MOZAMBIQUE

UPSCALING NATURE-BASED FLOOD PROTECTION IN MOZAMBIQUE'S CITIES

Cost-Benefit Analyses for Potential Nature-Based Solutions in Nacala and Quelimane

January 2020

NBS Nature Based Solutions

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Building Disaster Resilience in Sub-Saharan Africa

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ABREVIATIONS

CBA	Cost Benefit Analysis
CEADIR	Climate Economic Analysis Development, Investment, and Resilience
CES	Consulting Engineers Salzgitter GmbH
EIRR	Economic Internal Rate of Return
FIRR	Financial Internal Rate of Return
Ha	Hectares
IL SE	Inros Lackner SE
MZN	Mozambican metical
USAID	U.S Agency for International Development
W&H	Wagener & Herbst Management Consultants GmbH

EXECUTIVE SUMMARY

The Consultant conducted a cost-benefit analysis (CBA) with financial support from the World Bank. The CBA will comprise the data and adopt the methodology in the evaluations of the CEADIR activity prepared for USAID. [1] This has allowed the CBA to consider ecosystem services such as carbon sequestration and storage estimations, natural hazards and agricultural production. In addition to further externalities such as climate change impacts over time. (Narayan, Foley, Haskell, Cooley, & Hyman, 2017)

The purpose of this analysis was to provide technical assistance to the Government of Mozambique to enhance and upscale the implementation of nature-based solutions for urban flood risk management in Nacala.

Flooding and erosion is significantly accelerating in the city which is exacerbated by tropical cyclones. A need for flood risk management and support is apparent. Nacala city is experiencing drainage and significant erosion problems as storm water runoff has washed out several gullies and stresses both natural and man-made channels.

Flooding is significantly accelerating in Quelimane which are exacerbated by tropical cyclones. A need for flood risk management and support is apparent. Quelimane city is experiencing accelerated peri-urban growth and mangrove degradation which disrupt natural protection from flooding.

This study estimated the costs and benefits of revegetation of land in the less densely populated areas and a combined measures approach for inner city areas which included retention ponds, improved drainage system, toe protection of gullies and small scale revegetation in Nacala city. The consultancy service for Nacala city focuses on nature-based flood protection measures, across 13 previously described catchment areas to reduce erosion of gullies and protect the residents. The analysis used CES data on the economic and environmental costs and benefits of revegetation of land and the combined measures and evaluated it against the cost and benefits of no-project scenario.

This study also estimated the costs and benefits of vegetation of land and a combined measure which includes construction of retention ponds, drainage channels, rehabilitation of existing drainage channels, outlets and flap gates, green revetment, dike with green revetment, constructions of protection of bridge abutment and a certain area allocated for the protection and re-growing of mangroves, in Quelimane city. The consultancy service for Quelimane city focuses on nature-based and hybrid based flood protection measures, across 11 catchment areas to reduce flooding risks and protect the residents. The analysis used IL data on the economic and environmental costs and benefits of vegetation of land and the combined measures and evaluated it against the cost and benefits of no-project scenario.

W&H conducted the CBA in a Microsoft Excel file that serves as a companion to this report. This file allows users to adjust the assumptions in the analysis and examine additional scenarios.

[1] Tulika Narayan, Lindsay Foley, Jacqueline Haskell, David Cooley, and Eric Hyman. 2017. Cost-Benefit Analysis of Mangrove Restoration for Coastal Protection and an Earthen Dike Alternative in Mozambique. Washington, DC: Climate Economic Analysis Development, Investment, and Resilience (CEADIR) Activity, Crown Agents USA and Abt Associates. Prepared for the U.S. Agency for International Development (USAID).

SCOPE

NACALA

The CBA quantified the potential costs and benefits of revegetation of land and a combined measure alternative which included retention ponds, improved drainage system, toe protection of gullies and small scale revegetation in Nacala in monetary terms to help determine whether one adaptation option would be preferable in the study areas.

The study area for this analysis included 13 catchment areas across Nacala city. The study area encompasses 18,519 hectares (ha) of land that was designated as prioritized protection areas. That of which 1,296 ha are allocated for the application of solution measures including 1,221 ha selected for potential revegetation of land (of which 20% will be regarded for urban gardening) and 75 ha allocated for the combined measures approach.

The solution measures will be built across 11 catchment areas and in each area, a certain percentage of land area was allocated for the solution measures. The study area included 5,401 households potentially affected and a total of 27,005 of affected population. (CES, 2018)

The following table summarizes the total land area size in each catchment area and the corresponding allocated land for the nature-based solutions aforementioned: (CES, 2018)

Table 1-1: Total Land Area in Hectares Allocated for Solution Measures in Catchment Areas

Catchment Area	Total land area [ha]	Land area allocated for revegetation of land [ha]	% share of land area allocated for revegetation of land [ha]	Land area allocated for combined measures [ha]	% share of land area allocated for revegetation of land [ha]
Area 1	929	650	70% of total land area		0% of total land area
Area 2	75	53	70% of total land area		0% of total land area
Area 3	108	76	70% of total land area		0% of total land area
Area 4	175	123	70% of total land area		0% of total land area
Area 5	351	246	70% of total land area		0% of total land area
Area 6	164	8	5% of total land area	8	5% of total land area
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Area 9	533	27	5% of total land area	27	5% of total land area
Area 10	154	8	5% of total land area	8	5% of total land area
Area 11	301	15	5% of total land area	15	5% of total land area
Area 12	5,257	-		-	
Area 13	10,121				
Total	**18,519**	**1,222**		**75**	

A revegetation of land project includes planting a range of tree and shrub species that will provide a filter strip between the residential areas and the watercourse. In addition, it will allow for urban gardening and agricultural production for the surrounding community. These plants include vetiver grass, elephant grass and Moringa trees. CES have also regarded that 20% the revegetated land will be dedicated for urban gardening and the consultant will consider this in the calculations when measuring the benefits of revegetating the land. (CES, 2018)

The combined measures include; a toe of slope protection measuring a total of 45,171 meters in length, in addition to rehabilitation of drainage system for 27,118 meters in length, as well as 99 retention ponds. (CES, 2018)

Potential damages in the catchment areas were defined by the expected storm to hit Mozambique, and two types of storms were regarded; current 2019 rainfall and future heavy rainfall expected in 2036. (CES, 2018)

For each scenario, the consultant estimated costs and benefits using primary data from field studies and benefit-transfer methods, and secondary data from a literature review.

QUELIMANE

The CBA quantified the potential costs and benefits of vegetation of land and a combined measure which included; the construction of retention ponds, drainage channels, shore protection and green revetment against the alternative do nothing scenario.

The study area for this analysis included 11 catchment areas across Quelimane city. The study area encompasses around 1,686 ha of land that the city has designated as a protected area. That of which 175 ha are allocated for the application of solution measures including 96 ha selected for potential planting and 80 ha allocated construction measures. (IL Survey, 2019)

The solution measures will be built across the 11 catchment areas and in each area, a certain percentage of land area was allocated for the solution measures. The study area included 138,190 households potentially affected and a total of 63,375 of affected population. (IL Survey, 2019)

The following table summarizes the total land area size in each catchment area and the corresponding allocated land for the solutions aforementioned: (IL Survey, 2019)

Table 1-2: Total Land Area in Hectares Allocated for Solution Measures in Catchment Areas

Location	Total area of catchment sites [ha]	Area used for Grass community [ha]	Area used for Wetland plant mix [ha]	Area used for Mangroves [ha]	Area used for Construction Measures [ha]	Total area used for solution measures [ha]
Whole area of Quelimane	**3,009**					
Site 1	214	11	11	0	11	32
Site 2	34	0	0	0	2	2
Site 3&4	509	8	5	0	25	38
Site 5	158	3	0	13	8	24
Site 6	64	3	0	13	6	22
Site 7	29	1	0	0	1	3
Site 8	288	0	0	7	14	22
Site 9	293	0	15	0	7	22
Site 10	50	1	0	0	2	4
Site 12	47	2	2	0	2	7
Sum (Sites 1 to 12)	**1,686**	**30**	**33**	**33**	**80**	**175**

