Samoa Pacific Adaptation to Climate Change (PACC)

Tafitoala Coastal Management Demonstration Project (Samoa, First National Communication to the UNFCC, 1999)

Cost benefit Analysis

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Contents

1. Introduction

Samoa is part of the Pacific Adaptation to Climate Change programme and it selected as a focal area for its adaptation strategy the coastal zone management sector.

Among the activities that the Government of Samoa is undertaking within PACC, there is the implementation of 5 pilot demonstration projects. The lessons learnt and the results of these adaptation pilot projects will be a helpful tool for policy makers in the future decision making process.

The results of a project can be assessed in different ways, but when it is feasible, cost benefit analysis can give us helpful information about the effectiveness of the investment. In this report we will present the cost benefit analysis of one of the five pilot project implemented by the Government of Samoa. The project object of the study is located in a village in the south coast of Upolu called Tafitoala. It consists in a sea wall that will protect the area and its infrastructures by coastal erosion and sea surges that have been experienced by population at an increasing rate in the last decades.

The objective of this analysis is to assess whether the construction of a sea wall represent a worthwhile option to be implemented for coastal management in Samoa. A secondary objective is to assess potential constraints to realising project benefits and provide recommendations on how to overcome these problems. Finally this report will try to establish a methodology to evaluate the effectiveness of hard adaptation strategies such as the construction of sea walls. Some words will be spent to discuss the role, the strengths and the weaknesses of cost benefit analysis in the project designing and managing process.

The rest of this report is organised as follows:

1. Background
2. Problem Statement
3. Objectives
4. Options
5. Methodology
6. Results
7. Findings and Recommendations

2. Background

Problem Statement

Samoa is considered a highly vulnerable country to climate change. About 70 percent of Samoa's population and infrastructure are located in the coastal area, as reported in the Initial National Communication Report (Samoa, First National Communication to the UNFCC, 1999). Nearly all the coastal settlements are located in low-lying areas, (IPCC, 2007)thus making them more vulnerable to climate change and sea level rise.
The IPCC's Fourth Assessment Report (IPCC, 2007) (Samoa, Coastal Infrastructure Management Plan, 2002)provided a comprehensive analysis of how climate change is affecting natural and human systems in small island states in the Pacific region. Such impacts include extensive coastal erosion, flooding, storm surge, and other coastal hazards, which are exacerbated by sea level rise. These impacts threaten vital infrastructure, such as coastal roads and bridges, freshwater supplies, settlements and facilities, and will compromise human health and the socio-economic well-being of island communities.

It is in this scenario that PACC called on participating countries to identify a development sector in which to focus their adaptation efforts. Following an evaluation of existing Samoan development programmes, the status of existing baseline assessments and co-financing abilities, and given the pressing adaptation requirement in the sector, Samoa selected coastal zone management and its associated infrastructure as a priority sector for adaptation intervention.

One of the outputs of PACC Samoa is the demonstration of climate change risk reduction through community interventions in 5 Districts for which CIM plans have been developed. This output is designed to enable the government of Samoa to develop its capacity to plan and demonstrate a community based integrated coastal protection model. Specific measures will include mangroves restoration, constructing protective coastal infrastructure (seawalls), coastal tree replanting and strengthening road protection.

Samoa demonstration sites

Three of the main management demonstration pilot projects are characterized by a hard adaptation approach with some minor elements of soft adaptation. In these villages the adaptation measures undertaken consist in the construction of three seawalls to protect lowlands inhabited areas from extreme sea surges and coastal erosion.

We will analyse the seawall that has been erected in defence of the Tafitoala coast. It is 900 meters long, has a 25 years lifespan and it is made mainly by rocks. It has been implemented supported by some minor soft adaptation strategies:

1. Replanting of salt tolerant coastal plants to create natural barriers along the coastline.
2. Capacity building and awareness raising workshops.
3. Formulation of bylaw to manage the water resources as part of ridge to reef effort.
4. Replanting along streamside from ridge to coastline

According to the CIM plans of the area of Safata, Tafitoala has some of the main infrastructures located in the Coastal Erosion Hazard Zone and in the Coastal Flood Hazard Zone (Samoa, Coastal Infrastructure Management Plan, 2002). Infrastructures like churches, houses and roads that are located in these hazards zones are willing to be damaged by extreme events such as cyclones that will become more likely in the Samoan region according to the IPCC and the Australian bureau of meteorology. Sea level rise and coastal erosion will also affect somehow the coast of Tafitoala. The sea level rise measured from 1993 to 2010 was on average 5mm per year. This figure coincides by and large with the word average figure that is between 0,4 mm and 3,2 mm.

