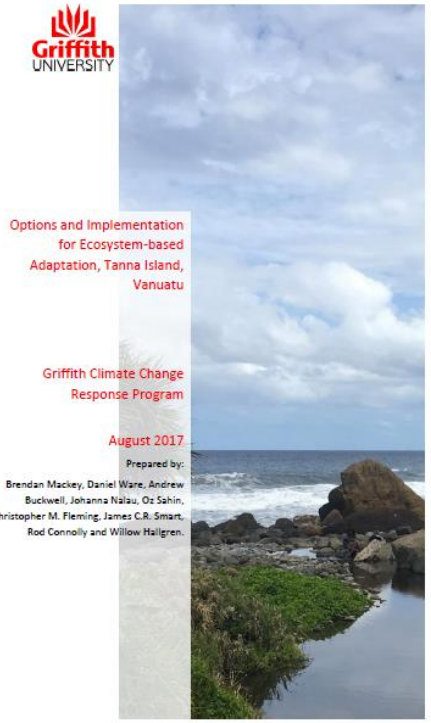
Cost Effectiveness Analysis

Case Study from Tanna Island Vanuatu

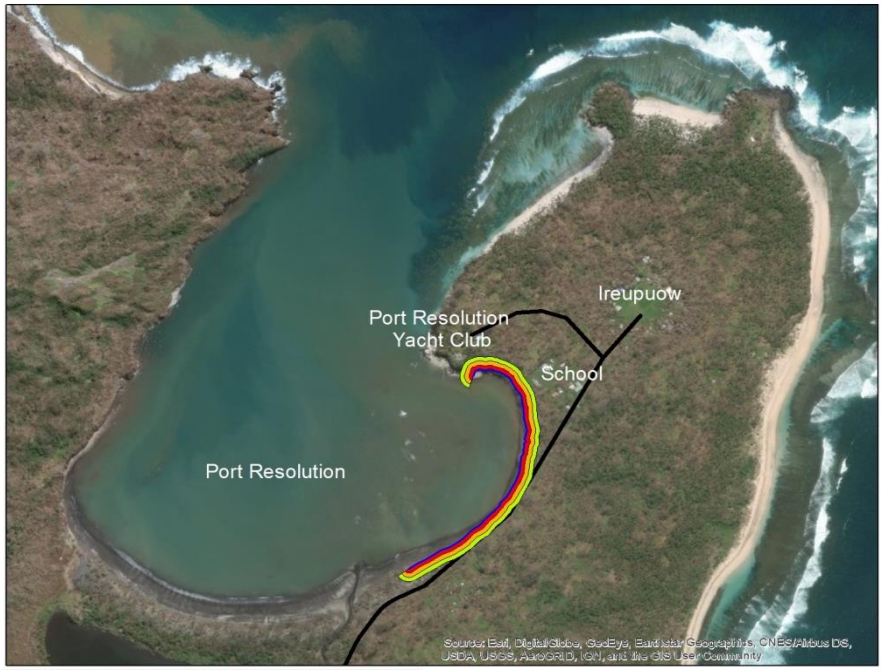


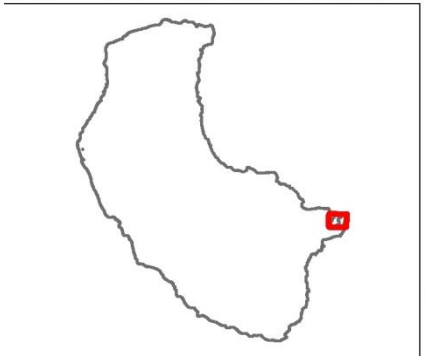
Source: Brendan Mackey et al. 2018. Options and Implementation for Ecosystem-based Adaptation, Tanna Island, Vanuatu. SPREP: Apia pp 30-39 (in publication)

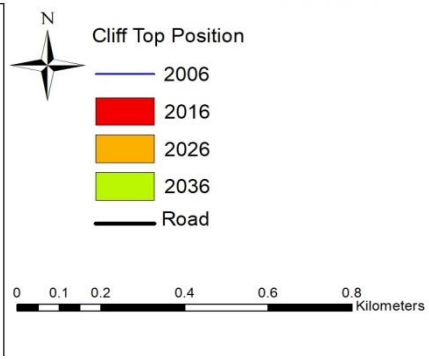
For further information contact hermant@sprep.org

Problem being addressed

Eroding coastal sandstone cliff at Port Resolution is threatening a local school and a village access road.





