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Coastal Protection in the aftermath of the Indian Ocean tsunami:
What role of coastal forest and trees?

The Role of Coastal Forest and Trees in Combating Coastal Erosion

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What is coastal erosion ?
-coastal erosion as a natural processes
-coastal erosion as a problem
Managing the erosion problem
-understanding the cause of erosion
-the options


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What is Coastal Erosion ?

- Coastal erosion is a natural processes.
- Many coastlines are naturally dynamic, and cycles of erosion are often an important feature of their ecological character.
- Wind, waves and currents are easily moved the unconsolidated sand and soils in the coastal area; resulting rapid changes in the position of shoreline.



The shorelines change (erosion and accretion) take place over a range of time scales; it may occur:

- in response to smaller-scale (short term) events, such as storms, or regular waves, tides and winds, and
- in response to large scale (long term) events such as glaciations or orogenic cycles that may significantly alter sea levels (rise/fall).

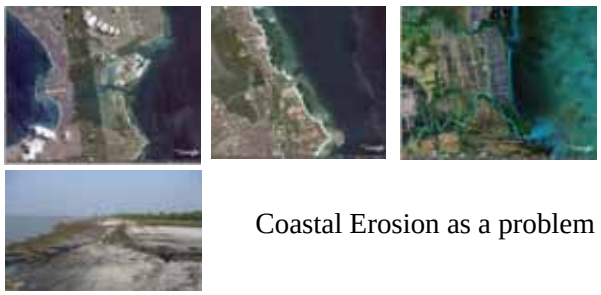
Without human involvement, those processes are just the basic movement of evolution to natural system.

Mangroves succession due to tectonic in Babi Island, off Sumatera Coast in Indian Ocean

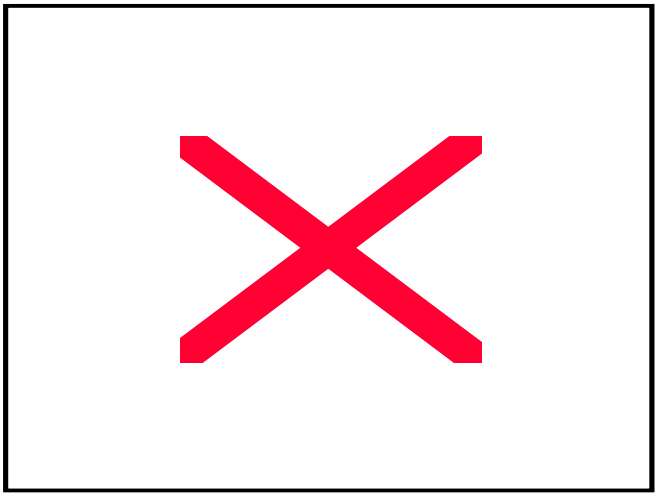
Human activities :

- along the coast (ie. reclamation, port development, shrimp farm);
- within the river catchments (ie. river damming and diversions), and
- offshore (ie. dredging, sand mining),

in combination with those natural forces have exacerbated coastal erosion in many places and jeopardize the possibilities for the coasts to fulfill their economical, social and ecological role on the long term and at a reasonable cost for the society.



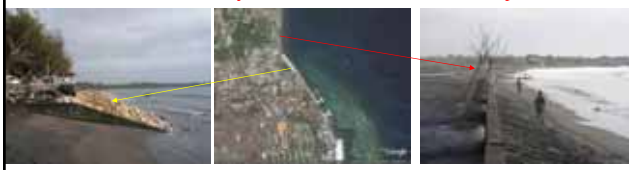
Coastal Erosion as a problem



The erosion problem become worse whenever the countermeasures that had been applied were:

- inappropriate,
- not properly designed, constructed, or maintained, and
- without careful evaluation on the effects to the adjacent shores,

and it's often stop locally at specific place or at regional or jurisdictional boundaries, rather than at system boundaries that reflect natural processes



Development within coastal areas has increased the interest in erosion problems and has led to major efforts to manage the coastal erosion problem and to restore the ability of coast to accommodate short and long term induced changes occurring due to combination of human activities, extreme events and sea level rise.