Community information

Tafitoala is 46 Km from Apia, located in the Safata District on the south coast of Upolu. The village is located in a low-lying area and is at particular risk from coastal erosion. *A broad plain ranging from 2 to 4 km in width sloping down to the coast and steep inland mountains. The village residential settlements spread along the plain and a sand-spit that is attached to the main land from East to West enclosing a wetland area. The coastline is generally that of a soft sandy type. Aside from mangrove wetlands, plantations and agricultural areas dominate the area. Most are located inland from the Main South Coast road but suitable areas between the road and the sea are also planted.* (Samoa, Coastal Infrastructure Management Plan, 2002)

Most of the community is located on the lagoon coast, with a total population of 393 people (Census 2006) and a total of 46 households with 16 residential houses and two churches located on the area. Within the CIM Plans, the main issues highlighted of which the community has a high level of *susceptibility given the sandy nature of the coastline are erosion, managing sandmining, flooding and guardianship of the Fisheries Management area.(ibid)*

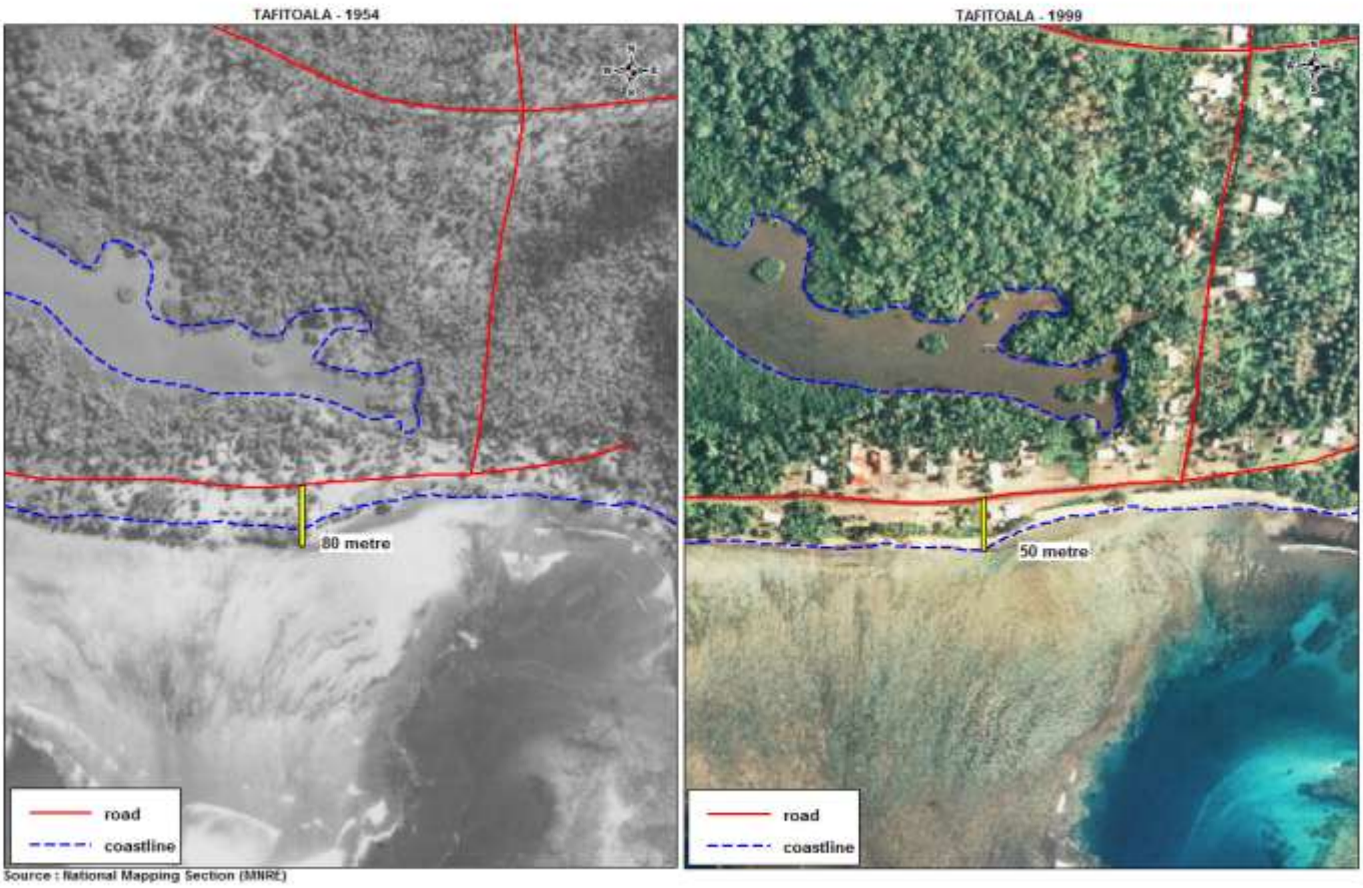
The population of the district of Safata, where Tafitoala is located, can be considered highly susceptible to climate change because it depends heavily on natural resources. 90% of the households rely on agriculture for subsistence or home consumption and the 49% is engaged in fishery. (Samoan Statistic Bureau, 2009).