The vegetated land includes a range of grass and mangroves species that will act as a filter strip between the residential areas and the excess water along the watercourse. These plants include 12 different species: (IL Survey, 2019)

1. Vetiver grass
2. Elephant grass
3. Buffalo grass
4. LM grass
5. Common Crowfoot
6. Basket grass
7. Miniature Papyrus
8. Papyrus
9. Common Reed
10. Red grass
11. Alkali Bulrush
12. Mangroves

The combined measures include; the construction of 5 retention ponds, 11,619 m of drainage channels, rehabilitation of existing 14,260 m of drainage channels, 9 outlets and flap gates, 3,149 m of green revetment,

a total of 3,720 m of dike with green revetment, 6 constructions of protection of bridge abutment and 1053227 m² allocated for the protection and re-growing of mangroves. (IL Survey, 2019)

Potential damages in the catchment areas were defined by the expected storm to hit Mozambique, and two types of storms were regarded; medium storm event and heavy storm events. For each scenario, W&H estimated costs and benefits using primary data from field studies and secondary data from a literature review.

ASSUMPTIONS

NACALA

The key assumptions for CBA of Nacala City follow:

- **With-project scenarios:** The "with project scenario" includes three components, including: (1) Revegetation of unused land project spanning across 1,221 ha of unused land in all catchment areas (2) 20% of the 1,221 ha used for revegetated land will be used for urban gardening (3) A combined measures solution across 75 ha including a toe of slope protection measures of a total of 45,171 m in length, in addition to rehabilitation of drainage system for 27,118 m in length, as well as, 99 retention ponds.
- **Time period:** 50 years
- **Discount rate:** The base case use 6 percent for economic analyses. Sensitivity analyses used discount rates of 0 percent, 3 percent, and 12 percent. The 6- percent discount rate was used in the sensitivity analysis of other parameters
- **Price of Carbon:** Carbon prices used in the sensitivity analysis of CEADIR CBA were used. CEADIR took into consideration carbon prices in the U.S. Regional Greenhouse Gas Initiative (RGGI) and California Air Resources Board cap-and-trade markets as well as the voluntary carbon offset market. As a result, four carbon prices—$0, $8, $15, and $25 per metric ton of carbon dioxide equivalent (tCO2e) were used in the sensitivity analysis.
- **Costs:** The Consultant estimated the construction costs, enforcement and labour costs, transportation, maintenance costs as well as value of damaged homes for all proposed measures.
- **Benefits:** The Consultant estimated the benefits from erosion protection and revegetated ecosystems, including market values of agricultural produce and economic values of carbon sequestration. The combined measures also provide benefits from erosion protection.
    - Increased quality of life, reduction of mortality and human health impacts are significant benefits expected to be accrued from erosion protection resulting from both solutions. However, the consultant did not estimate these benefits due to a lack of data. The CBA should thus be interpreted as conservative.
- **Without-project scenario:** The base case assumed storm damage costs under a constant probability of storm events. This assumption would not be realistic if severe storm risks increase over time due to climate change. As a result, the benefits of both project alternatives may be underestimated.
- **Financial and Economic analysis:** The financial analysis reflected the perspective of communities in the study area. Most of the available cost data was in U.S. dollars (USD). The team converted local currency costs and benefits to USD at an exchange rate of 63.97 meticais per dollar (based on CES, April 24th, 2019). The economic analysis adjusted for value added tax of 17%, while the financial analysis excluded these adjustments.

QUELIMANE

The key assumptions for CBA of Quelimane City follow:

- **With-project scenarios:** The "with project scenario" includes two components, including: (1) Green revetment with a total area of 95 ha which includes (1a) 31 ha for grass communities such as Vetiver grass, elephant grass, LM grass and red grass (1b) 33 ha for wetland plant mix including multiple cyperus species, common reed and more[2] (2) A combined measures solution across 80 ha including construction of drainage systems, shore protections, retention basins and protection bridges.
- **Time period:** 31 years
- **Discount rate:** The base case use 6 percent for economic analyses. Sensitivity analyses used discount rates of 0 percent, 3 percent, and 12 percent. The 6- percent discount rate was used in the sensitivity analysis of other parameters
- **Price of Carbon:** Carbon prices used in the sensitivity analysis of CEADIR CBA were used. CEADIR took into consideration carbon prices in the U.S. Regional Greenhouse Gas Initiative (RGGI) and California Air Resources Board cap-and-trade markets as well as the voluntary carbon offset market. As a result, four carbon prices—$0, $8, $15, and $25 per metric ton of carbon dioxide equivalent (tCO2e) were used in the sensitivity analysis.
- **Socio-Economic Impact:** The results of the assessment of potential socio-economic impacts, on an annual basis, of risk events is given in previous chapters were used. The difference in risk impact values between the "without project" and the "with project" scenario results in the economic benefit accrued from adopting the solution measures. The risk values are calculated on an annual basis.
- **Costs:** The Consultant estimated the construction costs, enforcement and labour costs, transportation, maintenance costs as well as value of damaged homes for all proposed measures.
- **Benefits:** The Consultant estimated the benefits from erosion protection and revegetated ecosystems, including market values of agricultural produce, economic values of carbon sequestration and socio-economic benefits realized by reduction in risk levels subject to willingness for funding of mitigation measures. The combined measures also provide benefits from erosion protection.
    - Increased quality of life, reduction of mortality and human health impacts are significant benefits expected to be accrued from erosion protection resulting from both solutions. However, the consultant did not estimate these benefits due to a lack of data. The CBA should thus be interpreted as conservative.
- **Without-project scenario:** The base case assumed storm damage costs under a constant probability of storm events. This assumption would not be realistic if severe storm risks increase over time due to climate change. As a result, the benefits of both project alternatives may be underestimated.
- **Financial and Economic analysis:** The financial analysis reflected the perspective of communities in the study area. Most of the available cost data was in U.S. dollars (USD). The team converted local currency costs and benefits to USD at an exchange rate of 63.97 meticais per dollar (based on CES, April 24th, 2019). The economic analysis adjusted for value added tax of 17%, while the financial analysis excluded these adjustments.

[2] Refer back to proposed measures for Quelimane for details

KEY FINDINGS

This chapter will summarize and explain the key findings of the Cost-Benefit Analysis made for both cities Nacala and Quelimane. Key findings include economic net present values in both financial and economic terms in addition to financial and economic internal rates of return, taking into consideration the assumptions for each city study as mentioned previously.

NACALA

The economic net present values (NPV) of solution measures exceeded those of the financial NPV with a financial rate of return of 1.26% at a 6 % discount rate and an economic internal rate of return of 62.04% at 6% discount rate at carbon price 25 $/tCO2e.

Table 1-3: Annuity Values for Financial and Economic Assessments

Annuity Values - Financial	***NPV***	***FIRR***
0% discount rate	*$1,885*	1.26%
3% discount rate	*$1,211*	
6% discount rate	*$388*	
12% discount rate	*-$1,343*	
Annuity Values - Economic	***NPV***	***EIRR***
6% discount rate (Carbon Price #1)	*$836*	2.85%
6% discount rate (Carbon Price #2)	*$5,725*	19.67%
6% discount rate (Carbon Price #3)	*$10,002*	35.90%
6% discount rate (Carbon Price #4)	*$16,112*	62.04%

With a total area of 1,296 ha allocated for the solution measures, the total investment cost was calculated to equalling around $ 31 million; of which the following CAPEX were considered:

- Rehousing and resettlement costs with a total of around 11,582 $/ha
- Ecological restoration 157 $/ha and initial planting of 1,996 $/ha for revegetated land allocated to 1,221 ha
- Construction of toe protection gullies, retention ponds and the rehabilitation of the drainage system resulting in a total of 10,193 $/ha

The financial and economic benefits accumulated over the period of 50 years for the total number of hectares of the study area (1,296 ha) were calculated at a 6% discount rate. The following table summarize the results. Although results are sensitive to the carbon price assumption, the solution measures will still have a positive NPV at carbon price of zero.

