

COASTAL ENGINEERING FOR CLIMATE CHANGE RESILIENCE IN EASTERN TONGATAPU, TONGA



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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.



Two trial projects were developed for eastern Tongatapu combining hard and soft engineering to provide climate change resilience that were focussed on learning more about the efficacy of their application in different physical environments and compare the design parameters in a temperate context versus a tropical coral sand coast; coastal engineering has been developed for temperate coastlines, which are significantly different than coral coastlines.

Both sites were subject to erosion and inundation which is due to a combination of:

- Sand-mining
- Removal of mangroves
- Damage to the fringing reef ecology (by humans and pigs) – coral beach sand is biogenic and created by the fringing coral reefs and the organisms that consume the coral; over-fishing, pollution, and other forms of damage break the 'sand-engine' that naturally nourishes the beaches with sand.
- SLR

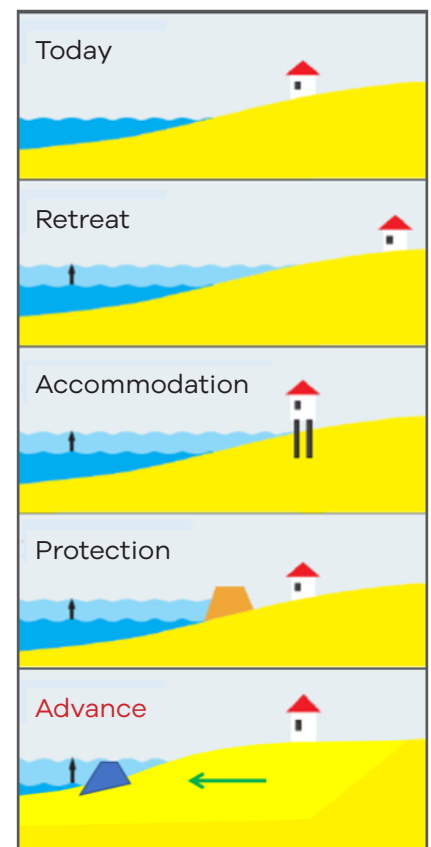
Together, these factors have resulted in reduced beach height and width (20-30 m of retreat since 1967) and removed sediment from the system faster than it can be replenished.

An important aim/factor associated with the project was the recognition of the inevitability of a need to retreat from these coastal sites due to their low-lying nature. The works were developed to 'Buy Time', 30-35 years, in order to plan for the retreat and relocation of the villages.

At a tidally dominated site, groynes with varying permeability placed at varying intervals along the beach were trialled, while detached breakwaters of varying lengths at varying intervals were trialled at a more exposed wave-dominated site. Both trials included beach renourishment and planting of coastal species – 'hybrid' solutions – as well as a detailed monitoring programme.

Five years after implementation, several important findings have emerged at the tidally-dominated site of the groynes:

- The all open and half open are working well in the northern part of the site without causing downcoast 'groyne-effects';
- The southern groynes where there is less wave energy are more suited to fully closed groynes;
- *Semi-permeable* groynes with a spacing that agrees with temperate design parameters (i.e. groynes should be spaced at ~3x their across-shore length) were found to be very effective at retaining renourished sand and widening the beach, 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).



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The results of the monitoring have led to the following adaptative management actions:

- Addition 8x 50% closed groynes in the 60 m gaps;
- Rotate half of the open units on the 6 groynes in the southern area to make fully closed;
- Bring in 2,000 m³ of sand for the southern groynes (not previously nourished), and;
- Continue enforcement of pig penning



The groynes spaced along the beach with varying degrees of permeability (i.e. impermeable, 45% permeable, and 90% permeable).

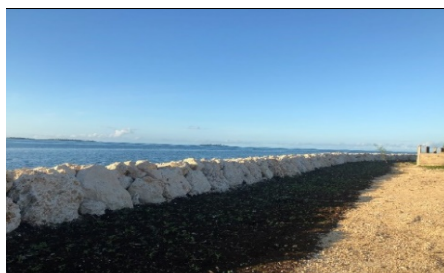
The detached breakwaters at the wave-dominated site have also proven to be very effective at sand retention and the creation of a buffer zone, as well as being very cost effective and allowing for better coastal access and amenity. No concrete conclusions were drawn with respect to location and spacing of the detached breakwaters, since the 'over-performed' and all created large tombolos and associated beach compartments.



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The detached breakwaters at Manuka, which 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. The usual response to coastal erosion in Tongatapu has been the construction of revetments. Coincidentally, 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, which also has only one access along its length.

The detached breakwaters (including sand transfer and planting) at Manuka were 4x as cost-effective than the 2 km of revetment; i.e., 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 it affect their response to inevitable retreat? The perceived 'safety' of the structure may encourage more housing development.



The 2 km revetment adjacent to the detached breakwaters at Manuka is inappropriate for an area where retreat is inevitable.