All these features make the area of Tafitoala an ideal place to be chosen as a demontration site for the implementation of the PACC Samoa pilot project.

Measurements

Looking at the satellite photos from 1954 and 1999, provided and processed by the Ministry of Natural Resources and Environment, emerges that the loss of coast is approximately 30 meters over this period. This number is subject to high uncertainty because it has been measured without taking in account the tides and different seasons. Moreover it is based on a single measurement instead of being an average of multi measurements.

Figure 1 Tafitoala coastal erosion from 1954 to 1999



The figure 1 shows the area of Tafitoala and the regression of the coastal line from 1954 to 1999

Even if there is highly uncertainty about these numbers we have evidence from other sources that Samoa has experienced high level of coastal erosion. For example in the village of Afega the loss of mangroves has increased the exposure of coastal development to damage from cyclones and heavy seas. In some areas the coastline has receded up to 40 metres since 1954. (CIM plans, 2007). Increased coastal erosion in the village of Tafitoala has emerged also during community consultation: it was reported that the beach is eroding at an average rate of about a metre per year. (CIM plans, 2007)

Both these resources can be biased, because slow changes such as coastal erosion are difficult to detect without accurate and scientific measurements. It is true that we cannot infer anything about the magnitude of the changes, but these resources show us that a change is happening and coastal erosion is a threat for Samoa coast lines.

Moreover we are not certain about the drivers of the changes and in which composition they are responsible for coastal erosion. Multyple factors can be involved such as increased human activity, loss of vegetation and also natural cycles of coast shape. Activities such as sand mining can be a serious threat for coastal protection and in Tafitoala this activity at the domestic level is a common practice.

Therefore if we try to anwser to oft-asked question of whether coastal erosion is caused by climate change the anwser is that it is the wrong question. Probably some of the coastal eriosion that Tafitoala is experiencing would have happened even without the effect of climate change because of the causes that we exposed before, but the changing in weather patterns is definetly exacerbating these effects.

To resume the previous discussion the following issues have been identified as the main causes of the problem.

Cause(s) of problem

- Seasonal or natural cycle of coastal erosion.
- Unregulated sand mining and lack of community understanding of negative impacts .
- Sea level rise due to climate change.
- Increased frequency of extreme events (Cyclones, sea surges).
- Deforestation of mangroves forests and lack of community understanding of negative impacts.

Climate Change projections

The main climate variables that can affect coastal erosion in Samoa are sea level rise and increase of extreme events such as cyclones and extreme sea surges.

There is high confidence that sea level will rise on a global scale because Sea-level rise is a physically consistent response to increasing ocean and atmospheric temperatures and projections arising from all CMIP3 models agree on this direction of change. (CSIRO, 2012).On the other hand there is moderate confidence in this range and distribution of possible futures, so there is high uncertainty

about the intensity on how this change will occur. The estimates range from 5 to 15cm increase of the sea level on the short term (2033) depending on the emission scenarios. On the medium term (2055) the projection range from 10 to 29 cm and in the long term (2090) they range from 17 to 59cm.
If we look at the records of sea level rise, according to the satellite measurements done by CSIRO from January 1993 to December 2012, Samoa is experiencing a sea level rise of 5mm/year.

