Annex 3: Economic and Financial Analysis

Project/Programme Title: Blue Action Fund (BAF) - GCF Ecosystem Based Adaptation Programme

1. Sample CBA - Analysis : Samoa Case

Source: ECA - Economics of Climate Adaptation - Shaping Climate Resilient Development, 2009.

Basic information:

Samoa suffers from tropical cyclones and coastal flooding, also caused by sea level rise

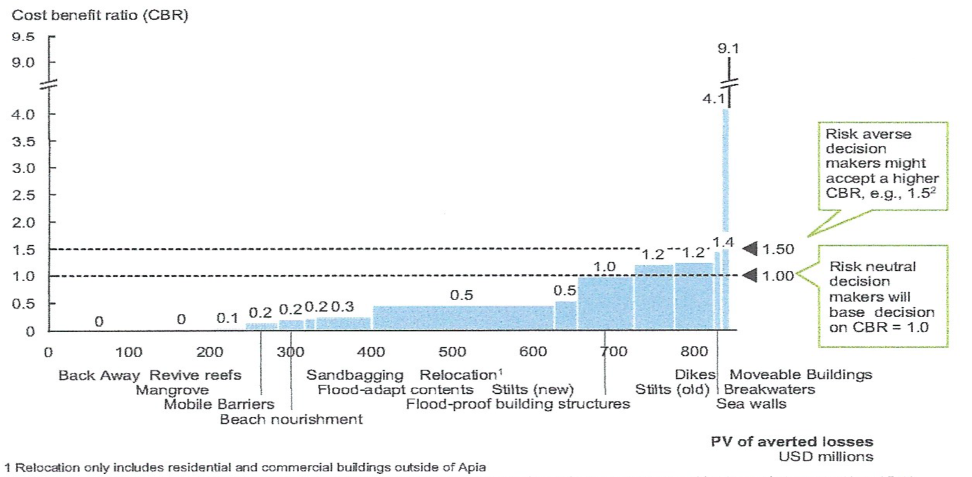
The potential impact of climate change is expected to increase coastal flooding events in severity, driven by sea level rise.

A number of adaptation measures could be put in place to minimize the risk of damage and increase resilience to climate threats. The test case developed and evaluated a comprehensive list of measures, which include infrastructure measures, technological measures, behavorial measures and ecosystem based adaptation measures, such as mangrove or reefs restoration.

Measures were analyzed in terms of costs and benefits. The resulting cost curve is shown in the graphic below:

04

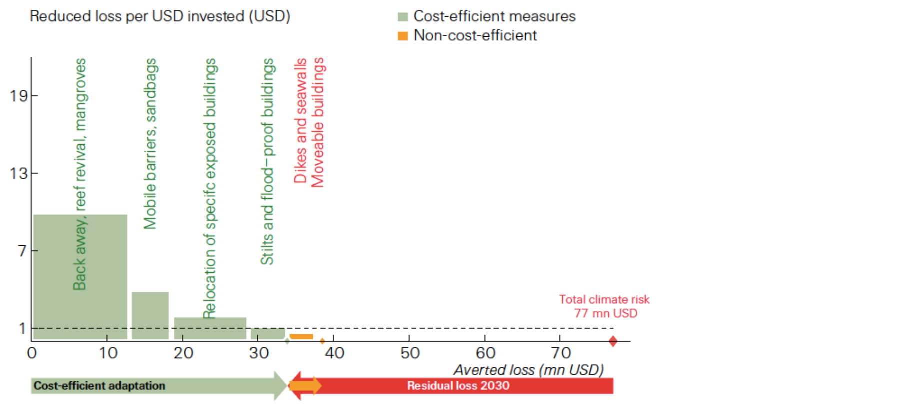
The overall cost-benefit assessment shows a variety of options to reduce coastal flooding annual expected loss



1 Relocation only includes residential and commercial buildings outside of Apia

2 For example, a cost benefit ratio of ~1.5 is implicitly accepted by customers purchasing an insurance contract with a loss ratio between 60 and 70%

SOURCE: ECA analysis



Source: Climate Change Uncertainty and Risk: from Probabilistic Forecasts to Economics of Climate Change Adaptation; ETH Zürich

Results:

1. As demonstrated by the graphic above, the cost-benefit ratio of mangroves and of reef revival is much lower than that of infrastructure measures.