Table 1-4: Financial and Economic Net Present Values of Solution Measures at a 6% Discount Rate

Total Value in USD for 1,296 hectares at 6 % discount rate	
Scenario:	***Solution measures***
Financial Net Benefits	$7,932,270
Financial Annualized Value	$503,262
$0 Carbon Price	
Economic Net Benefits	$17,087,108
Economic Annualized Value	$1,084,084
$8 Carbon Price	
Economic Net Benefits	$116,936,556
Economic Annualized Value	$7,418,961
$15 Carbon Price	
Economic Net Benefits	$204,304,823
Economic Annualized Value	$12,961,978
$25 Carbon Price	
Economic Net Benefits	$329,116,632
Economic Annualized Value	$20,880,574

The results show that both the economic benefits and the financial benefits have a positive result with the financial benefits reaching around$ 7.9 million and the economic benefits equalling around $ 17 million at $0 carbon price. The Consultant calculated the financial internal rate of return (FIRR) and it showed that with a discount rate of 1.26% can achieve breakeven

QUELIMANE

The economic net present values (NPV) of solution measures exceeded those of the financial NPV with a financial rate of return of 19.08% at a 6 % discount rate and an economic internal rate of return of 573.15% at 6% discount rate at carbon price #4; 25 $/tCO2e. In addition to the economic benefit accrued from carbon sequestration, the socio-economic benefits realized by reduction in risk levels subject to willingness for funding of mitigation measures estimates an EIRR of 22.48%.

Table 1-5: Annuity Values for Financial and Economic Assessments

Annuity Values - Financial	***NPV***	***FIRR***
0% discount rate	*$17,407*	19.08%
3% discount rate	*$15,584*	
6% discount rate	*$13,596*	
12% discount rate	*$9,409*	
Annuity Values - Economic	***NPV***	***EIRR***
6% discount rate (socio-economic benefit by reduced risk)	$35,075	52.64%
6% discount rate (Carbon Price #1)	$14,472	22.48%
6% discount rate (Carbon Price #2)	$52,610	81.11%
6% discount rate (Carbon Price #3)	$85,980	158.17%
6% discount rate (Carbon Price #4)	$133,652	573.15%

With a total area of 175 ha allocated for the solution measures, the total investment cost was calculated to equalling around $ 8.7 million; of which the following CAPEX per site were considered:

Site No.	Total Investment cost per SiteUS $	
Site 1	$	980,073
Site 2	$	750,000
Site 3&4	$	724,449
Site 5	$	47,235
Site 6	$	3,397,991
Site 7	$	1,156,829
Site 8	$	742,262
Site 9	$	51,000
Site 10	$	596,275
Site 12	$	230,652
various	$	71,300
Total	**$**	**8,748,066**

The financial and economic benefits accumulated over the period of 31 years for the total number of hectares of the study area (175 ha) were calculated at a 6% discount rate. The following table summarize the results. Although results are sensitive to the carbon price assumption, the solution measures will still have a positive NPV at carbon price of zero.

Table 1-6: Financial and Economic Net Present Values of Solution Measures at a 6% Discount Rate

Total Value in USD for 175 ha at 6% discount rate	
Scenario:	***Solution measures***
Financial Net Benefits	$33,285,526
Financial Annualized Value	$2,389,644
Socio-economic benefit by reduced risk	$85,868,901
$0 Carbon Price	
Economic Net Benefits	$35,430,210
Economic Annualized Value	$2,543,615
$8 Carbon Price	
Economic Net Benefits	$128,795,971
Economic Annualized Value	$9,246,551
$15 Carbon Price	
Economic Net Benefits	$210,491,011
Economic Annualized Value	$15,111,619
$25 Carbon Price	
Economic Net Benefits	$327,198,212
Economic Annualized Value	$23,490,288

The results show that both the economic benefits and the financial benefits have a positive result with the financial benefits reaching around$ 33 million and the socio-economic benefits by risk reduction equalling around $ 85 million, in addition to carbon sequestrated economic benefit reaching $35 million at $0 carbon price. The Consultant calculated the financial internal rate of return (FIRR), as previously calculated, and it showed that with a discount rate of 19.08% can achieve breakeven.

1 INTRODUCTION

The Mozambican coast has seen intense cyclones, rise in sea levels and substantial heavy rainfalls which are all threatening the livelihood and health of its communities and limiting their economic developments. One example is Quelimane, the administrative capital of the Zambezi Province, which has faced increasing sea level rise, cyclones, flooding and erosion, making it highly vulnerable to climate change. (World Bank, 2011). Another example is Nacala, a coastal city located in Nampula Province. As aforementioned, Nacala city is experiencing drainage and significant erosion problems as storm water runoff has washed out streets and overflowed both natural and man-made channels. Both cities contain coastal seaports and have areas prone to flooding, especially in the rainy season.

In Nacala, the poor state of the gullies and their inability to withstand the ever increasing rainfall due to climate changes have resulted in substantial erosions across multiple areas in the city, directly affecting and putting the houses and communities living closer to the gullies at risk. (CES Survey,2018)

The city of Quelimane is located 25 km from the mouth of the Rio Dos Bons Sinais; therefore the city itself and surrounding areas are vulnerable to climate change impacts and seasonal flooding, especially in the rainy season from October to February. Quelimane is highly prone to cyclones, flooding and erosion , moreover, the city has experienced an influx of people from rural areas as a result of Mozambique's Civil Ware 1977-1992, resulting in informal settlements in flood-prone parts of the municipality, increased mangrove deforestation and declining of agricultural productivity.

In 2018, the World Bank requested for a Cost Benefit Analysis of nature-based flood protection solutions proposed for Quelimane and Nacala. The purpose of this analysis was to provide technical assistance to the Government of Mozambique to enhance and upscale the implementation of nature-based solutions for urban flood risk management in Nacala. The Consultant focused on 13 catchment areas in Nacala and on 11 catchment areas in Quelimane after consultations with the municipal governments.

The study for nature-based solutions to be implemented in Nacala estimated the potential costs and benefits of revegetation of land and a combined measure which included; retention ponds, improved drainage system and toe protection of gullies. The study area included 13 catchment areas focusing on the communities surrounding gullies, erosion channels and unused lands. The study encompassed a total of 1,221 ha of land allocated for revegetation (of which 244 ha is used for urban gardening) and 75 ha for the combined measures. The analysis used CES data on the data on the economic and environmental costs and benefits of revegetation and the combined measures.

This CBA is based on the initial assessment of the flood protection benefits of revegetation of land combined with retention ponds, toe protection of gullies and improved draining system as they took into consideration resettlement issues for the communities near flood prone areas as described in the "task 3" report. In general, a nature-based approach was elaborated. For this CBA, a no project scenario was considered as an alternative to the solution described above.

The study for nature based and hybrid solutions to be implemented in Quelimane estimated the potential costs and benefits of vegetation of land and a combined measure which included; the construction of retention ponds, drainage channels, rehabilitation of existing drainage channels, outlets and flap gates, green revetment, dike with green revetment, constructions of protection of bridge abutment and a certain area allocated for the protection and re-growing of mangroves. The study area included 11 catchment areas focusing on the communities surrounding flood prone areas. The study encompassed a total of 95 ha of land allocated for vegetation and 80 ha for the construction measures. The analysis used IL data for the economic and environmental costs and benefits of vegetation and the combined measures. This CBA is based on IL initial assessment of the flood protection benefits of vegetation of land combined with various hybrid solution measures as aforementioned, as they took into consideration resettlement issues for the communities near flood prone areas.