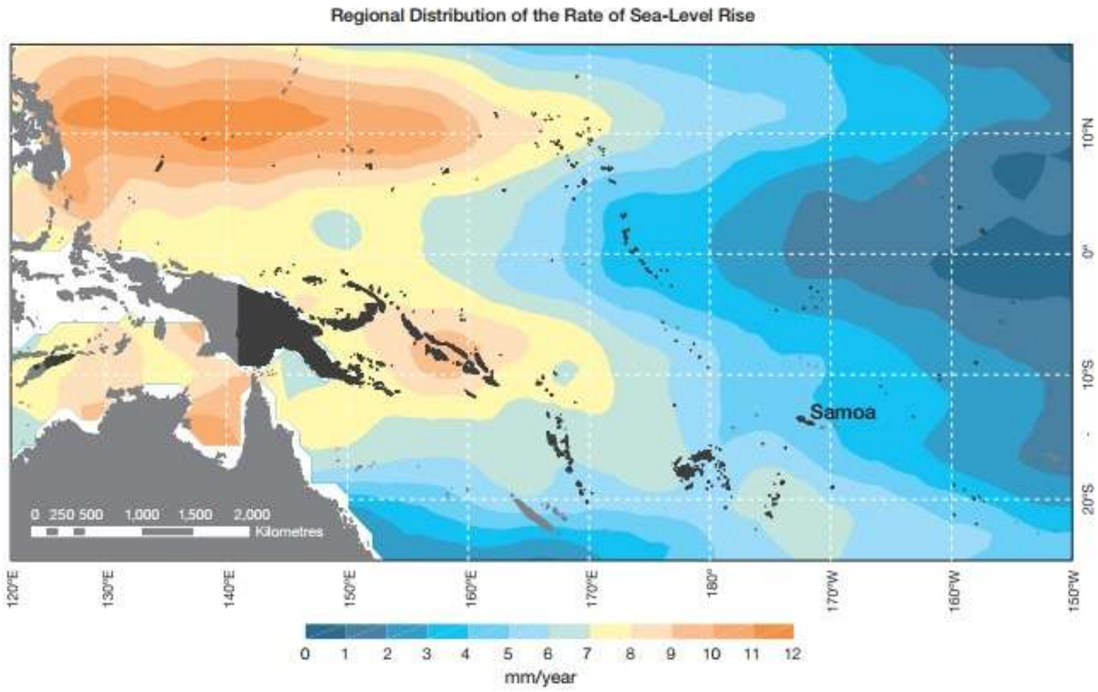


Figure 2 The regional distribution of the rate of sea-level rise measured by satellite altimeters from January 1993 to December 2010, (CSIRO, 2012)

For what it concern the change of extreme events patterns, the area of the eastern Pacific Ocean basin (0–40ºS, 170ºE–130ºW) will experience a decline of tropical cyclone over the course of the 21st century. There is moderate confidence in this direction of change because many studies suggest a decline in tropical cyclone frequency globally (Knutson et al., 2010) and tropical cyclone numbers decline in the south-east Pacific Ocean in the majority assessment techniques.

As we will see later in the methodology section, climate change will not be included in the analysis of the expected costs. The main reasons of this choice are that there is low confidence on the projections on sea level rise and if we included these variables it would have made the analysis more complex without increasing the quality of the work.

3. Study objectives

The PACC programme in Samoa focuses on coastal infrastructure management and one of the outcomes of the program is the implementation of a demonstration site.

For what it concerns the cost benefit analysis of Samoa, it has been conducted after the construction of the seawall. The exercise is an ex post analysis, so it does not have the main objective of the typical CBA that are often used to select the most effective option among a set of different possibilities to implement a project. As we anticipated, this is a demonstration project, so this ex post CBA is important to assess the repeatability on a larger scale.

Do the benefits repay the costs of the project? Is worth it to replicate the project on a larger scale in other vulnerable areas of Samoa? These are some of the questions that we try to answer in this report.

The second objective of this cost benefit analysis is to understand the role, weaknesses and opportunities of this tool in project management with a focus on the challenges of measuring costs and benefits of adaptations measures. This second objective is really important because we will try to clarify what answers a CBA can give and how policy makers can rely on this kind of tool. We believe that this is a key passage because strengths and limits of cost benefit analysis are not usually clear among policy makers.

4. Methodology

The methodology adopted for this analysis is a standard cost benefit framework.

First of all we will provide a taxonomy of all the benefits and the costs involved in the project. We will then decide which of these measures will be taken in account in our quantitative analysis. The final approach selected will consider the damages avoided by the seawall as the benefits of the project. In the next section these benefits will be discounted using the common discount rate employed by the other PACC projects and finally compared with the costs.

The majority of the costs and the benefits of the project will not be included in the quantitative analysis, so at the end of the paper the results will be enhanced with some qualitative considerations.

Costs

Measuring the cost of the project by considering only the nominal cost of equipment and labour would have not meant capturing the real cost of the project. So in the table below we list the costs of different nature that can arise in the construction of a seawall.

In the other columns you can find a categorization of the costs, the measurement technique and the approach adopted in this report.

Cost	Type of cost	Measurement technique	Approach selected
Equipment cost and labour cost	Direct monetary cost	The equipment costs are recorded in the project documents.	They are included in the analysis because they are accountable for an high percentage of the

			cost and they are measurable economic costs.
Maintenance cost	Direct monetary cost	Maintenance costs are generally estimated by the constructor.	The maintenance costs are estimated by using existing projects as a reference. We will assume that the costs are the same of a EU Hondsbossche Seawall in Netherlands
Loss of tourism due to the loss of natural ecosystem	Indirect monetary cost. (functional value)	Measurable with businesses income survey.	Due to the modest touristic activity (there are no accommodations in the area) this cost will be not take into account. A regression to be statistically meaningful needs a bigger sample.
Noise pollution due to the construction of the sea wall	Indirect non monetary cost (intangible cost)	Measurable with contingent evaluation method.	The contingent evaluation method is characterized by high level of uncertainty and the influence of this value on the overall cost Is modest, therefore this cost will be assessed by a qualitative point of view.
Alteration of the sea ecosystem with consequent alteration of fishery activity	Indirect monetary cost. (functional value)	Measurable with fishery survey.	These tools can be very expensive and their cost is not justified for the scale of the project.
Alteration of long-shore drift patterns, affecting neighbouring villages	Direct monetary cost	Expected value of area of land loss reduced	Quantitative analysis considering the average value of land in Samoa and measuring the expected land erosion comparing satellite photographs.