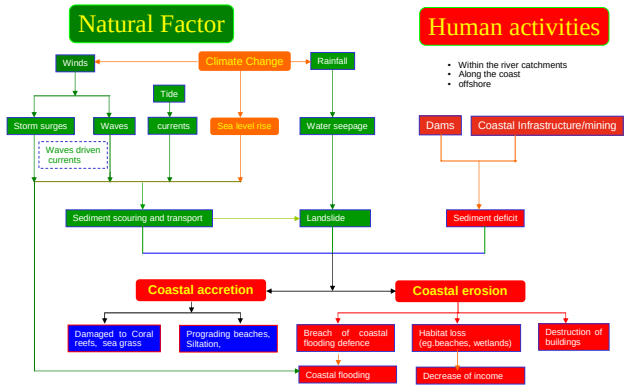
Need to understand the key processes

The key parameters that need to be comprehended to understand the coastal processes are:

Coastal Geomorphology	determining the coastline type and giving an indicative of coastal processes
Winds	the main forces in wave generation, may transfer sediment from the beach environment landward
Waves	the most importance forces for sediment erosion and transport in the coastal zone
Tide	importance on beach morphodynamics, modulate the action of waves , driving groundwater fluctuation and tidal currents
Vegetation	important in improving slope stability, consolidating sediments and provide some shoreline protection

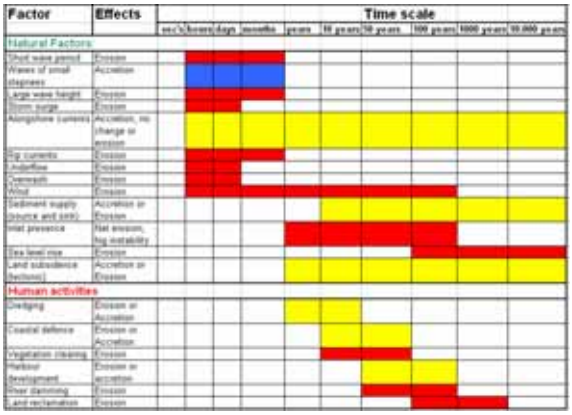
THE PROCESSES

Coastal erosion and accretion: a complex process



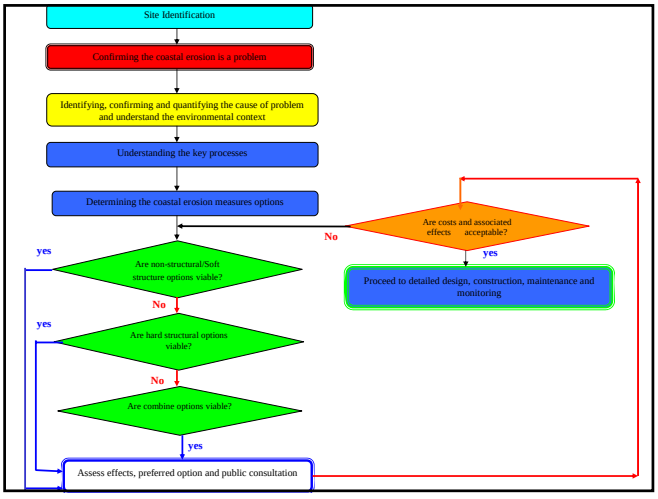
Modified from Eurosion 2004

Potential human activities and natural factors influencing shoreline change over a range of time scales (source: NRC 1990, Eurosion 2004).



Managing the problem (NRC 1990, ARC 2000)