2 NACALA

2.1 SCOPE AND METHODS OF THE COST BENEFIT ANALYSIS

The CBA for Nacala assessed the cost and benefits accrued from its nature-based solution that includes the revegetation of land and a combined measure that includes retention ponds, improved drainage system and toe protection of gullies.

The Consultant conducted the CBA in a Microsoft Excel workbook that serves as a companion to this report.

The revegetation of land option in this analysis covers a total of 1,221 ha (of which 20% is used for urban gardening), the combined measures approach covers a total of 75 ha.

In regards to the nature based solutions recommended for Nacala City, based on the consultant's study and assumption, the following table summarizes the total land area size in each catchment area and the corresponding allocated land for the nature based solutions aforementioned: (CES, 2018)

Table 2-1: Total Land Area in Hectares Allocated for Solution Measures in Catchment Areas

Catchment Area	Total land area [ha]	Land area allocated for revegetation of land [ha]	% share of land area allocated for revegetation of land [ha]	Land area allocated for combined measures [ha]	% share of land area allocated for revegetation of land [ha]
Area 1	929	650	70% of total land area		0% of total land area
Area 2	75	53	70% of total land area		0% of total land area
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Area 12	5,257	-		-	
Area 13	10,121				
Total	**18,519**	**1,222**		**75**	

A revegetation of land project includes planting a range of tree and shrub species that will provide a filter strip between the residential areas and the watercourse. In addition, it will allow for urban gardening and agricultural production for the surrounding community. These plants include vetiver grass, elephant grass and Moringa trees. The Consultant has also regarded that 20% the revegetated land will be dedicated for urban gardening and will consider this in the calculations when measuring the benefits of revegetating the land. (CES, 2018)

The combined measures approach includes; a toe of slope protection measuring a total of 45,171 meters in length, in addition to rehabilitation of drainage system for 27,118 meters in length, as well as 99 retention ponds. (CES, 2018)

The Consultant estimated the costs and benefits from primary data collected during field visits and secondary data from existing literature.

The Consultant obtained information on the cost of revegetation of land and the aforementioned combined measures. In addition, the Consultant estimated the benefits of revegetation of land from existing literature in addition to previous estimates. This information included the results of the agricultural production and urban

gardening achieved and benefits accrued from replanting over time. In addition to the erosion protection, carbon sequestration was also considered as one of the key benefits for the revegetation of land in regards to its economic benefits. The community identified main crops that can be harvested such as maize, cassava, sorghum, beans and sweet potatoes.

The Consultant prepared both a financial analysis and an economic analysis. The financial analysis included market-based benefits to the local government and community. The economic analysis also included extra market benefits of revegetation, such as carbon sequestration. Both the financial and economic analyses accounted for the total costs of each option, but taxes were only included in the financial analysis.

2.1.1 Financial Analysis

The financial analysis in this study considered both cities of Nacala and Quelimane and used different parameters where differences occurred; In Nacala, the CBA focused on revegetation of land and further combined measures previously specified.

W&H used market prices, estimated the annual cash flows for benefits (including revenues and subsidies) and costs (construction investment, maintenance, and labour), as well as annuity net cash flows for both cities.

The financial analysis also reflected the cost of the 17 percent value-added tax on goods and services, but not the opportunity cost of unpaid community labour for revegetation of land and pole wood harvesting.

The financial analysis accounted the erosion protection (measured by the reduction in storm damages to houses) and agricultural production (as a result of urban gardening) as benefits to the Nacala community.

2.1.2 Economic Analysis

The economic analysis took into account all financial costs and benefits within the communities studied as well as the value of the carbon sequestered by the growing vegetated land in Nacala. The costs included in the economic analysis were the same as in the financial analysis, except for taxes, which was omitted from the economic analysis as transfer payments

Although revegetated land in Nacala could provide many other economic benefits including reduced mortality and health and safety impacts from storms, water filtration, biodiversity, due to a lack of data the Consultant did not value them in monetary terms.

2.2 ASSUMPTIONS FOR NACALA CITY CBA

The nature based proposed measures for erosion and flood protection in Nacala city includes 1,296 ha across 11 different catchment areas in the city. 1,221 ha of which are allocated for revegetation of unused land; 244 ha of which is used for urban gardening and 977 ha is used for growing the Moringa trees, vetiver and elephant grass. The remaining 75 ha will include combined measures of rehabilitation of draining systems, construction of retention ponds and toe protection within gullies. The field surveys have shown that storm water runoff during heavy rainfall, which occurs seasonally in Nacala, has resulted in erosion of gullies and flooded the channels in the surrounding communities.

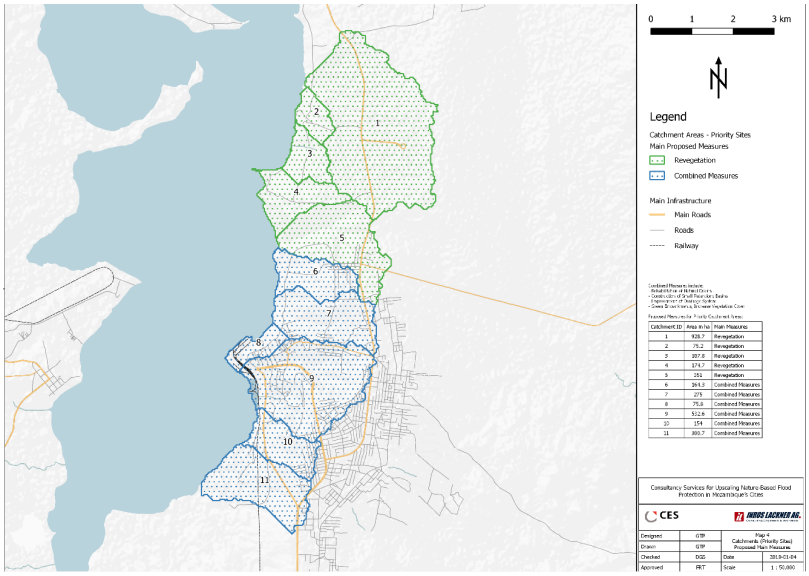

Figure 1: Catchment Areas in Nacala for Protection from Rising Waterfall Runoff

(CES, 2018)

The analysis did not consider possible benefit transfer of biodiversity, existence value, water purification and waste treatment resulting from revegetation of land. Considering these factors in the CBA would increase the benefits accrued from revegetation of land, in this case, the analysis is calculated at a lower bound estimated of the total benefits.

The Consultant followed real discount rate of 6% in the base case for the economic analysis as well as the financial analysis as per the CEADIR CBA. The Consultant also applied the range of discount rates used in the CEADIR including 0%, 3% and 12% in the sensitivity analyses for the economic analysis. This was done due to the fact that higher discount rates reduce the present value of both costs and benefits incurred in the more distant future. Also, with an intervention of this kind, benefits are likely to accrue over long periods of time, particularly as plants need time to grow and reach their maximum height.

The water runoff protection benefits of revegetated land occur 4 years after the plants leave the nursery, which they have spent two years in. The Consultant assumed that in the first year, benefits will be accrued by 31%, and gradually increases to 70% in the second year, 100% in the third year which is in proportion to the growth rate of the revegetation of land (regarding the Moringa tree, vetiver and elephant grass)

In contrast, runoff protection benefits resulted from the combined measures will occur as soon as construction and rehabilitation is completed. The Consultant assumed completion of the construction of retention ponds and toe protection of gullies as well as the rehabilitation of the drainage system within two years (2020 and 2021).

This analysis was done in USD since much of the cost and benefit data provided was in this currency. Therefore, the Consultant used an exchange rate of 63.97 meticais per USD, based on the exchange rate as of, April 24th, 2019.

2.2.1 Revegetation of Land Assumptions

The benefits from revegetated land vary with the different species of plants used since that affects the growth rate as well as the tree density over time. What also impacts the tree density are the number of seedlings and trees and their projected survival rates over time. The growth in revegetation of land and tree density affects the benefits accrued from erosion protection; carbon sequestration; agricultural production/urban gardening (20% of area proposed).