The loss of tourism and the alteration of the sea ecosystem in this context share a common problem that makes them impossible to be assessed by a quantitative point of view. Both of these costs need a pre project baseline to be compared with the actual situation. Our analysis is an ex post assessment, therefore baselines are not available.

This is certainly one of the lessons learnt that we will report extensively later in the report: cost benefit analysis has to be carefully planned in the inception phase of the project, so all the steps and the components required can be organized in advance.

As we can see from the table some of the costs that occur are left aside from the analysis for different reasons:

1. The first is that some values such as aesthetic ones are difficult to assess because they are intangible, non-market values, and the instruments that measure them are subject to a high level of uncertainty. Contingent valuation, travel cost method and hedonic pricing method need numerous assumption and the outcome of these methods of measurement are still object of debate among environmental economists.
2. Indirect economic values such as loss of tourism activity and fishery are values that need a baseline assessment to be compared to the scenario after the intervention. Even if we would have done these assessments the tourism activity and fisheries are undersized (because the demonstration site is small). This can affect the statistical reliability of this kind of tool.
3. Costs associated to noise pollution can be ignored because they just occur during the construction of the seawall.

These considerations are the reason of taking in account only labour costs, equipment costs and maintenance costs.

According to the Pilot demonstration report for Samoa, the Rock sea wall of Tafitoala costed $ 462,530 SAT that corresponds to USD$ 202,560. The amount includes equipment cost, and labour cost.

For what it concerns the maintenance costs of the seawall, exact figures are not available, so we assume that this cost is the same of what has been reported by a paper on the economics of coastal adaptation (King, McGregor, & Whittet, 2010). According to the paper the maintenance costs of the project are estimated to be on average 3,4% of the total costs of the seawalls. This maintenance costs are assumed to keep the seawall operating during the total of his life span.

The maintenance costs amount to USD$172,176. If we discount this amount for the discount rate of 8% that PACC adopted in his evaluation approach, we obtain that the total maintenance cost are USD$ 107590 So the total costs of the project, considering only the costs that we decided to take in account amount to USD$ 310,151

Benefits

To measure the benefits of the project we decided to use an avoided damages approach.

The seawall will create benefits for the community avoiding damages that will occur in a non intervention scenario. Comparing these 2 possible futures we will be able to measure the expected benefits of this adaptation strategy.

In the table below we can find a taxonomy of the expected benefits categorized by type of cost, measurement technique and approach selected in this analysis

Benefit	Type of cost	Measurement technique	Approach selected
Avoided coastal erosion	Direct monetary benefit	Expected value of area of land loss reduced	Quantitative analysis considering the average value of land in Samoa and

			measuring the expected land erosion comparing satellite photographs.
Avoided loss of infrastructure	Direct monetary benefit	Expected value of Infrastructure loss avoided. The value is estimated measuring assets with a survey.	Quantitative analysis. The value of the infrastructure is measured counting the assets in the expected coastal erosion area. The value of these assets is estimated using related studies values.
Decreased damages to infrastructures caused by cyclones and extreme sea surges.	Direct monetary benefit	Using historical records of sea surges or using models to measure the impacts	Qualitative analysis due to the lack of records of extreme sea surge,cyclones damages in the area and to resources and time constraints.
Decreased cleaning up costs related to extreme sea surges.	Indirect monetary benefit	Multiplying the number of days spent in cleaning up activities by the minimum wage in Samoa. Gill (2003).	Qualitative analysis due to the lack of records of extreme sea surge in the area and to resources and time constraints.
Reduced loss of income and revenue and cleaning up damages	Indirect monetary benefit	Multiplying the number of working days by the average income and revenue.	Qualitative analysis due to the lack of records of extreme sea surge in the area and to resources and time contraints.
Reduced stress and trauma related to sea surges.	Indirect non monetary benefit	Contingent valuation	The contingent evaluation method is characterized by high level of uncertainty therefore this cost will be assessed by a qualitative point of view.

Not all the benefits that are listed in the table will be included in the quantitative assessment. Some of the reasons of this choice are similar to the costs estimation problems. The unreliability of the measurement techniques and time and budget constraints are the main issues that drove us to prefer a qualitative assessment instead of a quantitative analysis.

Valuation of the benefits

As we anticipated we will evaluate the benefit with a damage avoided approach.

The seawall that has been built has a 25 years life span and it is supposed to protect the area by coastal erosion and sea surges, but this second aspect is not considered in our analysis.

The image below is summarize how the benefits of the seawall are identified in the avoided damages approach.

