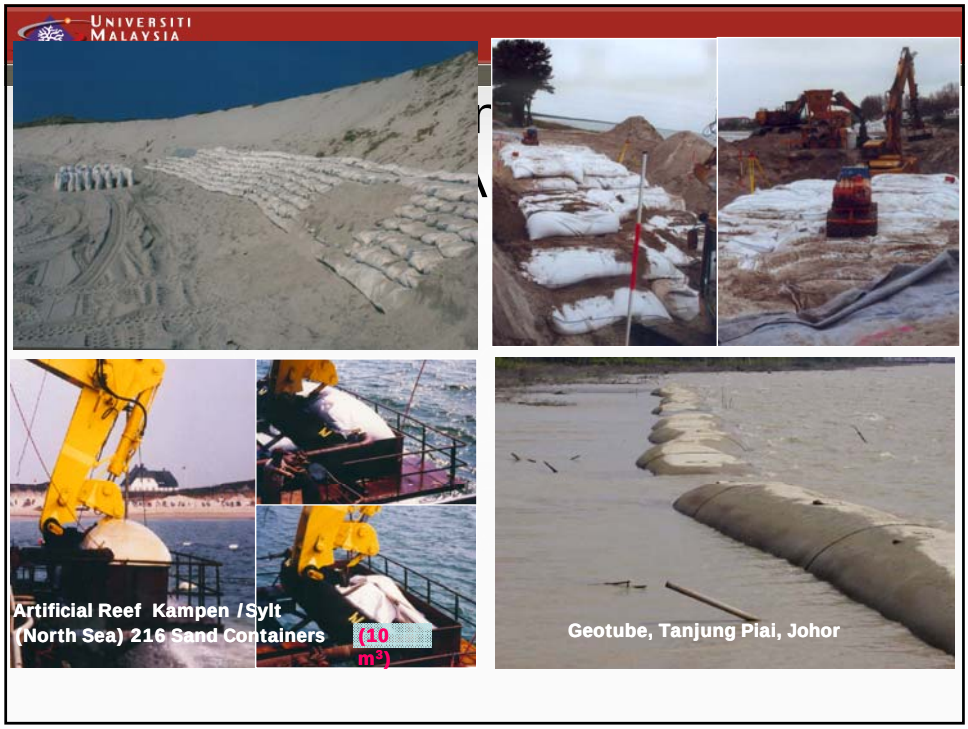
Rock Revetment, Kg Pasir Pandak, Kuching,Sarawak

(Source : Tan King Seng et al, 2005)

Coastal defence structures in the southern part of Kiel Bay (Baltic Sea). Dyke with T-groyne elements and additional beach nourishments.

Coastal defence structures in the southern part of Kiel Bay, Probstei a
(Baltic Sea). Dyke with T- groyne elements and additional beach nou


A seawall was constructed at the beginning of the last century on Usedom Island (Baltic Sea). It was destroyed (and reconstructed) several times due to storms.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Artificial Reef Kampen / Sylt (North Sea) 216 Sand Containers (10 m³)
Geotube, Tanjung Piai, Johor