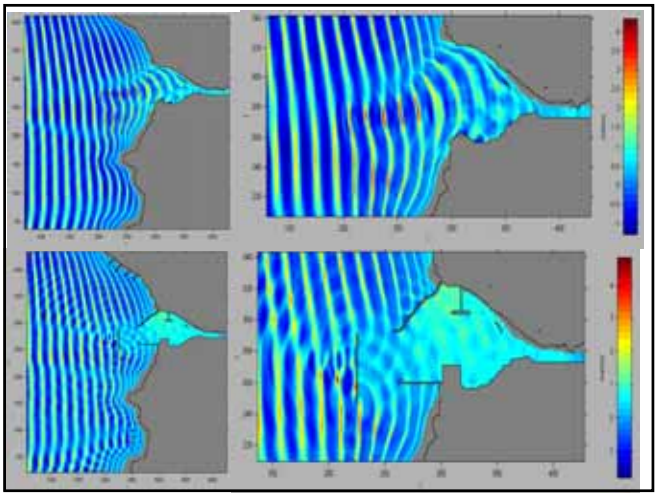
- Identify and confirm coastal erosion as a problem;
- Identify, confirm and quantify the cause of problem and ensure that any management option well thought-out this reason before implementing the coastal erosion measures options;
- Understanding the key processes and characteristic of coastal dynamics and system boundaries that reflect natural processes of the erosion problem;
- Determine the coastal erosion measures options and implementing it with proper design, construction and maintenance with careful evaluation on the effects to the adjacent shores.
- Considered the balance of the options cost and their associated benefits.



Options in Managing Coastal Erosion

Hard structural/Engineering Options

Structures placed on the beach (eg. seawalls, rip-rap/revetment groynes, breakwaters/headlands) or further offshore (offshore breakwaters). These options interfere the coastal processes to stop or reduce the rate of coastal erosion.



The extension of Ngurah Rai International Airport Run-way in Kuta Bali Indonesia cause an erosion problem on the adjacent shore

Soft structural/Engineering Options

Aims to dissipate the wave energy in the same way what the natural system works and maintain the natural form of coastal environment. These include beach nourishment/feeding, dune buildings, re-vegetations and others non-structural management options.

Mangroves nurseries and planting

Beach nourishment

Coastal forest re-vegetation

Combined Hard and Soft options

Necessary to improve the efficiency of the options and provide an environmentally and economically acceptable of coastal protection system.

Evaluation of the options

Hard structural/Engineering Options

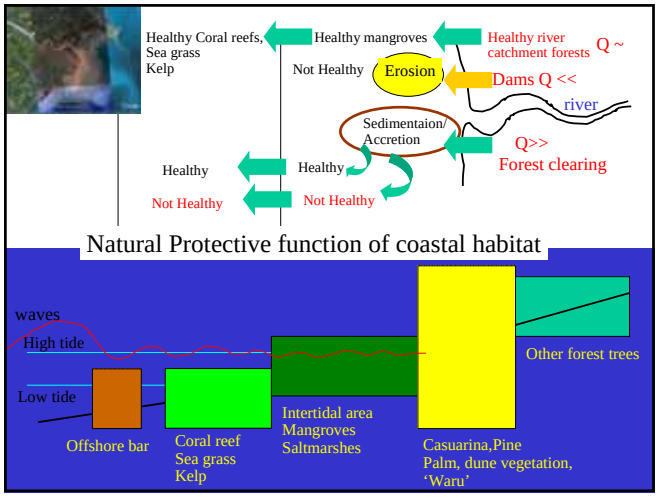
- causes erosion and unnecessary accretion,
- costly and often aggravated the problem,
- harming the aesthetical aspect of the beaches or coastlines they seek to protect, hence decreasing their economic value especially for tourism purposes
- only effective in short term

Soft structural/Engineering Options

- took sometimes before it works (not overnight or quick fix solutions) that makes a negative public response,
- are found to be effective solutions only in medium to long term perspective (5 to 10 years).

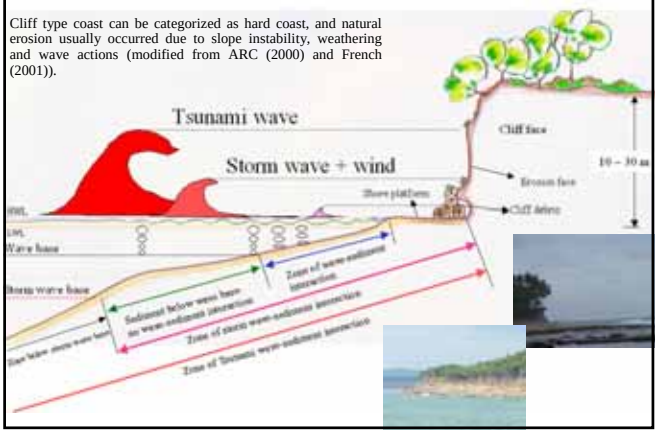
There is growing concern on natural protective function of the coastal system