2.2.1.1 Revegetation of Land and Carbon Sequestration Assumptions

It is foreseen to plant three native species - Elephant grass - *Pennisetum purpureum*, Vetiver grass- *Chrysopogon zizanoides* and Moringa trees. W&H took to secondary research sources to derive the carbon stock per plant or tree in order to result with carbon stock values per hectare. These results are included the results in the CBA economic benefits resulted from carbon stock at 4 different cost prices ($0, $8, $15, $25).

Following the survey answers (see annex 1) the Consultant estimated 6,000 plants grown per hectare; with 5,000 plants of Vetiver and Elephant grass and 1,000 Moringa trees. It was also assumed 90% survival rate after plants are released from the nursery and an 80% survival rate after maturity with an expected harvest rate of 200 units per hectare per year. It was assumed that the benefits of revegetated land will be fully accrued within three years.

The growth rate of the revegetated land was based on the expected growth of the Moringa tree which takes 3 years to reach its maximum height of 12 meters. The Vetiver and Elephant grass take up only half a year to reach their maximum height of 1.3 meters and 2.5 meters respectively. The following table provides the growth rates assumed across the three years:

Table 2-2: Growth rate of Revegetated Land

	Year 1	Year 2	Year 3
Growth rate	31%	70%	100%

The Consultant was able to define the amount of carbon stock for each plant or tree based on scientific studies on carbon sequestration of the specified plants/trees. These studies were held in different locations, either in Thailand, India or Ghana. Due to the limited information of carbon stock studies for Mozambique, the Consultant decided to adopt the values written in the studies.

According to a study in Northern Thailand[3], the carbon storage in Vetiver grass amounted to 96.90 g/plant, which is equal to 15.42 t/ha. Elephant grass on the other hand captures approximately 40 t/ha of carbon, as per study on the carbon sequestration in Ghana. [4]Based on a 2014 study in Jalgaon, India; Moringa trees are able to capture 0.789 t/tree of carbon. [5] The Consultant used these values for the CBA assessment as follows:

Table 2-3: Carbon Stock per plant or tree in tons

Plant	ton of carbon per hectare	Number of plants or trees per hectare	Share of plants or trees per hectare	Carbon stock per hectare [t/ha]	Carbon stock per hectare [t/ha] after third year (20% of trees are cut per year)	Carbon stock per plant or tree [t/plant]
Vetiver grass	15.42	2500	41.67%	6.425	6.425	0.000096
Elephant grass	40	2500	41.67%	16.667	16.667	0.000249
Moringa trees	789	1000	16.67%	131.500	105.2	0.789
Total		**6000**		**154.59**	**128.29**	

After deducing the number of plants or trees per hectare used in the study, as per CES data (CES Survey,

[3] P. Nopmalai, A. Suk hkase m, K. Kanjanathanaset, K. Wattanaprapat and I. Meesing (unknown): „Study on Carbon Storage and Carbon Balance in Vetiver Grass Cultivation Areas in Northern Thailand". Land Development Department,Chatuchak, Bangkok, Thailand.

[4] Danquah et al.; CJAST, 31(6): 1-12, 2018; Article no.CJAST.452: Elephant Grass (Pennisetum purpureum): A Potential Source of Biomass for Power Generation in Ghana. Current Journal of Applied Science and Technology 31(6): 1-12, 2018; Article no.CJAST.45224, ISSN: 2457-1024

[5] Suryawanshi, M.N.; Patel,A.R.; Kale, T.S.; Patil, P.R. (2014): "Carbon sequestration potential of tree species in the environment of North Maharashtra University Campus, Jalgaon (MS) India". Bioscience Discovery, 5(2):175-179, July - 2014. ISSN: 2231-024X (Online).

2019) the carbon stock per plant or tree t/plant was determined. An 80% survival rate after the second year was assumed for Vetiver and Elephant grass. As for the Moringa trees, it is assumed that the number of trees will remain constant with 1,000 trees per hectare since there is an annual replanting of the 200 harvested trees. Under these circumstances the carbon stock per hectare was calculated.

2.2.1.2 Revegetation Costs

The expenditures included the costs of buying the seedlings, labor for planting, maintenance, support staff and hydrological restoration. Since it is open land, it is necessary to restore the hydrological flow to ensure healthy vegetation. Re-establishment of the natural hydrological flows improves the likelihood of successful vegetation and increases the density of trees through natural recruitment. W&H provided the cost of manual labour, materials and equipments, and the costs of purchasing seedlings and maintaining the planted area under table 4-3.

The Consultant did not estimate the cost for licensing since it is open land and owned by the municipality.

The Consultant estimated that the local enforcement costs would be $17 per year, based on a staff-level labour rate of 5 percent of the person's time all year. The Consultant estimated annual labour required after implementation and planting of land by staff level; one senior staff with a monthly salary of $ 150, three mid-level staff for each 15 workers and 1 foreman for $ 120 a month and 45 junior staff/workers and guards for $ 60 per month.

The table below summarizes the cost incurred by the revegetation of land, these costs are used to calculate the costs of ecological restoration, initial planting and maintenance of the land (see annex).

Initial planting of the land includes 6,000 seedlings; 5,000 of which are elephant and vetiver grass and the remaining 1,000 is made of Moringa trees. Taking into consideration potential harvesting and damages through the years another 200 seedlings of Moringa trees are expected to be transported and replanted.

Table 2-4: Revegetation of Land Costs

Cost	Unit	Cost/Unit [USD/Unit]	Number of units per month or ha	Number of months	Total project cost [USD]	Cost per ha [USD/ha]
Ecological restoration - labor	Labour	$ 60	100	24	$ 144,000	$ 147.42
Ecological restoration - materials and equipment	Materials & Equipments		100		$ 9,768	$ 10.00
Maintaince after restoration	Person-Days	$ 60.00	10	12	$ 7,200	$ 7.37
Maintenance after restoration - materials and equipment			10		$ 977	$ 1.00
Seedlings grass	Grass	$ 0.10	5,000		$ 488,400	$ 500
Seedlings trees	Trees	$ 0.50	1,000		$ 488,400	$ 500
Seedling maintainance	Person-Days	$ 60.00	10	24	$ 14,400	$ 14.74
Planting labor	Person-Days	$ 60	200	18	$ 216,000	$ 221.13
Safety equipment for implementing partners including masks, gloves, etc for 250 people		$ 15.00	300	24	$ 108,000	$ 110.57
Transport of seedings from nursery	Truck rental and operations	$ 200	4	18	$ 32,496	$ 33.27
Bags for grass seedlings * environmentally acceptable bags	Bags	$ 0.10	5,000		$ 488,400	$ 500.00
Ropes and stropes for moringa tree seedlings	Ropes and stropes	$ 0.05	1,000		$ 48,840	$ 50.00
Replanting moringa trees (once 200 have been harvested every year)	Plants	$ 0.50	200		$ 97,680	$ 100.00
Transport of 200 seedings to be replanted from nursery	Truck rental and operations	$ 200	1	12	$ 5,416	$ 5.54
Ropes and stropes for 200 seedlings	Ropes and stropes	$ 0.05	200		$ 10	$ 10.00
During Implementation						
Senior staff: 6	Staff	$ 150	6	24	$ 21,600	$ 22.11
Mid-level staff for each 15 workers 1 foreman (20)	Staff	$ 120	20	24	$ 57,600	$ 58.97
After Implementation						
Senior staff: 1	Staff	$ 150	1	12	$ 1,800	$ 1.84
Mid-level staff for each 15 workers 1 foreman (3)	Staff	$ 120	3	12	$ 4,320	$ 4.42
Junior staff / workers and guards: 45	Staff	$ 60	45	12	$ 32,400	$ 33.17

2.2.1.3 Urban Gardening Cost

The potential for urban gardening for the locals within the study areas was regarded taking up 20% of the land used for revegetation, resulting in a total of 439.60 ha. The Consultant estimated the costs of planting and harvesting the agricultural products. These costs consisted of the tools and materials needed, labour per hour and water for the plants (CES Survey, 2019).