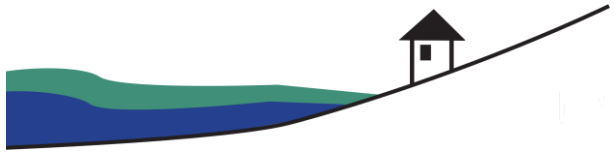


Cliff eroding 5m every 10 years
Road is 10m from cliff
School is 30m from cliff
Future rate of erosion is unknown

Adaptation options being considered

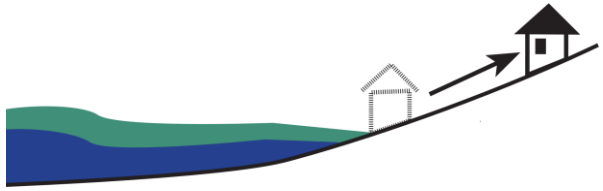
1. Maintain current management approach

   Allows for unmitigated coastal processes, which may, or may not lead to continued erosion, but avoids costs of construction of engineered structures.



2. Managed realignment

   Managed abandonment of land and removal (and potential re-use) of structures. This strategy has ecological benefits as it allows ecosystems to migrate naturally and retain function.

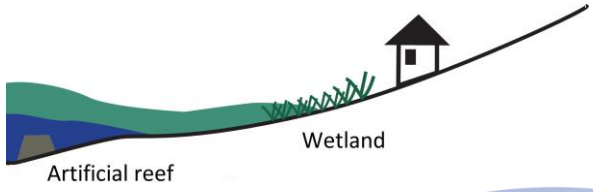


3. Hold the line

   The use of hard-engineered structures, such as sea walls of soft-engineered options, such as beach nourishment and artificial reefs.

4. Limited intervention (accommodation)

   Continued occupation of land by modifying building designs so they can be moved, or use of engineered ecosystems to increase protection.



PLANNING HORIZON – 15 years

<u>OPTION 1 - Maintain current management approach</u>
Allow coastal processes to unfold and only move the road after 10 years and the school after 15 years. These timeframes allow for a reasonable buffer against sudden, large-scale loss of cliff top.

<u>OPTION 2 - Managed realignment</u>
The school buildings are pre-emptively rebuilt in year 0 and the road is realigned in year 10. Coastal processes are allowed to unfold naturally.

<u>OPTION 3 - Engineering solutions</u>
Stop further cliff erosion by directly shoring up the cliff, or protecting the base of the cliff from wave energy. School and road remain in place.

<u>OPTION 4 - Limited accommodation</u>
Construct an artificial reef in the embayment to reduce wave energy on the base of the cliff to reduce erosion. Will likely also generate ecosystem service benefits.

COSTING OF OPTIONS

Item	Design costs (US$)	Construction costs (US$)	Annual maintenance cost (US$)	Lifetime (years)	Notes
School rebuild	10,000	55,046	-	-	
Realignment of road	1,000	50,000	-	-	
Engineering options					
Gabion seawall	94,800	6,320,00	500	25	*Dependent on sourcing of coral or stone rubble and local labour*
Geotextile seawall	59,250	3,950,000	1000	10	*Assumes sediment availability*
Shotcrete	1,066,500	7,110,000	0	25	*Final costs heavily dependent on consulting report on additive mixtures, fixings and fibres*
Epoxy injection	3,555,000	23,700,000	0	25	*Final costs heavily dependent on consulting report on number of injections*
Boulder seawall	592,500	3,950,000	0	50	*Costs based on importation of suitable stone*
Timber seawall	59,250	3,950,000	1000	10	*Costs based on the availability of local timber*
Artificial reef	20,000	2,500,000	0	50	

RISK PROFILE & PREMIUMS

Option	Description	Risk of failure	Risk justification
Maintain current management	Move school after 15 years.	1 in 100 years	For each year the school is not moved a risk premium is applied. After the school has been moved no further risk premium is applied.
Move school	Move school immediately.	No risk	No risk premiums applied.
Realign road	Realign road after 10 years.	1 in 50 years	For each year the road is not moved a risk premium is applied. After the road has been realign no further risk premium is applied.
Gabion seawall	Immediate engineering solution with lifespan greater than 25 years.	1 in 50 years	Risk premium applied every year following initial construction.
Geotextile seawall	Immediate engineering solution with lifespan of 10 years.	1 in 10 years	Risk premium applied every year following initial construction.
Timber seawall	Immediate engineering solution with lifespan of 10 years.	1 in 10 years	Risk premium applied every year following initial construction.
Shotcrete	Immediate engineering solution with lifespan greater than 25 years.	1 in 100 years	Risk premium applied every year following initial construction.
Epoxy injection	Immediate engineering solution with lifespan greater than 25 years.	1 in 100 years	Risk premium applied every year following initial construction.
Boulder seawall	Immediate engineering solution with lifespan greater than 25 years.	1 in 100 years	Risk premium applied every year following initial construction.
Artificial reef	Immediate hybrid EbA/engineering solution with lifespan greater than 25 years.	1 in 100 years	Risk premium applied every year following initial construction.