2. Cost benefit ratio of mangroves planting is below 0.1, of reefs revival is 0.1., compared to sea-walls or breakwaters with 1.9 and respectively 5.7

3. Back away (restricting new building to a 4-m elevation), reef revival and planting a protective mangroves buffer are the most cost-efficient measures identified

Annex 3: Economic and Financial Analysis

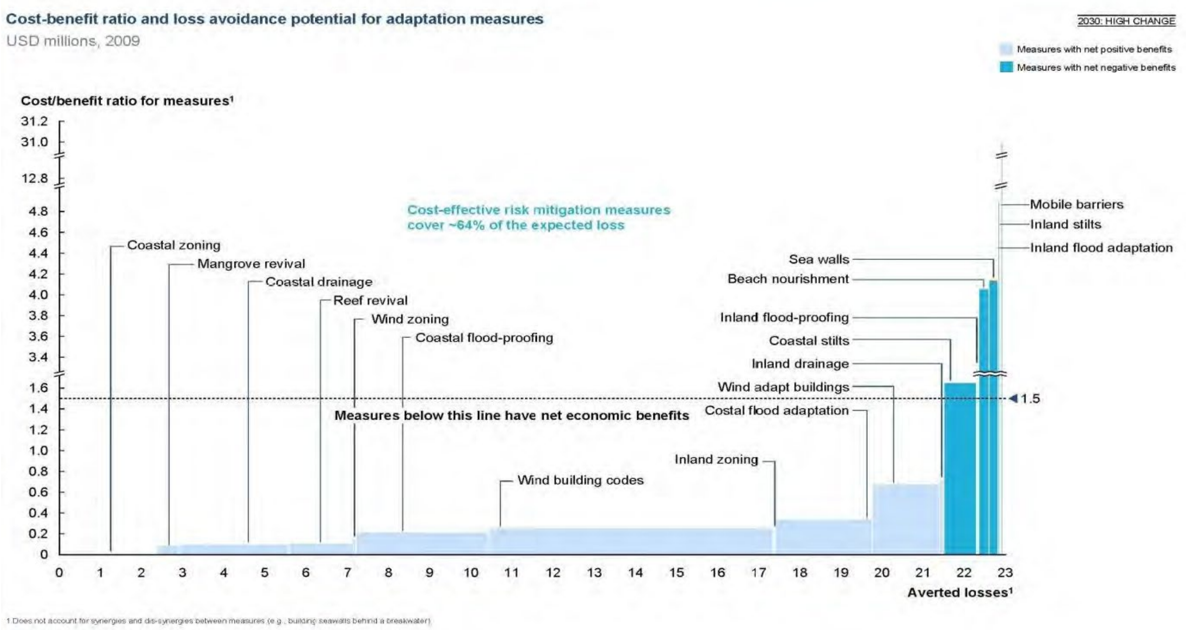
Project/Programme Title: Blue Action Fund (BAF) - GCF Ecosystem Based Adaptation Programme

2. Sample CBA - Analysis : Antigua and Barbuda Case

Source: CCRIF, The Caribean Catastrophe Risk Insurance Facility, Enhancing the climate risk and adaptation fact base for the Caribbean, preliminary results of the ECA Study, Cayman Islands, 2010.