Table 2-5: Costs related to Urban Gardening

Benefit	Cost	Value [MZN/unit]	Quantity	Cost [MZN]	Cost [USD]	Source
Urban Gardening	Plants / seeds	5	20,000	100,000	$1,558	CES
	Water for plants	10	20,000	200,000	$3,115	CES
	Tools and accessries	700	200	140,000	$2,181	CES
	Labor (per hour)	25	48,000	1,200,000	$18,692	CES

2.2.2 Combined Measures Assumptions

In addition to the revegetation of unused land, a combined measure of constructing retentions ponds, toe protection of gullies and rehabilitating the drainage system are considered. The following table describes the proposed measures:

Table 2-6: Description of Combined Measures

Measure	Description
Retention ponds	Number of ponds: 99 ponds
Toe protection	Length of gullies: 45,171 m
Rehabilitation of drainage system	Length of drainage system:27,118 m

These combined measures together with revegetation of land are to be conducted in main erosion channels, typically within gullies. The following map shows the combination of these measures for one erosion gully in Nacala: (CES, 2018)

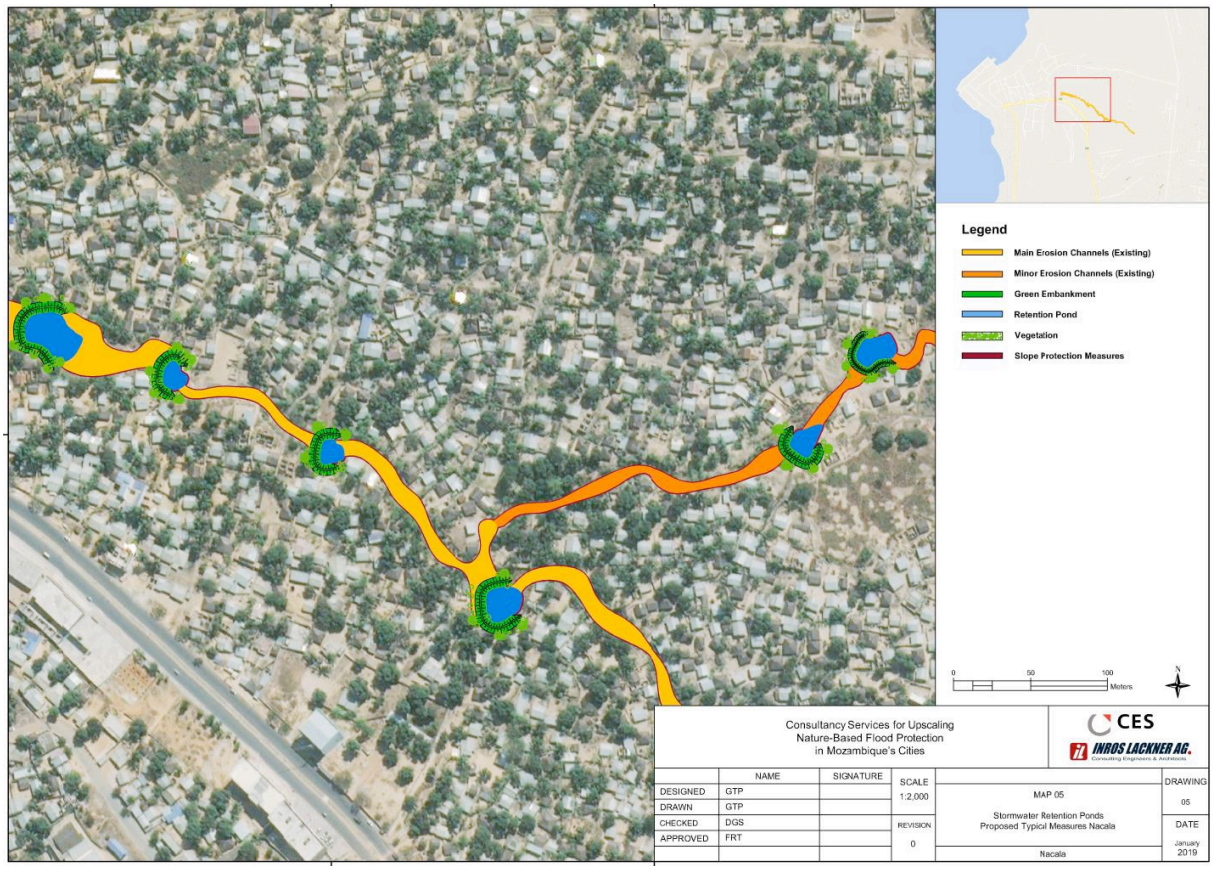

Figure 2: Typical measures for one erosion gully

The Consultant estimated the costs of the combined measures based on previous projects and results of the field surveys (CES Surveys, 2018 & 2019) as listed in the table below. These included; construction and maintenance costs of the three measures, taking into consideration the potential costs for repair in medium waterfall runoff (current 2019 rainfall) event and rebuilding in large waterfall runoff event (heavy rainfall 2036).

Table 2-7: Estimated Costs of the Combined Measures

Parameters	Value	Unit
Retention ponds		
Construction cost	4,000	[USD/pond]
Number of ponds	99	ponds
Maintenance cost	500	[USD/year]
Repair cost after (2019 rainfall)	200	[USD]
Rebuilding cost after (2036 heavy rainfall)	400	[USD]
Toe Protection		
Construction cost	5.50	[USD/m]
Length of toe protection	45,171	[m]
Maintenance cost	1.00	[USD/m/year]
Repair cost after (2019 rainfall)	0.20	[USD/m]
Rebuilding cost after (2036 heavy rainfall)	0.40	[USD/m]
Rehabilitation of Drainage System		
Rehabilitation cost	120,000	[USD]
Maintenance cost	90,000	[USD/year]
Repair cost after (2019 rainfall)	0	[USD]
Rebuilding cost after (2036 heavy rainfall)	0	[USD]

Nacala city faces heavy rainfall events regularly in the rainy season; CES has assumed that generally such events occur 10 times per year. Taking into consideration the impact of climate change on the rate and volume of rainfall expected to increase, two storm events were projected. The current rainfall of 2019 occurring 10 times a year and a more severe event expected to occur by 2036, due to climate change impacts, still to occur in rainy season (CES, 2018)

2.2.3 Benefits

The Consultant estimated the benefits from the reduced risk of erosion damage to gullies and surrounding housing with revegetation of land in combination with the construction of retention ponds, toe protection in gullies and the rehabilitation of the drainage system, the Consultant also included the financial and economic benefits of erosion protection, urban gardening and carbon sequestration.

2.2.3.1 Erosion Protection

The Consultant estimated the erosion protection benefits by the value of rebuilding or repairing the houses damaged or destroyed and compensation costs for potential resettlements. The main building materials used for the houses in the study area stone, cement and metal roofing, with access to water, sewage and power. The Consultant estimated that the value of per house is $ 8,000. Compensation and transportation costs are assumed to be around $ 5,000, taking this value and the value of the house, a total cost of resettlement would equal to $ 13,000.

The study area included 5,401 homes affected, if no solution measures were taken. It is assumed that in current storm event of 2019, 50% of the houses will be damaged while 100% will be damaged by the future storm event of 2036. (CES Survey, 2018)

It was assumed that under the solution measures scenarios, 842 houses would be damaged in the current 2019 storm and 1,137 houses damaged in the future 2036 storm. (CES Survey, 2019)

Taking into consideration the above values, the total cost of damage from future storm event 2036 with solution measures and without solution measures were calculated, following the annual damage cost for the next 16 years (from 2020-2036) with and without scenarios. Then the annual cost of damage difference between the without and with solution measures was calculated to define the benefits accrued from households saved in the with solution measures scenario.

