

COASTAL ENGINEERING FOR CLIMATE CHANGE RESILIENCE IN EASTERN TONGATAPU, TONGA



eCoast
eTakutai

This European Union (EU) funded, SPC supported project (The Pacific Community's Global Climate Change Alliance: Pacific Small Island States (GCCA: PSIS) was the proud recipient of the 2019 Energy Globe Award, recognised for its outstanding work and contribution towards advancing peer to peer learning in climate change adaptation among Pacific communities.

1. THE PROJECT

Increasingly large amounts of funding are becoming available for CC adaptation projects throughout the SIDS (Small Island Developing States), which is due to the recognition that these nations contribute <1% of CO₂ emissions that are driving CC but are some of the planet's most vulnerable areas. The Secretariat of the Pacific Community (SPC), specifically the Global Climate Change Alliance: Pacific Small Island States (GCCA:PSIS) project in the Strategic Engagement Policy and Planning Facility, funded a climate change (CC) resilience demonstration project in north-eastern Tongatapu, Tonga. The aim of the GCCA:PSIS projects was to develop CC resilience strategies that can be applied by the local population utilising local materials, and potentially be replicated where similar physical conditions exist. Unlike many previous projects on SIDS, a comprehensive monitoring programme was funded as a part of the project in order to determine the project's success and apply an adaptive management approach. Two trial sites were selected in; Talafo'ou to Makaunga (Figure 1 – Site A), a tidally-dominated coast, and Manuka (Figure 1 – Site B), a wave-dominated coast. Sediment tunnel groynes and breakwaters were proposed for the respective sites.