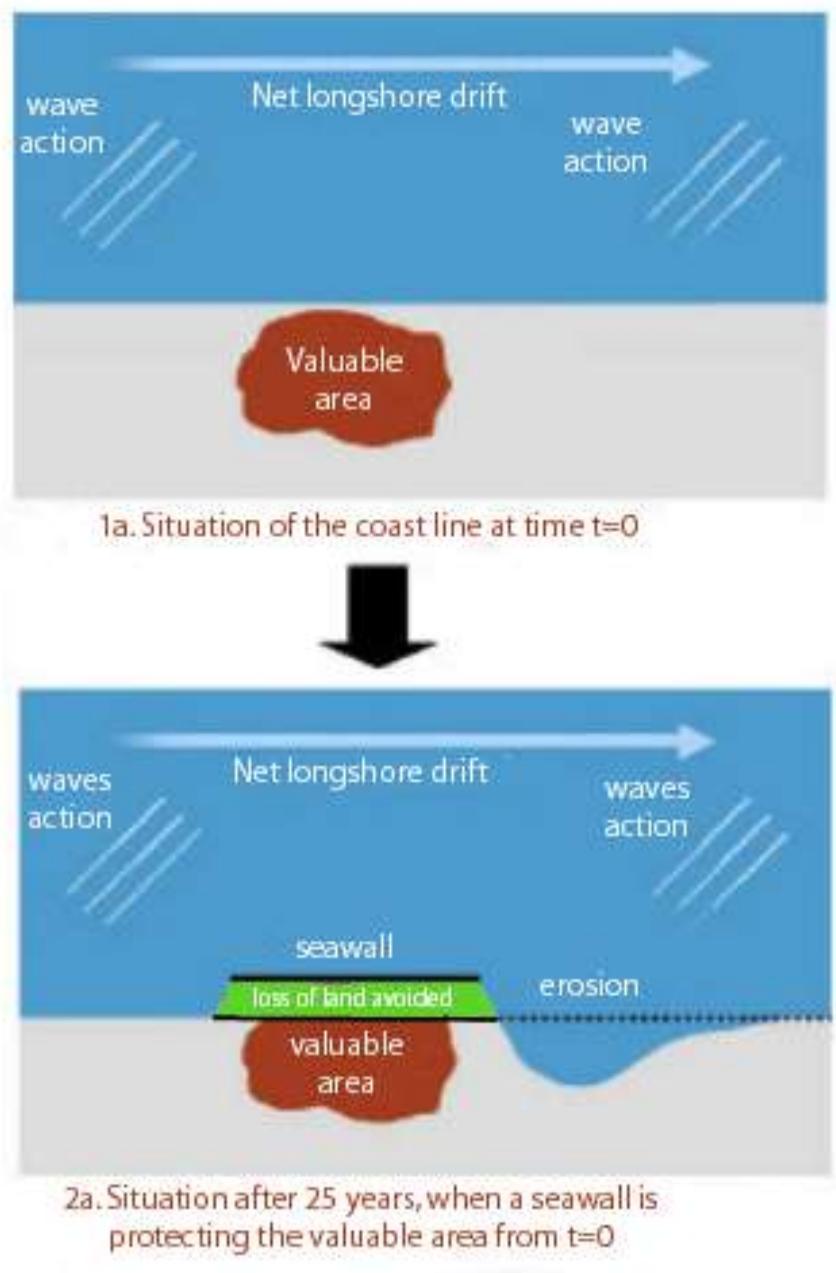


Figure 3 Exemplification of benefits provided by the seawall. Figure modified (European Commission, 2004)

In the next passage of the analysis we will have to investigate which is the area that is expected to be loss in a no intervention scenario.

As we have anticipated in the introduction of the report, Tafitoala has experienced 30 meters of coastal erosion from 1954 to 1999. It means that during that period the coastal erosion rate was 0,65m/y. This figure has been produced by the MNRE looking at the satellite measurements for the relative years.

As we anticipated, this figure is subject to a high level of uncertainty due to the numerous measurement methodology issues that we exposed earlier in the report.

To estimate the expected area loss under a no intervention scenario we have to make one important assumption. We know that climate change will exacerbate these changes, but we do not know at which magnitude and we also ignore if other drivers of coastal erosion will occur in the future at the same level of the period 1954-1999.

Not considering these two possible problems we can assume that the coastal erosion will remain constant at the rate of 0,65 m/y occurred during the period 1954 to 1999.

The figure below shows the expected area loss in a no intervention scenario.

Figure 4 Expected land area loss in a no intervention scenario at rate of coastal erosion of 1954-1999.

The next assumption that we have to make is about the impact of the seawall on the coastal erosion. To simplify this exercise we will consider that the seawall reduces to 0 the rate of coastal erosion, as it is assumed also by other relevant papers about incorporation of cost benefit analysis into the implementation of shoreline management measures. (European Commission, 2004).