Table 2-8: Estimated Storm Damages

Storm Scenarios	Without Solution Measures	With Solution Measures
Current 2019 rainfall		
Number of houses damaged (assumed 50% of 5,401 houses)	2,701	842
Future 2036 heavy rainfall		
Number of houses damaged	5,401	1,137
Total cost of damage [USD]	$70,213,000	$14,779,837
Annual cost of damage [USD/year]	$2,976,800	$274,785
Difference in cost damage under scenario forecast	$2,702,015	

The values above were then measure across 2020-2036 and divided by the number of hectares in order to measure the number of houses damaged, the corresponding cost of compensation and resettlement per hectare which is then used in the CBA.

The following table summarizes the results by a 5 year interval between 2020 and 2036, considering both with and without project scenarios, in addition to the corresponding difference which acts as a financial benefit to the “with project scenario”. The number of houses damaged were calculated through a compounded annual growth rate (CAGR), taking into account that by 2036 a total of 5,401 houses will be damaged in the without case scenario and only 2,701 damaged houses in 2020, this results in a 4%.

Similarly, in the “with project scenario” a CAGR of 1.89% was used.

Table 2-9: Estimated Storm Damage Compensations per Hectare

Storm Scenario	2019 Storm				2036 Storm
Years	2020	2025	2030	2035	2036
Without project scenario					
Number of houses per hectare damaged without project scenario	2	3	3	4	4
Compensation and resettelmenent cost	$ 27,088	$ 1,426	$ 1,771	$ 2,200	$ 2,297
With project scenario					
Number of houses per hectare damaged with project scenario	1	1	1	1	1
Compensation and resettelmenent cost	$ 8,446.15	$ 172.48	$ 189.45	$ 208.08	$ 212.03
Difference (without - with) project scenarios					
Difference of number of houses per hectare (with and without scenario)	1	2	2	3	3
Difference in compensation and resettelmenent cost	$ 18,642.20	$ 1,253.74	$ 1,581.72	$ 1,991.45	$ 2,084.89

2.2.3.2 Urban Gardening

The potential for urban gardening for the locals within the study areas was regarded, taking up 20% of the land used for revegetation, resulting in a total of 439.60 ha. The most common crop yields found in Nacala were identified including maize, cassava, rice, beans and sweet potatoes; their yield per kg per year per household and their corresponding market prices were determined. The Consultant also followed assumptions that an increase in agriculture production will begin three years with 20% of benefits accrued in the first year, 70% in the second year and 100% in the third year (CES Survey, 2019).

The table below summarizes the amount of crops produced per household in kg/year/ha and the price of each crop in USD/kg. The crop yields above are per household, thus the value was multiplied by three since there are three households per hectare.

Table 2-10: Crop Yield and Corresponding Value per Kg

Crop	Yield Production per household [kg/year/household]	Household Production in study area [kg/year/ha]	Value [USD/kg]
Maize	850	2,550	0.18
Cassava	4,500	13,500	0.23
Sorghum	450	1,350	0.28
Rice	1,200	3,600	0.433
Bean	450	1,350	0.42
Sweet Potatoes	1,500	4,500	0.23

In order to complete the calculation for crop revenue per hectare, a share of crop per hectare was determined as per the previous planned crop production and land use. The following table summarizes these shares and corresponding crop yield per hectare of urban gardening.

Table 2-11: Total Crop Yield per ha and Crop Revenue per year

Crop	Share of Crop per hectare [%]	Production [kg/year/ha]	Value [USD/kg]	Crop Revenue [$/ha/year]
Maize	45%	12,083	0.18	$ 2,174.85
Cassava	45%	12,083	0.23	$ 2,778.98
Sorghum	2%	537	0.28	$ 150.36
Rice	0%		0.433	$
Bean	5%	1,343	0.42	$ 563.85
Sweet Potatoes	3%	806	0.23	$ 257.76

The total agricultural revenue, and/or benefit, would then amount to 5,925.80 $/ha/year.

2.2.3.3 Value of Carbon

The plant species appointed for the study areas in Nacala, to be planted around the gully banks, include the Vetiver grass, Elephant grass and Moringa trees. All three of which are important carbon sinks. The sale of carbon offsets can be a potential revenue source for large scale revegetation of land. On the other hand, it would also require substantial costs to arrange transactions and meet the specific requirements for sale of carbon credits; the MVR, or measurement, reporting and verification.

Owe to the fact that the Consultant has regarded the USAID CEADIR CBA as a reference and guide for the CBA, the price of carbon in the sensitivity analysis was adopted in this study. This included 4 different carbon prices in the sensitivity analysis—$0, $8, $15, and $25 per tCO2e. (Narayan, Foley, Haskell, Cooley, & Hyman, 2017)

2.2.3.4 Other Potential Economic Benefits that were not included

Human mortality and injuries reduction are an important economic benefit of flood risk management and flood protection solutions. In this year (2019), the powerful cyclone “Idia” had almost completely destroyed the city of Beira in Mozambique, leaving 90% of it wiped out. More than half a million people were affected, roads and infrastructure across Mozambique have been destroyed and floodwaters have not receded even within 10 days after the storm. (Tara John, CNN , 2019). Including these values would increase the storm protection benefits, substantially. However, it is difficult to predict the number of fatalities from a storm and the number of storm deaths that could be avoided with the solution measurements considered.

Similarly to the CEADIR CBA a benefit transfer method has been proposed to estimate the value of statistical life based on differences in income in various developed and developing countries. However, it is difficult to find studies for countries in sub-Sahara Africa; in addition, there is a dispute in using value transfer method specifically when adjusting values from developed to developing countries. These potential benefits, if calculated would have a considerable impact on the total estimated benefits, as a result, this analysis is considered at a lower bound estimate of the total benefits.

The analysis did not consider possible benefit transfer of biodiversity, existence value, water purification and waste treatment resulting from revegetation of land. Considering these factors in the CBA would increase the

benefits accrued from revegetation of land, in this case, the analysis is calculated at a lower bound estimated of the total benefits.

2.3 RESULTS

The without project scenario does not consider the solution measures recommended in this study; revegetation of land in combination with rehabilitation of drainage system, construction of toe protection in gullies and retention ponds. The table lists the assumptions for the without project:

Table 2-12: Without Project Scenario Assumptions

Parameter	Base Scenario Value
Time horizon	50 years
Average house value	$ 8,000

The table below lists the assumptions for the solution measures scenario that includes the revegetation of land and combined measures (rehabilitation of drainage system, construction of toe protection in gullies and retention ponds).

Table 2-13: With Project Scenario Assumptions

Parameter	Base Scenario Value
Time horizon	50 years
Plants survival after maturity	80%
Seedling survival rate	90%
Price of carbon ($/tCO2e)	$0, $8, $15, and $25

2.3.1 Financial Analysis

The table below lists the financial costs for 2019-2025 with project scenario including land revegetation in combination with rehabilitation of drainage system, construction of toe protection in gullies and retention ponds. These costs include ecological restoration, initial planting, maintenance, travel costs, rebuilding after storm events, and taxes. The values provided are based on previous estimations and provided through surveying (see in annex)

This scenario considers the cost and benefits under baseline conditions, without investments in revegetation of land and combined infrastructure development measures. The study area includes catchment areas 1-11 in Nacala, with a land area of 977 ha for revegetation of land, 244 ha for urban gardening and 75 ha for combined measures. All values in are in USD/ha/year.