Basic information:

The Caribbean islands suffers from hurricane-induced wind damage, coastal flooding and storm surge and inland flooding
The potential impact of climate change is expected to increase coastal flooding events in severity, driven by sea level rise.
A number of adaptation measures could be put in place to minimize the risk of damage and increase resilience to climate threats. The test case developed and evaluated a comprehensive list of measures, which include infrastructure measures, technological measures, behavorial measures and ecosystem based adaptation measures, such as mangrove or reefs restoration.
Measures were analyzed in terms of costs and benefits. The resulting cost curve is shown in the graphic below:



Results:

1. As demonstrated by the graphic above, the cost-benefit ratio of mangroves and of reef revival is much lower than that of infrastructure measures.

2. Cost benefit ratio of mangroves planting is below 0.1, of reefs revival is 0.1., compared to coastal stilts or sea-walls which are fare above a CBR of 1.5 (considered as the upper lin

3. Coastal zoning, mangrove revival, coastal drainage and reef reviva are the most cost-efficient measures identified.

Annex 3: Economic and Financial Analysis

Project/Programme Title: Blue Action Fund (BAF) - GCF Ecosystem Based Adaptation Programme

3. Case study: Ecosystem Services Valuation of Mangrove Forests in the Zambezi Delta - Mozambique (baseline scenario for 2013-2015)

Total area of mangroves (ha 37,034
Total population: 188.206

Observation: The case study is a representative case regarding the proposed EbA measures in the BAF-Programme, as it covers the Programme region and activities very similar to those which potentially will be financed.

A WWF study estimates the value of ecosystem services provided by mangroves in Zambezi Delta . The main mangrove uses identified for the Zambezi Delta were for direct use: timber, poles, fuelwood and charcoal, and for indirect use: habitat and nursery, which comprises breeding, spawning and nursery habitat for commercial fish species, regulating capacity, which was essentially erosion control and storm buffering, carbon sequestration, and cultural services. See the economic and ecological value in the table below:

Provisioning of goods - Direct use of mangroves					Ecological value - Indirect use of mangroves			
Product	Harvesting Rate trees / ha / yr	Yield US$ / ha / yr	Economic value / yr US$ / yr	Income / cap / yr US$	Category	Production rate kg / ha / yr	Yield US$ / ha / yr	Yield whole Delta million US$ / yr
Charcoal 1)	156	1,200	**44,440,800**	236	Regulating (coastal protection) 3)		20,000	740,680
Poles 2)	312	1,040	**38,515,360**	205	Habitat and Nursery	209	600	22,220
					Climate regulation (carbon sequestration)	463,000	6,000	222,204
					Maritime transport (passengers and goods) 5)			264,000

The cost of restoration of mangroves shows a high variety. However, median total restoration costs for mangroves are estimated at ~ 3,000 USD/ha (2010). The most cost-effective project is planting of seeds, seedlings or propagules. Costs for this type of restoration are estimated at around 800 USD/ha in a developing country. The low cost of mangrove restoration is mostly related to projects involving communities and volunteers. A high availability of mangrove seeds, seedlings and propagules and the accessibility of mangrove restoration sites also contribute to lower costs.

Results:

If compared to the income from the direct use of mangroves only, the break-even for mangrove reforestation can be reached within the first year (in the conditions of the WIO)
Considering the indirect use of mangroves and their ecological (macroeconomic) value, the investment is highly beneficiary.

1) commercial size of a mangrove tree of 7.5 m height, 2.5 m perimeter, forest density of 1800/ha; charcoal efficiency of 20 bags/13 trees; sustainable harvesting of 13 trees/ ha/month: US$ 100/ha/month and US$ 1,200/ ha/ yr.
Income from charcoal / cap /yr is equivalent to the average GDP per capita in Mozambique
2) sustainable harvest at a rate of 26 trees/month; earning of US$ 86 / ha/month, eq. To US$ 1,040 / ha/ year
1) and 2) are alternatives for income generation
3) Considering a strip of mangrove of 1,500 m long and 500m wide (750,000 sqm) necessary for prevention of the village Chinde from erosion in the Delta, the value of protection was calculated with US$ 2.00/sqm, or about US$ 20,000 per ha(yr.
(The calculation is based on existing infrastructure assets of US$ 1,5 million for harbor and maritime administration building; warehouse, brickhouse, typical pole and cement houses) .
4) Assuming a market price of carbon of US$13 / tCO2. Hence, the carbon sequestered by the mangroves in the Zambezi Delta is worth US$6,000/ha/yr; for the total mangrove area in the Delta the total income would be 223 million US$ per yr.
5) Gross income from passengers transport: US$ 64.000/ yr and from transport of goods: US$ 200,000/ yr.