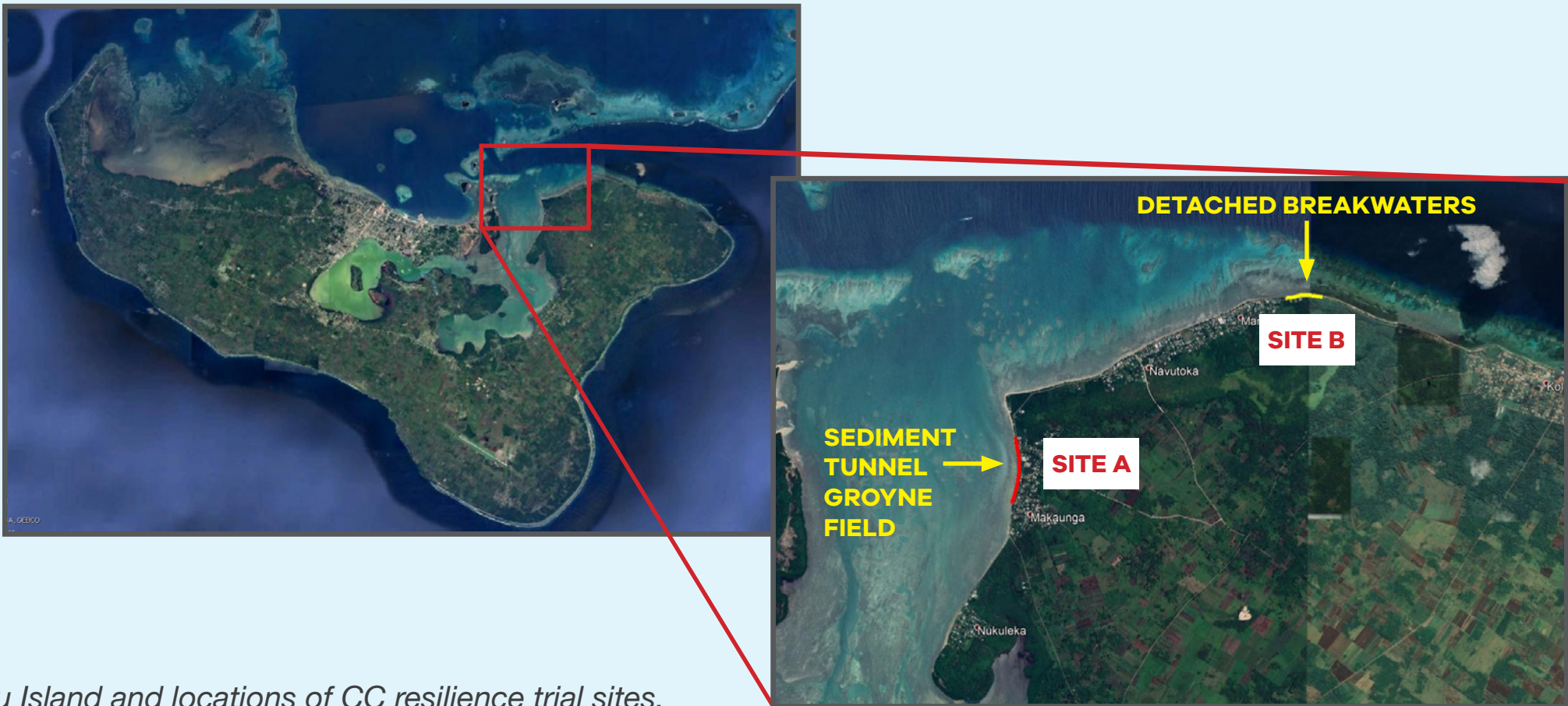
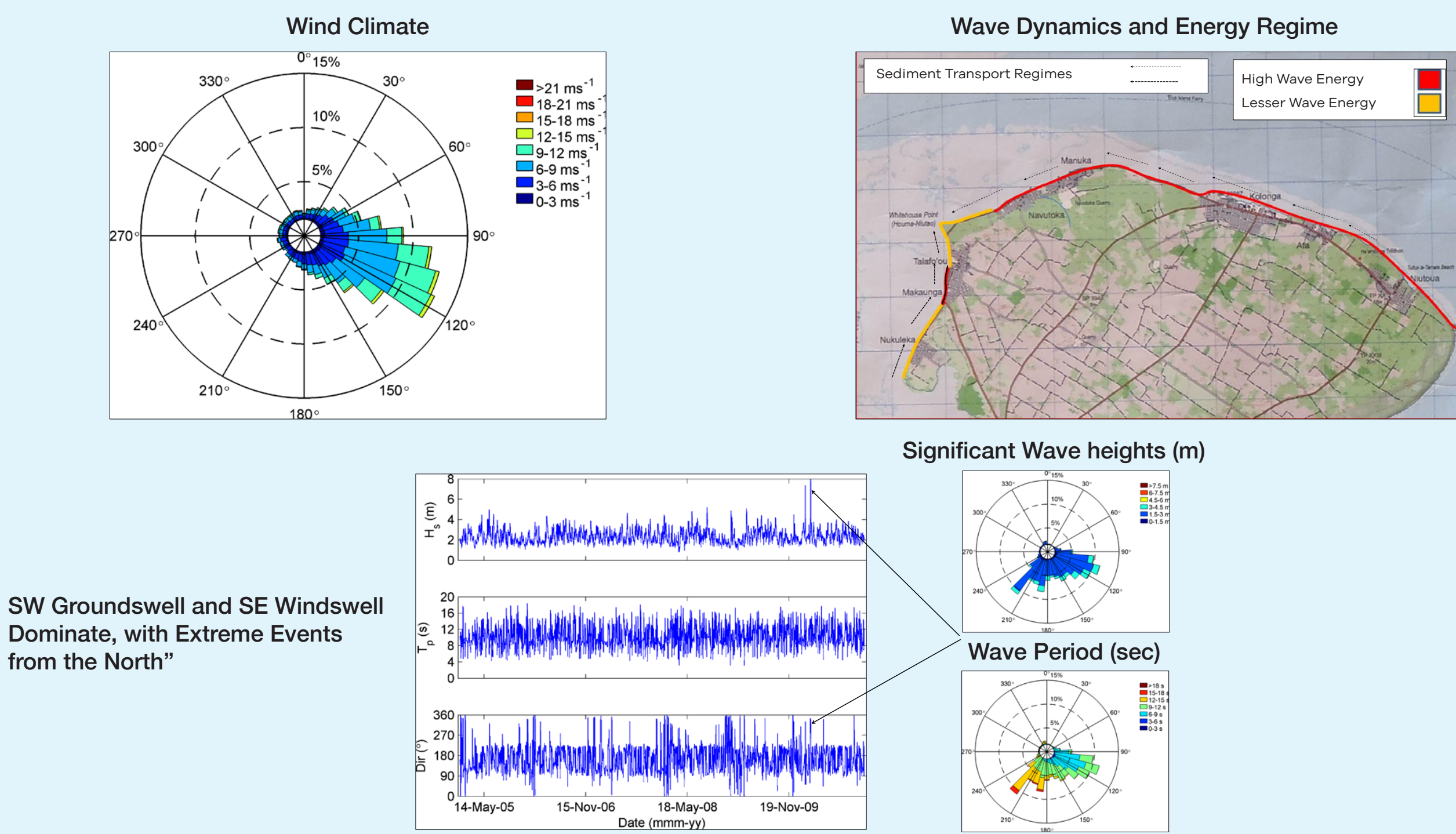


