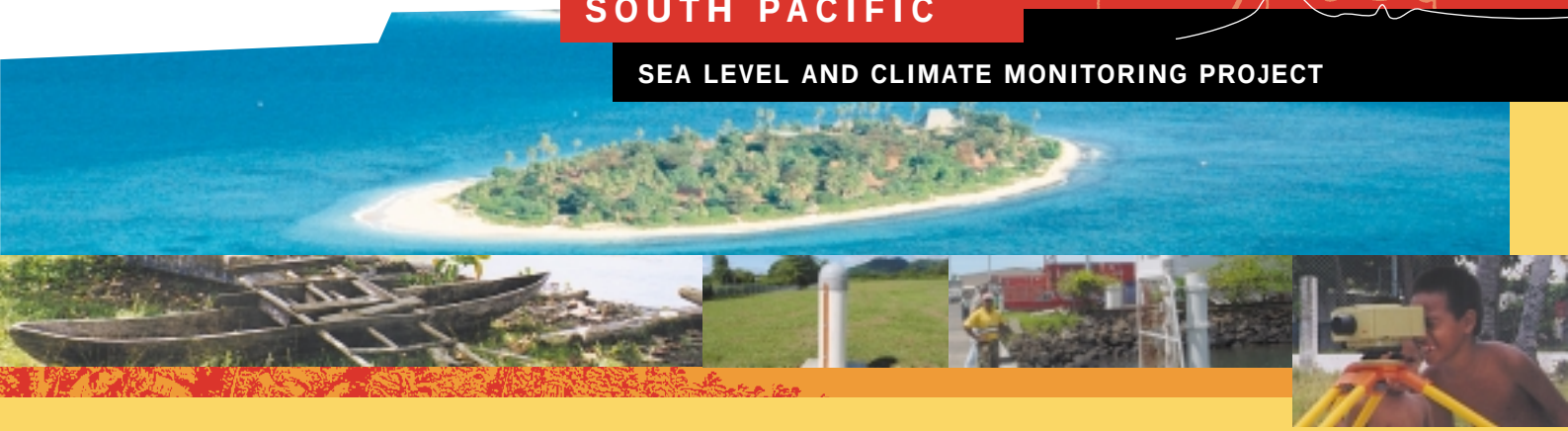

COASTAL EROSION

A Project supported by the Australian Government

COASTAL EROSION

Coastal erosion is the permanent loss of land along the shoreline. This is observed as the landward movement of the shoreline vegetation. Coastal erosion is widespread throughout the Pacific Islands and has serious consequences for Pacific Island nations (Fig. 1).

Fig. 1. Eroding shoreline has stranded this coconut tree on the active beach, southern coast of Viti Levu, Fiji.

Beaches are important coastal environments in the Pacific. Most human settlement and economic activities are located on low-lying land immediately behind beaches. Erosion can seriously damage and threaten communities and development on the coast, therefore posing an important management issue in Pacific Island countries.

WHAT CONTROLS COASTAL MORPHOLOGY?

Formation and evolution of Pacific Island shorelines have occurred over a time scale of years to centuries. Waves and tidal currents act on sediments transported and deposited on the coast. Variations in the size, elevation and position of coastal environments reflect differences in wave and tide processes and sediment supply in constructing shorelines. For example, windward shorelines tend to be steeper and composed of coarser sand and gravel than leeward coastlines, which tend to have shallower gradients and be composed of fine sand-size material (Fig. 2).

CHANGES IN COASTAL MORPHOLOGY

The coast is constantly adjusting to changes in wave and tide processes and sediment supply. As a result the position of the coastline advances and retreats. This is a natural and expected process on sandy shorelines. Changes in the shoreline also occur over a range of time scales. It is important to distinguish between short-term changes in the coast and long-term coastal erosion.

Fig. 2. Lagoon shoreline Buariki Island, Kiribati. Note low gradient beach and presence of mangrove that traps and stabilise sediment at shoreline. This beach has much finer sand size material and is a low energy beach.

Short-term shoreline change occurs over periods of days to several years. It is most obvious during storms when high wave energy actively removes sand from beaches on many Pacific coasts. A higher storm ridge usually backs the active beach. During storms waves reach this backshore area and erode sand from it. The important function of this backshore is to act as sand reservoir during storms. In the following months normal weather and wave patterns may cause sand to be replaced on beaches. These short-term changes do not constitute coastal erosion. The beach is described as fluctuating within an 'envelope of change'. This style of beach behaviour has been documented in a number of countries in the Pacific including Tonga and Kiribati where beach position may fluctuate over distances of five to twenty metres over periods of several years.

Long-term coastal erosion occurs over years to decades. The varying coastline, or 'envelope of change', is observed to gradually move landward, as is its associated vegetation line. This recession of the shoreline represents long-term erosion.

CAUSES OF EROSION

The causes of erosion are many and varied and can be divided into those that are natural and those promoted by human actions.

Natural causes of erosion

- Changes in wave climate such as an increase in wave height, change in the angle of wave approach or increased frequency of high magnitude waves. These changes influence the amount of energy that affects the shoreline and can alter the main direction of sediment transport.
- Reduction in the amount of sediment delivered to the coast from reefs, which are the only source of sediment in atolls, or deposits from river catchments on high islands.
- Rising sea level may increase water levels at the coast and allow greater wave energy to erode the shore. It is commonly asserted that under rising sea level sand is removed from beaches and transported offshore.