Source: WWF. 2017. Ecosystem Services Valuation of Mangrove Forests in the Zambezi delta. Mozambique. 106pp.

Annex 3 Economic and Financial Analysis

Project/Programme Title: Blue Action Fund (BAF) - GCF Ecosystem Based Adaptation Programme

Case Study 4: Consideration on Cost and Benefits for EbA - Coral Reef restoration

Coral Reefs	Range	
Value for coast protection (USD/ha/year) in Sri Lanka:	12300	42000
Value for coast protection (USD/ha/year) in Indonesia:	90	110000
	Average values	
Assumption for an average value for coast protection (USD/ha):		**40,000**
Restoration Cost (USD/ha) in Tanzania (low cost scenario)		13,000
Estimated break-even for coral reef restoration:		**3 years**

Explanations and further information on data: Coral reefs provide a valuable coastal protection function. The value can be estimated based on the damages that would be incurred through erosion and flooding if the protection function was lost. Due to the differences in infrastructure and land prices, the value differs significantly between countries and locations. In Sri Lanka, the value attached to reefs in performing the coast protection function is argued to be between 12,300 USD and 42,000 USD/ha/year based on the preventative expenditure approach. In Indonesia, coastal protection has been estimated to be in the order of 90 USD/ha/year for remotely populated areas and 110,000 USD/ha/year for areas with major infrastructure. Potential coral restoration costs also vary enormously. A study in Tanzania is one attempt to assess the feasibility of low-tech methods. The estimated costs (13,000 USD/ha) are based on a hypothetical full-scale rehabilitation effort. In order to keep costs down, the project was developed involving local fishers as the main labour force.
Regarding effectiveness, coral reefs can deliver wave attenuation benefits similar to or even greater than artificial structures designed for coastal defence. Restoring reefs is analyzed as being significantly cheaper than building artificial breakwaters in tropical environments. These findings are consistent with analyses from the re-insurance industry on the economics of climate adaptation (Swiss Re for the Caribbean region), which examined costs and benefits of 20 approaches to coastal risk reduction and adaptation: reef restoration was always substantially more cost effective than breakwaters when considering only coastal defence benefits. Moreover, reef restoration was one of the most cost effective of all approaches in seven of eight nations studied. In addition, coral reefs have high income and recreational benefits from fisheries and tourism activity. Studies worldwide on restoration cost and benefits arrive at varying results.[2]

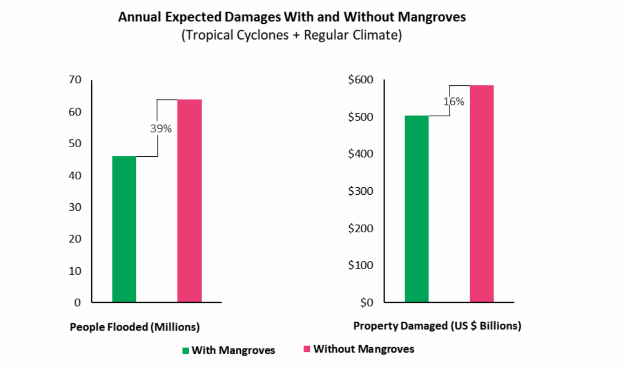
[1]Green E.P / Short F. World Atlas of Seagrasses. UIMEP World Conservation Monitoring Centre. University of California Press, Berkeley.
[2] Bayraktarov et al., 2016.