Figure 1. Tongatapu Island and locations of CC resilience trial sites.

2. EXPOSURE AND COASTAL DYNAMICS



3. EROSION AND INUNDATION

Increasingly large amounts of funding are becoming available for CC adaptation projects throughout The main conclusions based on existing information is that the vulnerability to the sites with respect to erosion and inundation are due to:

- Sand-mining
- Removal of mangroves
- Damage to the fringing reef ecology
- SLR

Together, these have resulted in reduced beach height and width (20-30 m of retreat since 1967) and removed sediment from the system faster than it can be replenished.

4. RESPONSES TO SLR – MANAGED ADVANCE TO 'BUY TIME'

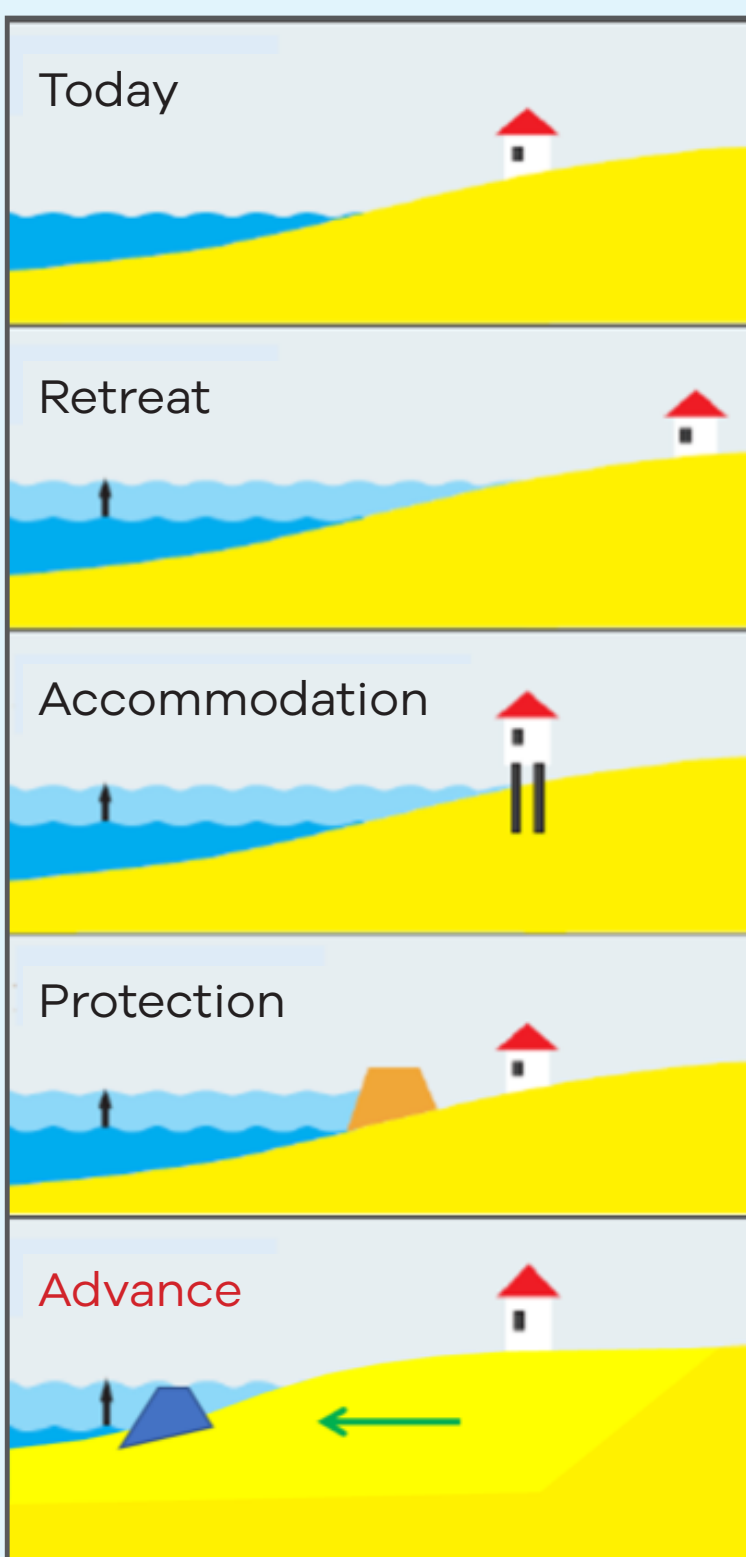
Increasingly large amounts of funding are becoming available for CC adaptation projects throughout The responses required to protect human life and property fall broadly into three categories: retreat, accommodation, and protection. However, managed advanced is being applied more and more often in some cases.