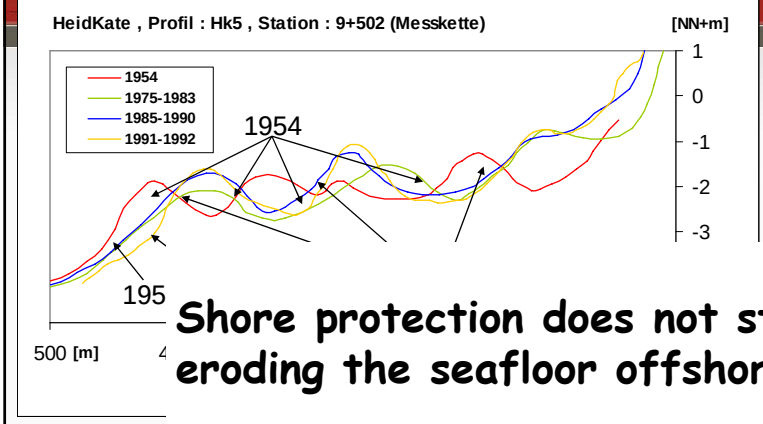
Keadaan Pantai Sebelum PEM

Keadaan Pantai Selepas PEM

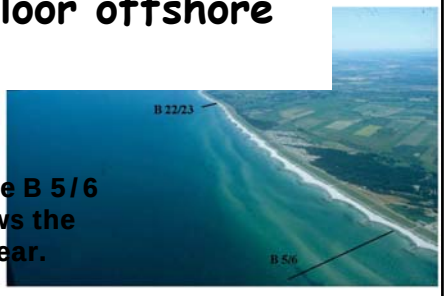
(Source : Tan King Seng et al. 2005)

Mangrove Replanting

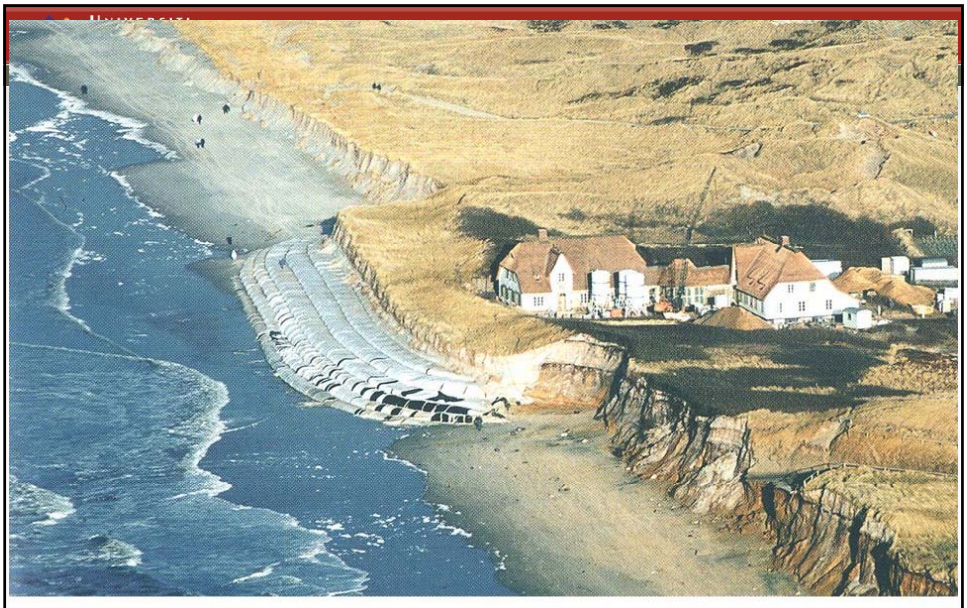
- Reduce erosion
- Mitigate effects of sea-level rise ?
- Further research is needed



Shore protection does not stop eroding the seafloor offshore



Development of the cross-shore profile B 5/6 from 1954 – 1992. Each profile shows the average of at least one survey / year.



Coastal defence on Sylt Island, Kampen, with the support by geotextiles and beach nourishment. It is a costly measure but it can not provide a permanent protection from storm surges (Source: MBM+F, 2002: The North Sea, Problems and Research Needs.)

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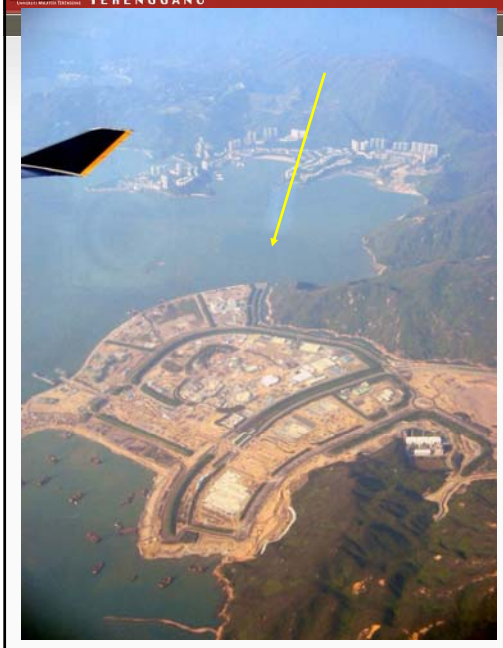
Growing demand on mineral Resources