Once that we have the area of the land loss avoided that is equal to 520 m^2 a year (0,65m*800m length of the sea wall) we have to estimate the value of it.

The value is deducted averaging the selling prices of lands over the period 1999-2000 and it amounts to USD$56. (Fairbairn-Dunlop, 2000) Then the price is adjusted to the official inflation rates of Samoa for the period 2000-2012 and after this period is adjusted per an inflation rate that is assumed to be 5,7 % that correspond to the average of the rates over the period 2000-2012. After this calculation the annual benefits are discounted to give the NPV of them.

The formula for calculating the net present value of the project is given by Present Value = Future Value/[(1+r)^t]

Where r is the discount rate and t is the time period for future value.

In this case a discount rate of 8% is used (as recommended by the Ministry of Finance) and from project document we expect a 25 years life span.

The NPV value of the benefits amounts to UDS$ 655,854.

In the calculation of the benefits we should include also the infrastructures that will not be forced to relocate thanks to the protecting effect of the seawall. The traditional and more reliable method to count the assets that lie in the coastal erosion area is a survey, but due to time constraint we decided to count the assets using the satellite maps of 2010. Based on a basic observation of the maps the number of houses that lie on the coastal erosion area is 6. Using the approach adopted in the cost benefit analysis of the flooding risk abatement measures of the Vasigano area (Woodruff, 2008) we can assume that the value of houses in Samoa is comprised between WST 25,000 and WST 40,000 depending on the material construction. Therefore we assume that the average cost of a family house of less than 150 square meters is WST 32,500.

Since we do not know when the relocation will occur, we distribute the benefits of the avoided house reconstruction homogeneously during the 25 years of the project.

After converting the benefits in USD$ and discounting them using the 8% rate we obtain a NPV of USD$ 42,741.

The total NPV value of the benefits amounts to USD$ 698,596.

5.Results

Net Present Value and Benefit:Cost Ratio

Cost-benefit analysis aggregates the monetary valuations of the gains (benefits) and losses (costs) over time. This can be expressed as an absolute number - known as the Net Present Value (NPV) - or as a ratio of (present value) benefits to (present value) of costs. A positive Net Present Value or a B:C ratio that exceeds 1 indicates the project is expected to generate a net benefit for society.

This is the decision criteria adopted in this study. If the project option shows a positive NPV or B:C ratio greater than 1, then the project is considered worthwhile (and vice versa) and should considered for replication. B:C ratios are useful for comparing and prioritising project options of different size/scale when there are budget constraints.

Aggregating the costs and the benefits we obtain a positive NPV of USD$ 388,400and a positive benefit/cost ratio of 2.25.

Sensitivity Analysis

As outlined in the report, there are significant information gaps and uncertainties about the future - which has required the use of assumptions. This section tests how sensitive the results are to changes in some of the key assumptions. This is done in order to assess the robustness of the results and hence the confidence we can place in them for informing decision-making.

The assumptions tested are those 'weak' assumptions outlined above in body of the report. These are:

1) *Value of land:* the price of land has been deducted looking at the average sale prices over 1999-2000 . The selling prices mainly refer to the sales in the Apia area because unfortunately there are not records of the Tafitoala area. The village is located 46 km far from the capital and it is characterized by an economy based on agriculture and fishing, so presumably the value of land would be lower than the capital district.
We created 2 different scenarios where the value of land is 25% (scenario 1) and 50% (scenario 2) lower than the first scenario. The new B/C ratios are respectively 1,38 and 0,90.

2) *Rate of coastal erosion:* as we anticipated before, future coastal erosion plays an important role in determining the cost/benefit ratio and there is a high uncertainty around this measure. We based our analysis on the measurement of coastal erosion during the period 1954-1999. Since it appears to be a really high value we decided to do a sensitivity analysis that underestimates it.
Looking at a report on the economics of sea walls in California (King., 2010) we can see how coastal erosion is expected to have a rate of 0,27m/y on lowlands region of Carpinteria State Beach. Assuming that this measure will be the same in Tafitoala we obtain a B/C ratio of 1,06. (scenario 3)
Assuming that the rate of coastal erosion would be much lower: 0,1 m/y we obtain a B/C ratio of 0,5. (scenario 4)

In the section measurements we have already anticipated that the drivers of the coastal erosion in Tafitoala can be different. Sand mining, deforestation of mangrove forests, natural cycles of coast shape and impacts of climate change can concur simultaneously to the increase of coastal erosion.

6.Findings and recommendations

As we stated widely in the report the results of this study should not be taken as certain. The final B/C ratios are based on a high number of assumptions that can bias enormously the conclusive results.

