Coastal Erosion in Pacific Small Island Developing States (SIDS) - the need for an approach to integrated coastal management (ICM)

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SIDS and ICM – towards Sustainable Development

Small Island Developing States (SIDS) are generally characterised by their relatively small land area in comparison to their large ocean space in their respective Exclusive Economic Zone (EEZ).

In the South and North Pacific, SIDS account for a large percentage of ocean space, but very small land areas. The percentage of land/sea area was calculated for twenty North and South Pacific SIDS (American Samoa, Cook Islands, Federated States of Micronesia, Fiji, French Polynesia, Guam, Kiribati, Marshall Islands, Nauru, New Caledonia, Niue, Palau, Papua New Guinea, Samoa, Solomon Islands, Tokelau, Tonga, Tuvalu, Vanuatu, Wallis and Futuna). The results show that this percentage varies between 0.0028-2.445, with fifteen of these SIDS having percentages of less than 1.0. This includes SIDS such as Tokelau, with a land area of only 10km^2.

As a result of their small land areas, SIDS are particularly vulnerable to oceanographic and atmospheric process within their large EEZs. These include ocean swells, tsunamis, storms, typhoons or hurricanes, the scale of which are usually several orders of magnitude greater than most islands and their EEZs. These atmospheric and oceanographic processes cause dis-equilibrium along the coast and beaches, resulting in loss of valuable land.

The loss of land in SIDS, due to coastal erosion, can pose a significant threat to coastal infrastructure and facilities and threaten the livelihood of coastal communities. In addition, coastal land loss decreases space available for building and development activities.

In many SIDS, coastal land loss is exacerbated by poor coastal management practice and land tenure. To correct this problem, efforts should be directed towards integrated coastal zone management (ICM) strategies.

ICM is a planning and coordination process, which relies on information on all aspects of the natural and human environment for the development and implementation of management strategies. These strategies are dynamic and adaptive and evolve over time, to facilitate optimum utilisation of coastal resources in a sustainable manner. Sustainable use and conservation of natural resources is essential, and should not impair their capacity to benefit future generations. In this way resources can be managed in an optimum fashion, with minimal environmental impacts.

Case Study

The Government of the Federated States of Micronesia (FSM) requested the South Pacific Applied Geoscience Commission (SOPAC) to undertake a study to assess coastal erosion, in twenty-one atoll islands of the FSM territory. The study area is located in the North Pacific Ocean, between $2 - 12^{o}$ N latitude and, $138 - 165^{o}$ E longitude.

Residents on many of these islands of the FSM indicate that the coastline are being aggressively eroded. A study was conducted between 20 July 1998 to 12 August 1998 to investigate this process. The islands surveyed are atolls of Pohnpei, Chuuk and Yap States, FSM. The islands were Pingelap, Mokil, Sapwuafik and Nukuoro in Pohnpei State; Satawan, Losap, Pollap, Polowat and Alet in Chuuk State and Lamotrek, Elato, Fechaulap, an un-named island, Ifalik, Woleai, Tagaulap, Falalis, Utagal, Saliap, Eauripik and Mogmog in Yap State.

Methodology

Discussions were held with the local residents to obtain information about recent shoreline change. Inquiries were made as to the effects of recent storms and typhoons on local beaches and coastline.

Representative beaches and coastline were surveyed. Beach sediments, beach slope, erosion scarps, scouring and shoreline retreat were described and measured in the field.

Aggregate extraction and construction along the coastline were documented. This included land reclamation, airstrip construction, and seawall and groyne construction. Waste disposal and surf zone circulation was also noted (as it relates to reef health, carbonate sand production and beach dynamics). Photographs were taken of representative sites, erosion problems and failures of various constructed facilities along the coastline for each island.

Results

Based on the information collected, there are several factors which are responsible for erosion and coastal land loss on these atolls. These can be summarised under two main headings:

- Natural Processes and
- Man-made Processes

Natural processes account for significant and continuous erosion on all the atoll islands surveyed. These include wind waves and swells generated by North East Trades, westerlies, storms and typhoons.

Storms and typhoon are the main agents of erosion and sediment transport. Although these are not daily events, they are the major agents influencing the evolution of coastlines of these small island states.

Erosion and coastal land loss can be up to several metres, with up to 2.5 m high erosion scarps. This is common during the Northern Hemisphere winter or local dry season, during which time winter swells and large NE Trade wind waves affect the coastline. These cause significant wave run-up into agricultural areas, toppling of coastal trees, damage to shorefront buildings, airstrips, coastal stabilisation structures and general property damage on northern and eastern coastlines.

Typhoons, which are common between the second to third quarter of the year, also cause similar havoc. However, local erosion is more common on the western and southern coastline and is more significant than NE Trade wind wave or winter swell erosion. Coastal land loss can be in the order of several metres. Major reef sections are damaged and eroded, large section of beaches are washed away and sediment accretion between islands in the atoll systems are usually completely eroded and deposited into adjacent back reef lagoons.

Ifalik, Woleai, Tagaulap, Falalis, Utagal, Saliap, Eauripik and Mogmog in Yap State are particularly prone to typhoon damage, as they are close to the birthplace of typhoons, in this part of the Western Pacific Ocean.

In addition to erosion, extreme weather and oceanographic events cause significant sediment accretion. This usually results from re-distribution of coastal sediments by storm waves. Storm and typhoon banks are the main depositional features, along the south and west coasts of these islands.

Accretion sites usually consist of coarse coral debris, mainly gravel and boulders, piled high along the typhoon/southern and western coastlines and tongues of coarse debris in back-reef and lagoon areas. The south and westerly coastlines are particularly prone to accretion, since these coastlines are impacted on first, by westerly originating storms and typhoons.