Retreat involves no effort to protect the land from the sea. The coastal zone is abandoned and ecosystems shift landward. This choice can be motivated by excessive economic or environmental impacts of protection. In the extreme case, an entire area may be abandoned.

Accommodation implies that people continue to use the land at risk but do not attempt to prevent the land from being flooded. This option includes erecting emergency food shelters, elevating buildings on piles, converting agriculture to fish farming, or growing flood of salt tolerant crops.

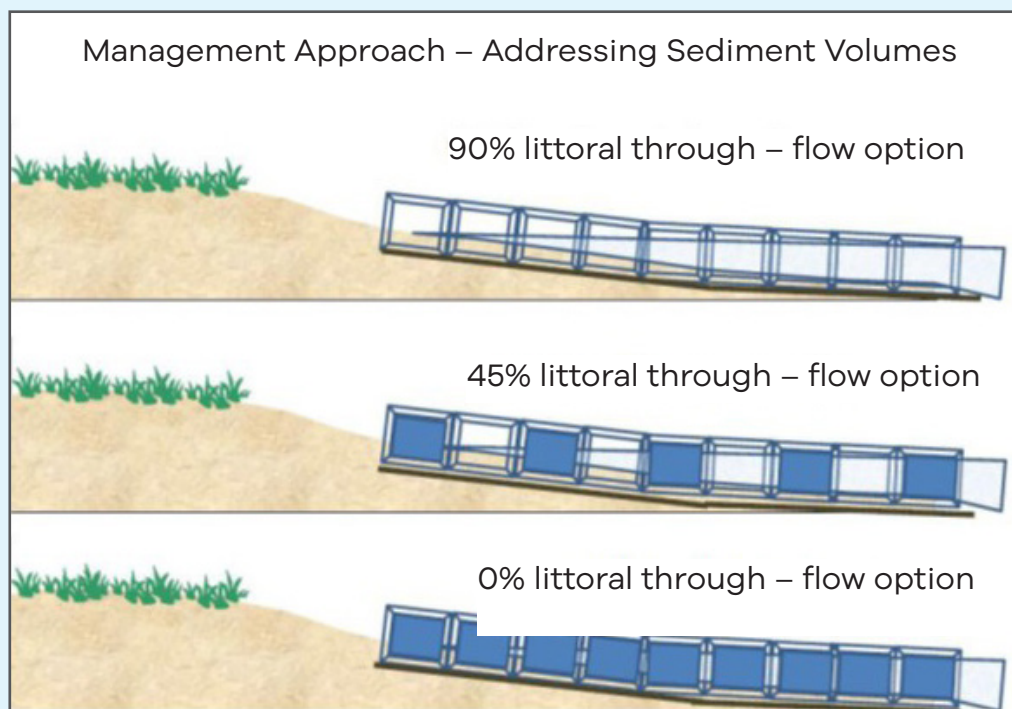
Protection involves hard structures such as sea walls and dikes, as well as soft solutions such as dunes and vegetation, to protect the land from the sea so that existing land uses can continue.