For the past two decades sea level rise has been singled out as a likely cause of erosion throughout the Pacific. While rising sea level is one possible factor, climatic variability may also be a significant cause of coastal erosion. Currently interannual changes in weather patterns, such as those caused by ENSO events, can alter the wind, wave and sea level patterns on islands throughout the Pacific. For example, in the Republic of Kiribati, El Nino causes changes in wind conditions from the prevailing easterly direction to westerly winds and raises mean water levels up to 50 cm. Under such conditions westerly waves are generated in the lagoon and promote erosion of the lagoon shorelines. It is clear that Pacific Island countries are currently subject to changes in water level and wave conditions that affect coastal behaviour. Of interest is whether such climatic variability will change under projections of global climate change.

Human-induced causes of erosion

A wide range of human activities can alter wave and tide processes and the supply of sediment at the coast, thereby promoting erosion. Some of the most common causes identified throughout the Pacific include:

- Sand extraction from beaches that reduces the sand volume of the coast.
- Coral mining, which can increase water depth across reefs, allowing greater wave energy to affect the coast and reduce sediment supply.
- Insertion of structures such as seawalls and groynes (Fig. 3). Such structures locally alter wave processes and change sediment transport patterns.
- Construction of causeways that alter tidal circulation and wave processes around islands and change sediment transport patterns.
- Removal of mangroves, which exposes low energy shorelines to increased energy and reduced sediment stability.

Fig. 3. Typical seawall used to prevent erosion. Note, sand has been removed in front of seawall.

- Dredging channels, which increases water depths at the shoreline and changes wave energy.

Effective management of coastal erosion is dependent on identifying the precise cause of erosion. This is a difficult task, particularly where both natural and human-induced causes may contribute to a specific erosion problem. Such difficulties are compounded in most Pacific Island countries where baseline information on coastline change does not exist.

SPSLCMP INFORMATION – HOW IT CAN HELP

The data collected and information produced by the South Pacific Sea Level and Climate Monitoring Project can assist in better understanding and addressing some of the issues created by coastal erosion in PIC's

Sea levels as measured by **Seaframe** tide gauges show the response of the sea surface to a large number of forces. The wind can have a direct effect on raising the water at the land-sea interface through wind set-up, and is to some extent dependent on the wind direction. Sea levels increase with a decrease in barometric pressure, or decrease when pressure increases, if the temporal and spatial (time and space) scales are large enough. Wind conditions locally and regionally may produce long period swells that contribute greatly to erosion in the surf zone. These waves also result in higher sea levels measured by gauges.

In order to study these effects and plan coastal development, records of sea levels during storms are vital. Engineers need to know the probability that certain levels will be exceeded during the lifetime of roads, bridges and harbour construction in the near-shore. It is not enough to simply estimate the high water mark at spring tides, which is primarily due to the tidal component alone. Vital information must be gathered on the response of sea level to meteorological conditions and combined with tidal information.

Global-Positioning System, or GPS, is able to measure and quantify erosion and deposition at a high temporal and spatial resolution. This provides an important contribution to the understanding of local coastal erosion and sediment deposition patterns. Erosion and sediment deposition rates can be monitored, as can the location of sediment deposits; hence the transportation patterns of material can be determined. This is significant in decision making for coastal management. Using additional GPS observations and the data from the established project **Continuous Global-Positioning System**, or CGPS stations as the reference:

- A Digital Terrain Model, or DEM, can be developed at a high spatial resolution using high precision GPS kinematic surveying together with the CGPS station data. Repeated DEM surveys using GPS quantifies the erosion patterns, volume of material that is moved and the rates of the erosion.
- The required ground control for large-scale and high-resolution satellite imagery can be provided. This may be used for monitoring vegetation lines. GPS can be used to provide the reference frame for Synthetic Aperture Radar Interferometry (Satellite Remote Sensing data) to determine erosion patterns at a high temporal and spatial resolution.
- Local deformation in developed coastal areas as a result of erosion can be monitored. This information forms the basis for decisions about lessening disaster impact.
- Differential positioning relative to the CGPS station can be provided for echo sounding along the coastal waters, and used to monitor the deposition of eroded material – quantifying location, seasonal variations in deposition patterns, rates and transportation of sediment once it is eroded.

Fig. 4. Typical beach erosion on the islands – Tuvalu.

FURTHER INFORMATION

Regional Coordinator
AMSAT
PO Box 17955
Suva FIJI
Telephone +679 3304 003
Facsimile +679 3304 003
Email amsatck@is.com.fj

Project Manager
AMSAT
PO Box 341
Curtin ACT 2605 AUSTRALIA
Telephone +61 2 6281 8450
Facsimile +61 2 6281 8436
Email amsatho@amsat.com.au

Director
NTFA
GPO BOX 2100
Adelaide SA 5001 AUSTRALIA
Telephone +61 8 8201 7532
Facsimile +61 8 8201 7523
Email ntf@flinders.edu.au

Director
Space Geodesy Analysis Centre
National Mapping Division
Geoscience Australia
PO Box 2
Belconnen ACT 2616 AUSTRALIA
Telephone +61 2 6201 4371
Facsimile +61 2 6201 4366
Email rameshgovind@auslig.gov.au

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FORUM SECRETARIAT

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SOUTH PACIFIC REGIONAL ENVIRONMENT PROGRAMME

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