Storm banks along the coast vary from 4-9m high and have 25-30^{o}, concave seaward profiles. Debris is well rounded and well abraded. These storm banks can be up 200m wide along the southern and western coastline of many islands. As a result, extreme events can also cause significant shoreline progradation. Site surveys show several discrete deposits corresponding to separate typhoon events. Older deposits are partly vegetated and covered with some leaf litter and plant debris. These deposits are actively mined for construction material.

On one of the islands in Faraulep atoll, Yap State, sediment accretion covered an area, greater than the size of the island. Part of the accretion area, which was visible above mean tide at the time of the survey, was more than 700m long and more than 600m wide, with relief of up to 4m above mean water level. Shoaling of waves in adjacent back reef areas, indicate that this deposit extends much further beyond the water line, estimated to be an additional 1000 m wide. However, the elevation of that part of the deposit is almost at mean water level. The estimated volume of this deposit is in excess of 3M m^3. The colonisation of

this deposit with coastal shrubs and coconut palms over the past five years, testify to its relative stability under normal wave climate and weather conditions.

Man-made processes, in particular coastal construction and reclamation are the main factors affecting the rates and severity of local erosion. Aggregate removal from the coastal zone is the single main human factor contributing to coastal erosion and a key "erosion" process.

Aggregate mined include coral, Molluscs, foraminifera and *Halimeda spp.* sands and gravels and beach rock. These are mined from the surf zone, back beach and beach berms. Coral reef rubble is mined from the reef flat, back-reef and lagoons. Live and dead coral heads, in particular massive varieties, like *Montastrea spp.* are also mined.

Aggregate is mined for airstrip construction, housing, seawall and groyne construction, reclamation of beach and surf zone areas for housing, paving pathways and ceremonial purposes. As an example of the volume of aggregate extracted, airstrips 300m long and 40m wide use between 25,000-36,000m^3 of coral rubble and gravel. In addition, these are sometimes built in back-reef/lagoon areas on live coral, and around small islands, less than 1km long and 0.5km wide.

The construction of seawalls and groynes also cause major erosion problems. Interlocking coral rubble structures are the most common. These use either tabular beach rock or coral reef boulders. Masonry and steel reinforced concrete is also used.

It is widely felt that these coastal structures will prevent or reduce erosion. However, these structures only exacerbate the erosion problem, especially on down-drift areas. Flanking and basal scouring are common, with ultimate toppling and collapse of every structure around these islands.

In addition, construction results in the death of reef species, either due to reclamation, sediment smothering or pollution, due to alteration of surf zone circulation.

Recommendations for ICM

Several recommendations can be formulated for reducing coastal erosion and improving shoreline management. Many of these recommendations emphasise preservation of the natural ecosystem, and non-interference with sediment transport and movement along the coastline.

For small atoll islands like those surveyed, non-interference with natural sediment processes cannot be over-emphasised. Interference with longshore transport, such as by the construction of sea walls, can cause considerable erosion and should be discouraged.

Seawall construction has caused several meters of land loss in several of the islands surveyed. Several meters of land loss is large, when one compares it the size of some of these islands, which can be 150 –200m wide, e.g. Losap or Eauripik. For this reason also, buildings should be setback from the coastline, well into the interior of the island. This will reduce their risk of exposure and damage from extreme oceanographic events.

Communities should also try to re-vegetate coastal areas which has been affected by previous storms or which has been cut or burnt. These serve as wind breaks and stabilise soils and beach sediments, reducing their erosion by up-rush. The planting of common local coastal species are encouraged, e.g. mangroves, mahogany, pandanus and coconut. Larger species like mahogany and mangroves are particularly encouraged. Site visits showed that coastlines with this vegetation are relatively stable and much less eroded.

The disposal of waste in mangroves and cutting of these species should be discouraged, as they are important coastal stabilising vegetation, in addition to contributing to the productivity of coastal ecosystems, like fisheries.

As for aggregates, these should be obtained from offshore or onshore areas, preferably from adjacent islands or from mainland areas. Their extraction locally, should be stopped. The selective extraction and mining of mineral aggregate resources in the coastal zone needs to be carefully monitored and controlled. While these resources are renewable, they are not at the rates at which they are removed.

Technical assessments and an environmental impact assessment (EIA's) should precede major construction activities, such as airstrips, reef channel cutting or sand mining. These studies will identify the best options for pursuing the desired activities in an environmentally sound manner.

As population increases on these islands and needs increase for natural resources, such as aggregate, housing material and land area, efforts must be made to address these needs. If the same finite volume of these resources is tapped, at an increasing rate with time, then these resources can be easily dwindled.

An important issue, which must be addressed to this end, is the carrying capacity of these small islands to sustain the activities such as aggregate extraction and coastal construction. In addition, since many of these islands are small and affected by erosion, land area will decrease. An option, which therefore must be entertained eventually, is re-location of population.

Based on discussions with islands residents, it became apparent that most of the population were un-aware of the dynamic relationships which exists between beach processes, erosion, sediment transport, pollution, coastal vegetation and reef dynamics (both biological and physical). It is a widespread feeling that only activities on the beach affect beach erosion and deposition.

To effectively implement and pursue coastal erosion management guidelines, this misconception must therefore be clarified. This requires the implementation of a public education program, for the island residents, on the use and management of coastal resources.

Further, it is recommended that local technical personnel be trained in coastal zone management to effectively address local issue affecting the islands of FSM.