NATURAL
PROTECTIVE FUNCTION OF THE COASTAL SYSTEM

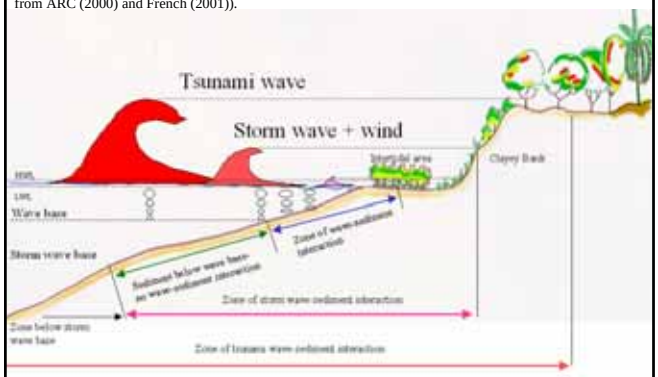


The Coastal type, Erosion Processes and The Forest Function

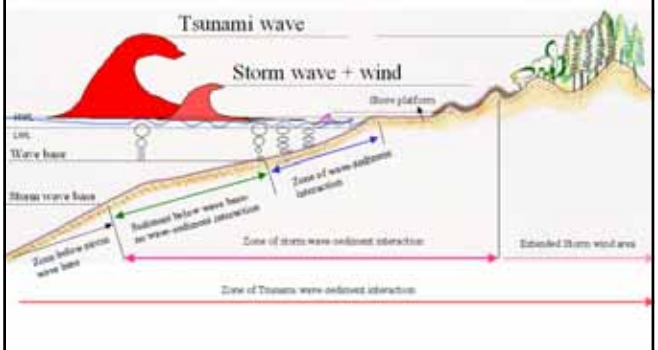
Cliff type coast can be categorized as hard coast, and natural erosion usually occurred due to slope instability, weathering and wave actions (modified from ARC (2000) and French (2001)).



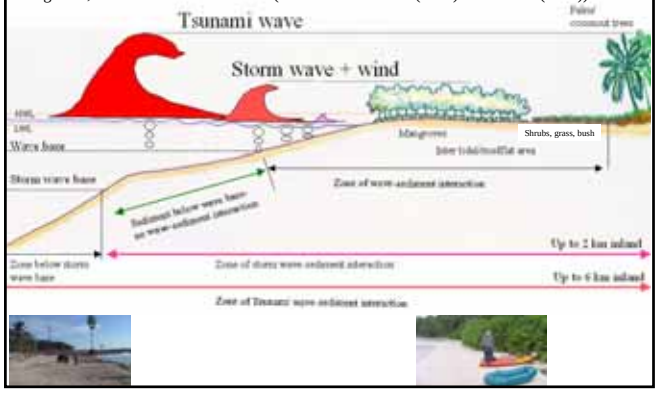
Clayey Bank type coast can be categorized as Semi-hard coast, and the rate of erosion is relatively high compare to hard-coast because it's comprised of weaker and less resistant material. Natural erosion usually occurred due to coastal processes, weathering and loss of vegetation cover (modified from ARC (2000) and French (2001)).



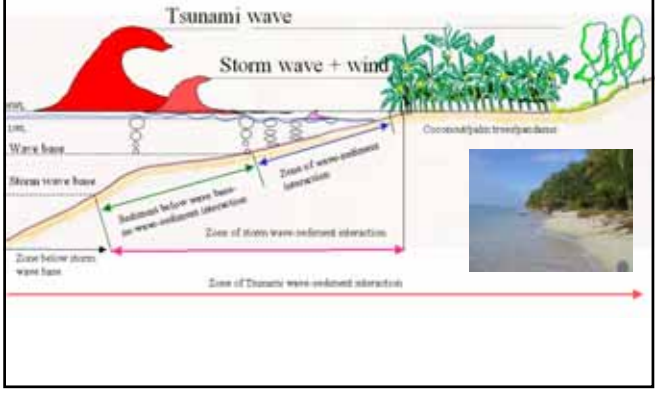
A sand dunes type coast can be categorized as soft coast. It consists of unconsolidated material mainly sand, cobbles and shell and its profile is depending of wave form and energy and wind blown. Mostly erosion occurred due to loss of vegetations cover (modified from ARC (2000) and French (2001)).