- Construction purposes
  - on land
  - in coastal areas
- Coastal protection strategies

View of the Hong Kong International Airport construction site d
(© K. Bartlett, Pacific century Publishers Limited)

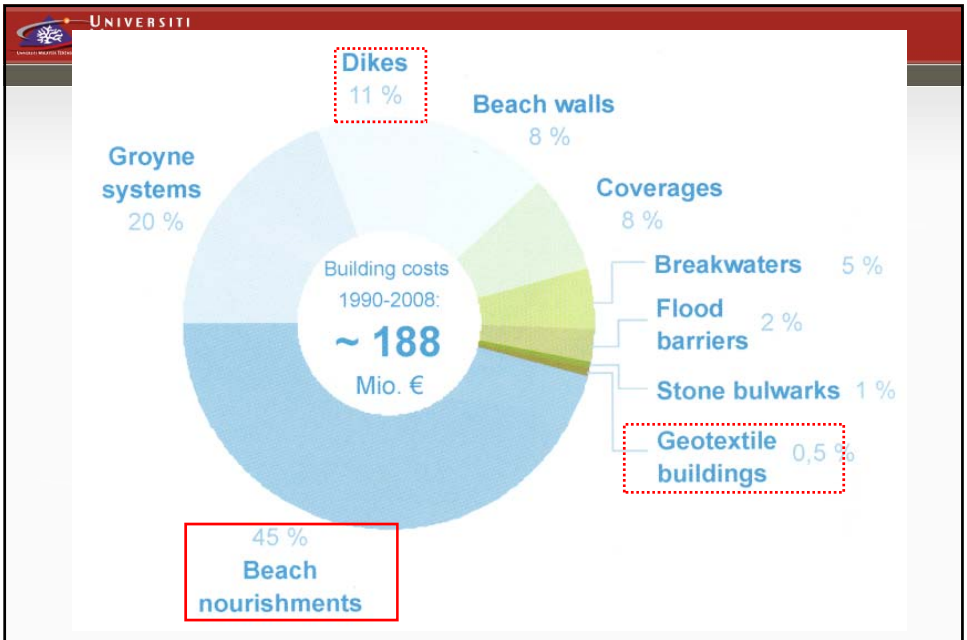
- Sultan Mahmud Airport
- Kuala Terengganu

Disneyland Hong Kong, 2005



Reclaimed land from Penney's Bay: 12,6 km²
Filled up from 30 m below sea level.
Construction is bigger than Hong Kong international airport.
Costs: 3.4 x 10^9 US $

Hong Kong, 2004



Compilation of costs for coastal protection measures in Mecklenburg-Vorpommern during the period 1990 – 2008 (Gurwell, 2008).

- **Due to anthropogenic impacts and sea level rise the demand for mineral resources will grow in the future;**
- **Resources are limited;**
- **Extraction seaward of the shoreface implies long regeneration times;**
- **The appropriate place for extraction should be a well-balanced compromise allowing relatively fast regeneration together with a minimised impact on the coastal sediment budget.**

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Action needed

The plan should determine the measures needed to adapt to projected sea level rise by identifying:

1. The most significant structural, environmental, aesthetic, social, cultural and historic resources that must be protected from inundation;
2. Those areas that are inappropriate for protection from inundation;
3. Those areas that are most suitable for wetland restoration, habitat enhancement and other opportunities that would enhance the biological productivity, and
4. Strategies and techniques that will make future conservation and development projects more resilient to climate change.

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Closing Remarks..

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Four General Adaptation Strategies

1.Bear the losses

Baseline response of “doing nothing.”

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Four General Adaptation Strategies

2. Share the losses

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Four General Adaptation Strategies

3. Modify the threat by minimizing other stresses to ecosystems

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Four General Adaptation Strategies

4. Continue to learn more about how to prepare for future changes in the environment……