Drawing the conclusions we can see how in the Scenario 0, that is characterized by a rate of coastal erosion of 0,65 m/y and an average value of land USD$ 57 we have a positive B/C ratio of 2,25. These results means that under our assumptions and measurements the Tafitoala demonstration project can be considered successful because it repays the initial investment and has positive benefits that account for USD$ 388,444.

Thanks to the sensitivity analysis we can see how changing these measures, (that in my personal view are highly overestimated) we see a more equilibrate scenario with 2 positive B/C ratios (1,38 scenario 1 and 1,06 scenario 3) and 2 negative cost benefit ratios (0,9 scenario 2 and 0,50 scenario 4)

We have also to note that these measures do not include the list of costs and benefits that we decided not to quantify. This is a very complex and delicate issues because environmental, intangible and aesthetic values are really difficult to quantify. The main reason that drove us to decide not include them is that we had time and budget constraint, but we also have to remark that including them could have increased, instead of decrease, the uncertainty. The tools that are used to quantify these kinds of costs and benefits are subject to numerous biases and economists do not agree on their reliability.

Below you can find some considerations about the values that are no quantitatively measured.

Costs	Considerations
Loss of tourism due to the loss of natural ecosystem	Tourism sector in Tafitoala is not well developed. This cost exists, but it should not highly bias the final output.
Noise pollution due to the construction of the sea wall	This cost is present, but it should not bias the results because it occurred only in the construction phase.
Alteration of the sea ecosystem with consequent alteration of fishery activity	This cost is likely to bias the results because coral reef is a sensitive ecosystem and population of Tafitoala relies on fishery.
Alteration of long-shore drift patterns, affecting neighbouring villages	This cost is likely to bias the results and the distribution of costs among different stakeholders. More studies are required to analyse this side effect

Benefits	Considerations
Decreased damages to infrastructures and cleaning up costs caused by cyclones and extreme sea surges.	These benefits are likely to bias the results of the report because a lot of the Tafitoala infrastructures are located close to the sea shore and they are highly vulnerable to these physical threats.
Reduced loss of income and revenue and cleaning up damages	These benefits are likely to occur, but they should not bias largely the final output because they are minimal compared with other variables.

Another issue that we should raise is that the measurement techniques of non monetary costs and benefits can be really expensive and policy makers should always decide if the use of them is suitable for the size of the project. We recommend their use in large scale programmes because not always their application is costly effective.

From the previous list we can infer that a large amount of benefits and costs are not captured by this report. One recommendation that emerge is that in the next studies analysts should focus their attention in identifying and, when it is possible, in quantifying these variables. This is easier if cost benefit analysis are planned before the implementation of the project. A planned approach gives the possibility to organize a baseline assessment that can be later on compared to the post implementation baseline.

One of the objectives of the report is to assess the possible replication and up-scaling of sea walls. We suggest to make further studies to better understand the causes, drivers and their magnitudes before we can confidently recommend the implementation of sea walls. Since the coastal erosion rate is one of the most influential variable in the economics of sea wall, a better understanding of this phenomenon will allow future policy makers to have a clearer idea of the benefits of these kind of adaptation interventions.

Moreover, identifying the main drivers of coastal erosion is one of the major issue that has to be solved also because different cause of the problem would require different actions. (e.g. if sand-mining is found to be a major contributor/driver then possibly, some form of sustainable management would be more appropriate).

Implementing a seawall to protect coasts from erosion when the main cause of the phenomenon is sand mining would be a clear case of maladaptation. This is particularly negative for the implementation of seawall because it will not mean just an ineffective allocation of adaptation funds, but will also mean some additional costs to the village. (Alteration of the sea ecosystem**,** Alteration of long-shore drift patterns.)

Moreover we should remember that especially for coastal management, the characteristics of the site may vary drastically and require different kind of intervention. We suggest to make feasibility studies or ex ante cost benefit analysis to identify the best intervention option in each site.

One of the unexplored issues that future policy makers should consider is the effects of the seawall on the long shore drift patterns. Decreasing the coastal erosion could mean increase the same phenomenon in contiguous areas. Therefore the B/C ratio could be positive for a specific area, but could be negative analysing the project from a wider prospective.

We can conclude that cost benefit analysis for the implementation of sea walls still require further studies to become a reliable tool for decision making. Even if in 3 scenarios out of 5 the CBA suggests that the benefits will be greater than the costs we cannot state that this project will be successful.

Therefore we suggest a cautious implementation of sea walls because they can result in maladaptation strategies.

Until science and economics will not give us more certain answers we recommend to prefer the implementation of *no regret* (Smith, 2012) adaptation strategies that will bring benefits even if coastal erosion or climate change will not occur in the way we expect.

A better urbanization planning and environment management coupled with mainstreaming and adaptation capacity building can be considered reasonable options to manage the uncertainty related to complex physical phenomenon such as coastal erosion. In fact these strategies will produce benefits in any future scenario.

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