A intertidal/muddy coast is characterized by fine grained sedimentary deposits predominantly silts and clay. Most of the coastal erosion occurred due to rivers dams that reduce the sediment suply, loss of vegetation cover (usually mangroves and saltmarshes), and lowering the mud-flats in front of the vegetations. Mostly vegetation on this type of coast is mangroves, saltmarshes and coconouts (modified from ARC (2000) and French (2001)).



A sandy coast can be categorized as soft coast. It consists of unconsolidated material mainly sand, branches coral and shell that comes mostly from the fringing reefs. The coconout/palms trees/ pandanus/waru/casuarina are common on this type of coast (modified from ARC (2000) and French (2001)).



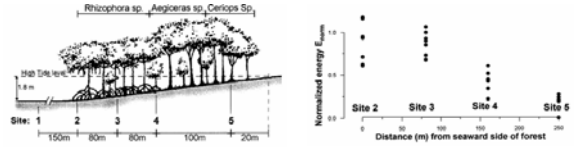
Scientific Back-up

The coastal forest and trees at some extent play a significant role in protecting the shoreline from erosion caused by wave action, wind and fast tidal currents, however, the scientific back up only concentrated on two type of vegetations:

- Mangroves forest i.e. Rhizopora Sp, Bruguiera Sp, Kandelia candel, Sonneratia and Avecenia,
- Saltmarshes i.e. Helophyte species (Phragmites australis (Cav.) Trin.ex Steudel and Scirpus Lacustris L.), and also Spartina as pioneer species.

• Mangroves forest and salt marshes can reduce wave height significantly (Mazda et al 1997, Massel et al. 1999) :

• Mangroves reduced the wave height over a relatively short distance by factors 86 – 90 % theoretically and based on observation, the wave energy reduced to 75 % when the wave passage through 250 m width of mangroves that consist of Rhizophora sp, Aegiceras sp and Cerioss Sp.

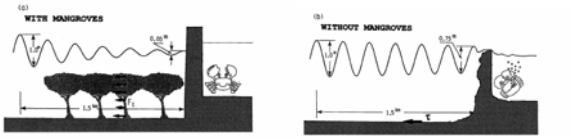


Wave attenuation on Mangrove at Cocoa Creek, Australia

(Source: Massel et al (1999)).

• Because of Rhizopora spp and Bruguiera spp have intricate and large prop roots or numerous pneumatophores compared to Kandelia candel, these facts suggest that the effect of the drag force on Kandelia candel on long period waves such as tidal waves is weak compare to those of Rhizophora spp and Bruguiera spp, however, on adult trees, their efficiency in attenuating waves is still high by factor up to 86 %.

• An effect of wave reduction does not decrease with increasing water depth, which is important in practical implications.



Wave reduction through mangroves forest based on study by Mazda et al (1997) at Thuy Hai, Vietnam

• Vegetation height and density and the width of the area to be planted and the alignment of vegetation or trees are important factors in reduction of the waves height. In term of an alignment, the staggered alignments are suggested to give more protections and barrier to the flow and water elevations.

• Recent studies (Winterwerp et al.,2005) suggested that the existence of 300 – 500 m of mangroves belt may help reducing the erosion rate

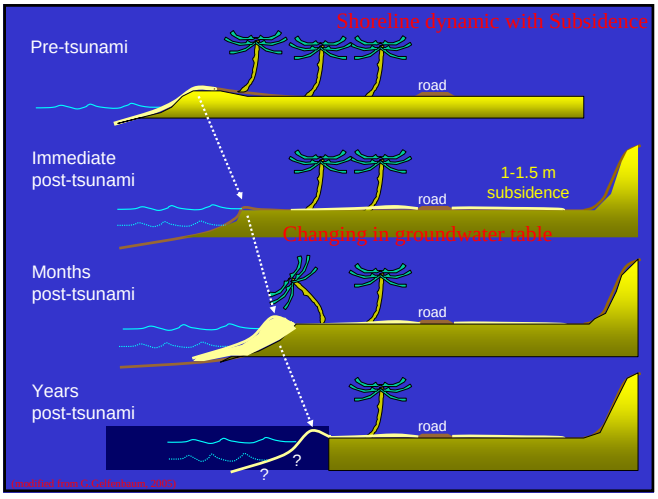
However, mangroves are susceptible for erosion especially during low water level when the waves attacked the soil below the root system.