Managed Advance Response. The application of Buying-Time" in order to prepare for the inevitable managed retreat for low-lying coastal areas. Appropriate works for a 20-30 year time-frame.



5. TALAFO'OU TO MAKANGA SEDIMENT TUNNEL GROYPE FIELD

Along the Talafo'ou to Makaunga coast (Site A), a groyne field comprising 10 m long groynes built from readily available 1x1x1 metre hollow concrete cubes on a concrete base platform (used for drainage and to convey cables and pipes under roads) was applied. Since the cubes were hollow on 2 sides, it meant that they could be turned to either allow water/sand to move through them (i.e. permeable), or to present a solid face (i.e. impermeable). The groynes were spaced at 30, 60 and 90 m along the beach with varying degrees of permeability. These variations were applied in order to test the validity of common 'rule-of-thumb' practices in temperate climates, such as a groyne spacing of 3 x groyne length. The monitoring results of the sand retention for the groynes at Talafo'ou to Makaunga indicate that:



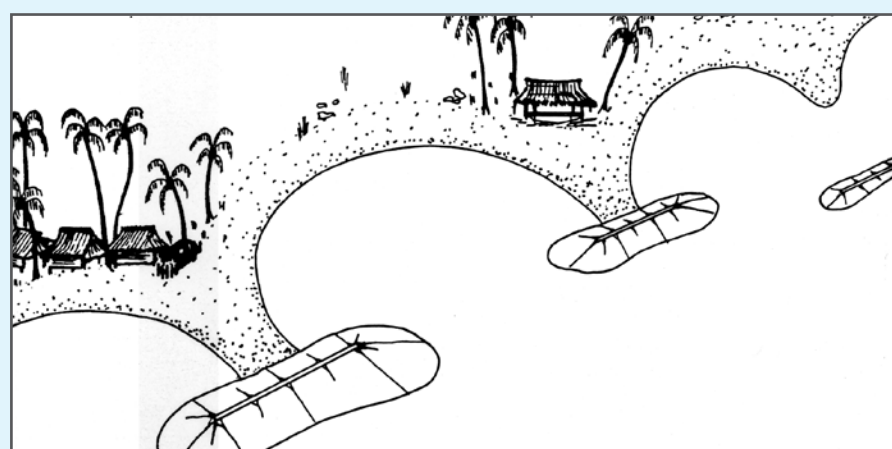
- The all open and half open groynes are performing well in the northern part of the site;
- The fully closed groynes result in the usual groyne-effect with more sand on one side than the other;
- 3x the length of the groyne for the gap between each groyne is the best spacing in this location (similar to temperate groyne field design), and;
- The groynes and associated beaches are being utilized by the local people, especially since there is now no scarp and rocks in these areas (they have been covered by the accumulated sand).

This trial proved that groyne fields consisting of varying degrees of permeability are an effective **Managed Advance Response** this tidally dominated section of coastline in north-eastern Tongatapu.



6. MANUKA DETACHED BREAKWATERS

At Manuka (Site B), 9 detached breakwaters were proposed and constructed 25 m offshore of the existing high tide mark, which was against a 1 m high scarp adjacent to the coastal road; the scarp was previously overtopped 2-3 times each year during extreme wave events, covering the road with rock and debris. Breakwaters were spaced 15 to 25 m apart and were 15 to 20 m long; similar to the range of groyne-spacings, this was applied in an effort to learn more about the design parameters of detached breakwaters on coral sand coasts.