Desired outcome for the CEA

An operational school and serviceable road at the end of a 15-year period.

Method used

Establish Present Value (PV) of all costs

$$PV = FV/(1+r)^t$$

FV is future value, *r* is the discount rate and t is the time period. Risk premium was also included.

Cost effectiveness of different approaches to treating coastal protection:Present value co								r=	10				
	Limited intervention										Artificial reef		
				Gabion seawa	Geotextile seawall	Shotcrete	Epoxy injection	Boulder seawall	Timber seawall			
	Do nothing	Move school	Realign road	Costs	Costs	Costs	Costs	Costs	Costs	Costs	Benefits	Cost-Benefit
Design and construction costs	65,046	65,046	51,000	6,414,800	4,009,250	8,176,500	27,255,000	4,542,500	4,009,250	2,520,000		
Lifetime	10	25	25	25	10	25	25	50	10	25		
Maintenance costs ($/yr)	0	0	0	500	500	0	0	0	1,000	0		
Benefits ($/yr/ha)											9,151	
0	0	65,046	0	6,415,300	4,009,750	8,176,500	27,255,000	4,542,500	4,010,250	2,520,000	0	-2,520,000
1	591	0	927	117,133	364,977	74,332	247,773	41,295	37,448	22,909	0	-22,909
2	538	0	843	106,530	331,843	67,574	225,248	37,541	34,134	20,826	0	-20,826
3	489	0	766	96,891	301,721	61,431	204,771	34,128	31,122	18,933	7563	-26,496
4	444	0	697	88,128	274,337	55,847	186,155	31,026	28,384	17,212	6876	-24,087
5	404	0	633	80,162	249,443	50,770	169,232	28,205	25,894	15,647	6250	-21,898
6	367	0	576	72,920	226,812	46,154	153,847	25,641	23,631	14,225	5682	-19,907
7	334	0	523	66,336	206,238	41,958	139,861	23,310	21,574	12,932	5166	-18,097
8	303	0	476	60,351	187,534	38,144	127,147	21,191	19,703	11,756	4696	-16,452
9	276	0	433	54,910	170,531	34,676	115,588	19,265	18,003	10,687	4269	-14,956
10	251	0	19,663	49,964	4,164,324	31,524	105,080	17,513	4,025,707	9,716	3881	-13,597
11	228	0	0	45,467	141,022	28,658	95,527	15,921	15,052	8,832	3528	-12,361
12	207	0	0	41,379	128,247	26,053	86,843	14,474	13,775	8,029	3207	-11,237
13	188	0	0	37,663	116,634	23,684	78,948	13,158	12,613	7,300	2916	-10,215
14	171	0	0	34,284	106,076	21,531	71,771	11,962	11,558	6,636	2651	-9,287
15	15,571	0	0	31,213	96,478	19,574	65,246	10,874	10,598	6,033	2410	-8,443
Sub total	***$20,363***	***$65,046***	***$25,537***	***$7,398,630***	***$11,075,967***	***$8,798,411***	***$29,328,037***	***$4,888,006***	***$8,339,447***	***$2,711,673***	***$59,095***	***-$2,770,769***
Cost	**$45,900**	**$90,583**	**-**	**$7,398,630**	**$11,075,967**	**$8,798,411**	**$29,328,037**	**$4,888,006**	**$8,339,447**			**-$2,770,769**

CEA RESULT

Option	r	Present Value Cost (US$)
Maintain current management approach	10	45,900
	15	29,191
	20	19,569
	0	134,332
Managed realignment (move school)	10	90,583
	15	82,519
	20	77,394
	0	125,226
Engineering solutions		
Gabion seawall	10	7,398,630
Geotextile seawall	10	11,075,967
Shotcrete	10	8,798,411
Epoxy injection	10	29,328,037
Boulder seawall	10	4,888,006
Timber seawall	10	8,339,447
Artificial reef	10	2,770,769‡
	15	2,711,783‡
	20	2,672,389‡
	0	3,016,967‡

Two most cost-effective options at r = 10:

- Maintain current management approach
- Managed realignment

Decision is narrowed to whether to move the school now or in the future.

CONCLUSION

Delaying the move to a later date is the most cost effective adaptation option; i.e. maintaining current management approach over the 15 year planning horizon.

- has the added benefit of allowing stakeholders time to raise funds and plan for the relocation at a future date.
- makes allowance for the possibility that the cliff may become stable as a result of changes in coastal processes and better management of human activities such as sand extraction.