This type of erosion also happened on other type of trees


During extreme events (tsunamis)


During extreme events (tsunamis)


During extreme events (tsunamis)


Shoreline dynamic with Subsidence
Pre-tsunami
road
Immediate
post-tsunami
road
1-1.5 m
subsidence
Changing in groundwater table
Months
post-tsunami
road
Years
post-tsunami
road
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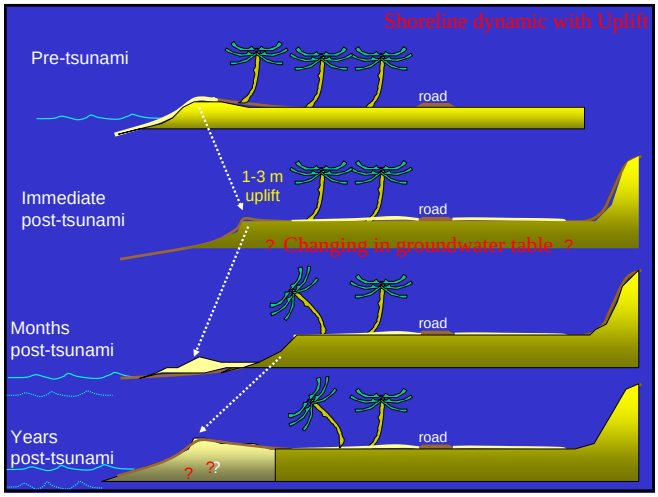
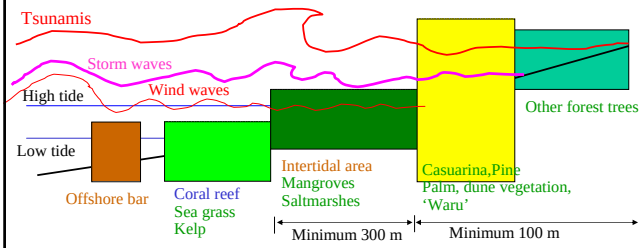
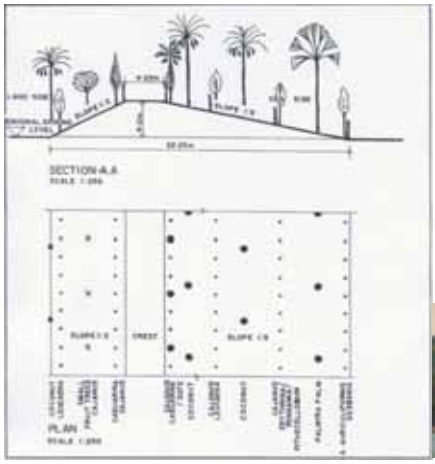
?



SETUP THE GREEN BELTS/BUFFER ZONE

- Identify the main cause of erosion
- Starting with the water's edge vegetation (ie. mangroves) and going to hydric species such as casuarina, pine, palm trees, cocounuts and fruits trees on higher soils or land.





An examples from Bangladesh (Clark. JC,1995)

Green Belt (Clark, JR 1996) should become:

- Social forestry
- Ecodevelopment
- Participatory planning

Local communities should involved in deciding the details, assist with nurseries and plantings, and directly received the benefits.

In conclusions:

- The trees control erosion and stabilize the littoral by holding sediments and building up land
- A green belt of trees will effectively reduce the force of devastating storm surges and waves that accompany cyclones and also tsunamis.
- It will provide an amenity and a source of food and materials for coastal community
- Beneficial to biodiversity and can create habitat corridors for wildlife.