Annex 3 / Appendix 1: Mangrove Risk Reduction Benefits

Project/Programme Title: Blue Action Fund (BAF) - GCF Ecosystem Based Adaptation Programme

Global Flood Reduction Benefits of Mangroves in terms of additional people and property that would be flooded and damaged if mangroves were lost.
Source: Beck, M.W. et al; 2018; The global value of mangroves for risk reduction and adaptation

Graphic 1:



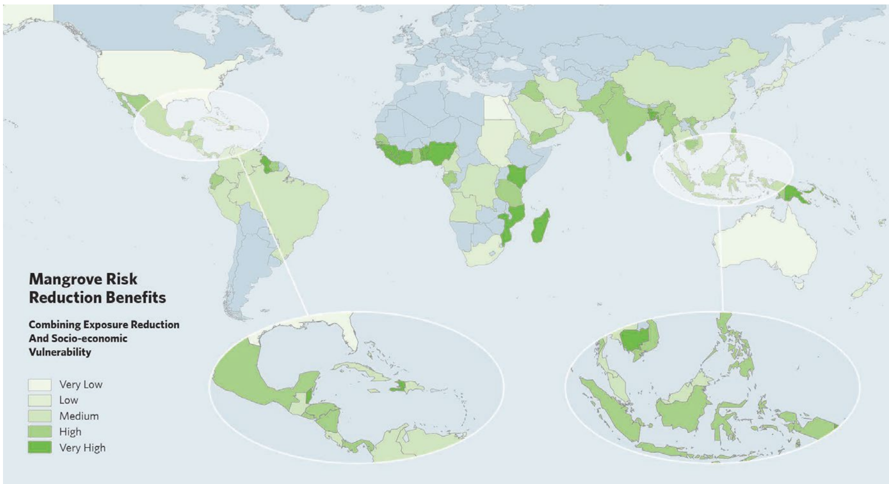
Mangroves reduce annual flooding to people globally by more than 39%, providing benefits to more than 18 million people every year.
Mangroves reduce annual property damages by more than 16%, with an annual value of more than US$ 82 billion

Examinating the spatial distribution of where mangroves provide the greatest annual expected benefits to people and property, the hotspots of benefits around the world can be identified. The map combines data on socio-economic vulnerability from the WorldRiskIndex (Bündnis Entwicklung Hilft 2017) with property flood reduction benefits from mangroves to rank the countries that likely receive the greatest risk reduction benefits from mangroves. Higher scores (in darker green) indicate likely greater overall risk reduction benefits from mangroves. Countries in gray do not have mangroves and are excluded from the analysis.

Results:

For all coastal nations that receive benefits from mangroves, the study combines estimates of flood exposure reduction with the vulnerability scores of the WorldRisk-Index to produce a ranking of countries that are estimated to receive the greatest overall risk reduction benefits from mangroves.
The countries estimated to receive the greatest risk reduction benefits from mangroves are Guinea, **Mozambique,** Guinea-Bissau, Sierra Leone and **Madagascar**.

Map: Mangrove Risk Reduction Benefits



Countries Receiving the Greatest Risk Reduction Benefits from Mangroves	
Vulnerability (WorldRiskIndex)	Overall Risk Benefits
Haiti	Guinea
Liberia	Mozambique
Sierra Leone	Guinea-Bissau
Mozambique	Sierra Leone
Guinea	Madagascar
Madagascar	Benin
Guinea-Bissau	Guyana
Nigeria	Solomon Islands
Comoros	Liberia
Togo	Cote d'Ivoire

Table 1:
The table combines information on vulnerability from the WorldRiskIndex with the flood exposure reduction data to estimate the countries that receive the greatest overall risk reduction benefits from mangroves. The countries in the vulnerability column are the top 10 most vulnerable countries from the WorldRiskIndex that have mangroves.