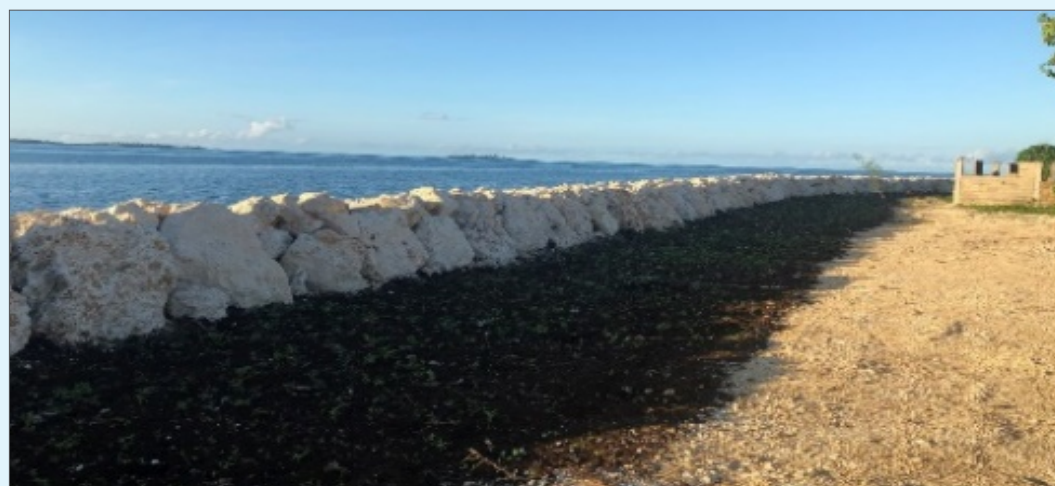


Only initial monitoring was undertaken at this site, and so quantitative information on the coastal response to each of the breakwaters is not available, although a full survey of the area is planned for early 2020. Even so, recent visual inspection indicated that the detached breakwaters at Manuka have been extremely effective at widening the beach to provide a buffer zone and stop over-topping onto the road. There is now 10-30 m of buffer zone and a series of crescent shaped beaches, as seen in the images below. This trial proved that detached breakwaters are an effective **Managed Advance Response** to this wave dominated section of coastline in north-eastern Tongatapu, **Buying Time** to plan for the inevitable need to retreat.



7. REVETMENT CONSTRUCTION – A GOOD OPTION?

In 2018 a 2 km long revetment was built on the same stretch of coast adjacent to the Manuka detached breakwater trial site (Site B). Part of the drive for the Talafo'ou to Makaunga and Manuka groyne and breakwater **Managed Advanced Responses** was to look at tourism opportunities for this part of Tongatapu – the construction of the revetment has negated this possibility.



In terms of cost, the detached breakwaters (including sand transfer) at Manuka cost \$300K to enhance and protect 400 m of this coast, while the 2 km long revetment cost \$6M. That is, 8 km of coast using more appropriate measures (i.e. detached breakwaters) could have been protected and enhanced with the available funds, or most of the funds could have been directed to other projects to increase Tonga's CC resilience. Furthermore, the revetment is **not a Managed Advance Response** and **does not** address the cause of beach loss. The revetment results in loss of beach access and amenity. Revetment does provide land resilience but what is the cost to the community and how will effect their response to inevitable retreat?

8. INTEGRATED COASTAL MANAGEMENT PLANNING

At present, integrated coastal management planning is required in Tonga to consider all components of the coastal processes and community needs, and to ensure that community resilience and not just land resilience in response to CC and sea level rise is applied appropriately. The projects presented here represent hybrid solutions that incorporate renourishment, sand-retention structures and coastal planting.

In Tongatapu, at trial Site A between Talafo'ou to Makaunga, the low-cost semi-permeable groynes constructed of readily available components (i.e. concrete cubes) have proven to be an effective response

to retaining sand and widening the beach at this tidally dominated site. The detached breakwaters at trial Site B in Manuka were also found to be a cost-effective approach to coastal protection and the development of a buffer zone for CC resilience at this wave dominated site. In contrast to more expensive and obtrusive coastal protection measures in the area (i.e. revetments), they provide a similar level of protection, although they also enhance amenity, aesthetics and beach access that are an additional benefit to the local people and community resilience to CC in areas that will inevitably be retreated from in coming decades.