Table 2-14: With Project Scenario Financial Costs per Hectare per Year

Year	2020	2021	2022	2023	2024	2025
Years:	1	2	3	4	5	6
Included in timeframe?	Yes	Yes	Yes	Yes	Yes	Yes
Costs						
CAPEX						
Annual house damage compensation due to storm events	$8,446	$338	$163	$166	$169	$172
Ecological restoration	$79	$79	$0	$0	$0	$0
Initial planting	$864	$1,132	$0	$0	$0	$0
Construction of toe and ponds and rehabilitation of drainage system	$10,193	$0	$0	$0	$0	$0
OPEX						
Maintenance/replacement of non-surviving plantings	$0	$7	$55	$156	$156	$147
Urban Gardening	$105	$77	$77	$77	$77	$77
Enforcement	$16.50	$17	$17	$17	$17	$17
Travel costs for support	$1.02	$1	$1	$1	$1	$1
Annual maintenance for combined measures	$1,809	$1,809	$1,809	$1,809	$1,809	$1,809
Repair and rebuilding of combined measures after storm events of current 2019 rainfall	$123	$123	$123	$123	$123	$123
Taxes - Revegetation of land	$28.65	$99	$3	$0	$0	$0
Taxes - Combined measures	$2,061.18	$328	$328	$328	$328	$328
Total Financial Costs	$23,726	$4,010	$2,576	$2,677	$2,680	$2,674

What can be noted from the table above is the following:

1. Annual house damage compensation due to storm events

The annual house damage compensation calculated per ha per year considers the total resettlement cost of $13,000 and the probable number of movements/resettlements per year in the “with project scenario”. And it is seen that the compensation is bound to decrease as the benefits of the solution measures are activated.

2. Ecological restoration and Initial planting

These values were taken from the “Revegetation of Land Costs” Table previously stating the total cost of each activity in USD per hectare. The total capital costs represented by the one time activities or capital activities were divided in two years, to be paid off in two years.

3. Construction of combined measures across all areas

This includes the total investment cost for all the sites regarding the construction of retention ponds, toe protected gullies and rehabilitation of drainage system, etc. The total cost is $ 764,441 for the total 75 ha which equals to $10,193 per hectare.

4. The Operational Expenditures (OPEX)

The OPEX includes maintenance costs, repairs and taxes costs on revegetated land and combined grey infrastructure measures. The costs are calculated per ha per year and are assumed to be consistent throughout the years.

The total financial costs include all CAPEX and OPEX in addition to the tax rates.

The table below presents the financial benefits accrued from taking the solution measures. The parameter with the largest impact was the increase in agricultural production which rises in with the maturity and growth of the revegetated land. The second benefit stream was provided by the erosion protection of houses calculated by the difference in compensation and resettlement cost between the “with and without project scenario” as aforementioned in table 3-8.

Table 2-15: With Project Scenario Financial Benefits per Hectare per Year

Year	2020	2021	2022	2023	2024	2025
Years:	1	2	3	4	5	6
Included in timeframe?	Yes	Yes	Yes	Yes	Yes	Yes
Financial Benefits						
Urban Gardening	$1,778	$4,148	$5,926	$5,926	$5,926	$5,926
House damage prevention with solution measures	$18,642	$746	$1,089	$1,142	$1,196	$1,254
Total Financial Benefits	$20,420	$4,894	$7,015	$7,068	$7,122	$7,180

What can be noted from the table above is the following:

1. Urban Gardening

The potential for urban gardening for the locals within the study areas was regarded, taking up 20% of the land used for revegetation, resulting in a total of 439.60 ha.

In order to complete the calculation for crop revenue per hectare, a share of crop per hectare was determined as per the previous planned crop production and land use

The total agricultural revenue, and/or benefit, would then amount to 5,925.80 $/ha/year.

2. House damage prevention with solution measures

The values represent the difference in cost of household compensation in the “without project” scenario. Details of this benefit are explained in the chapters above.

After calculating the financial net present value (NPV) and discounting it at 6% for 50 years, the total NPV for the proposed measures was 6,121 $/ha.

2.3.2 Economic Analysis

The economic analysis, in regards to the economic costs, adjusts the financial costs by calculating the sum of all costs considered (not including transfer payments such as taxes). The economic benefits include the carbon sequestration benefits. As aforementioned in sub section 3.3.4 Value of Carbon, the following lists the assumptions taken:

1. Assume that the 4 carbon prices were net of transaction and measurement, reporting and verification (MRV) costs and would not increase over time with climate change
2. Assume that the benefits of carbon sequestration could not be sold due to the limited involvement of Mozambique in the carbon offset market, in addition to lack of information on the transaction and MRV costs. Therefore, carbon benefits are considered in the economic analysis.
3. The Consultant therefore did not include marketable carbon sequestration benefits in the financial and economic analysis as a benefit to the communities or government nor as an extra market value to society.

The table below lists the costs considered for the economic costs including the capital and operational costs of revegetation and urban gardening activities, as well as the construction activities including the retention ponds, toe protected gullies and rehabilitation of drainage system. The only difference between the financial and economic costs is the inclusion of taxes, where the economic cost does not include transfer payments such as taxes.

Table 2-16: With Project Scenario Economic Costs per Hectare per Year

Year	2020	2021	2022	2023	2024	2025
Years:	1	2	3	4	5	6
Included in timeframe?	Yes	Yes	Yes	Yes	Yes	Yes
Costs						
CAPEX						
Annual house damage compensation due to storm events	$8,446	$338	$163	$166	$169	$172
Ecological restoration	$79	$79	$0	$0	$0	$0
Initial planting	$864	$1,132	$0	$0	$0	$0
Construction of toe and ponds and rehabilitation of drainage system	$10,193	$0	$0	$0	$0	$0
OPEX						
Maintenance/replacement of non-surviving plantings	$0	$7	$55	$156	$156	$147
Urban Gardening	$105	$77	$77	$77	$77	$77
Enforcement	$16.50	$17	$17	$17	$17	$17
Travel costs for support	$1.02	$1	$1	$1	$1	$1
Annual maintenance for combined measures	$1,809	$1,809	$1,809	$1,809	$1,809	$1,809
Repair and rebuilding of combined measures after storm events of current 2019 rainfall	$123	$123	$123	$123	$123	$123
Total Economic Costs	$21,636	$3,582	$2,245	$2,348	$2,352	$2,346

The table below presents the economic benefits of revegetation of land at four different carbon values:

Table 2-17: Incremental Economic Benefits from Revegetation of Land per Hectare

Year	2020	2021	2022	2023	2024	2025
Years:	1	2	3	4	5	6
Included in timeframe?	Yes	Yes	Yes	Yes	Yes	Yes
Economic Benefits						
Carbon stocks (Carbon Price #1)	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
Carbon stocks (Carbon Price #2)	$1,710	$3,982	$5,685	$5,288	$5,117	$5,117
Carbon stocks (Carbon Price #3)	$3,207	$7,467	$10,660	$9,914	$9,595	$9,595
Carbon stocks (Carbon Price #4)	$5,345	$12,444	$17,766	$16,524	$15,991	$15,991

As aforementioned in previous sections, the economic benefits are presented in a lower bound estimate since they do not include the reductions in human health and safety risks nor the additional benefits from revegetated land such as water filtration, biodiversity, and existence values.

As for the benefits accrued from the carbon sequestration; it included 4 different carbon prices in the sensitivity analysis—price #1 ($0), price #2 ($8), price #3 ($15), and price #4 ($25) per tCO2e

The table below presents the NPV per ha for the four carbon prices over the 50 year time horizon at a 6% discount rate. The economic NPV ranged from of $ 13,184 min at a carbon price 0$/tCO2e to 253,948 $/ha at a carbon price of 25$/tCO2e.

Table 2-18: Economic Net Present Value of Revegetated Land by Carbon Prices at 6% discount rate

Carbon Price [$/tCO2e]	Economic Net Benefit [$/ha]	Economic Net Benefit [$]
$ -	$ 13,184	$ 17,087,108
$ 8.00	$ 90,229	$ 116,936,556
$ 15.00	$ 157,643	$ 204,304,823
$ 25.00	$ 253,948	$ 329,116,632

2.4 RESULTS OF THE BASE CASE SCENARIO

The economic net present values (NPV) of solution measures exceeded those of the financial NPV with a financial rate of return of 1.26% at a 6 % discount rate and an economic internal rate of return of 62.04% at 6% discount rate at carbon price 25 $/tCO2e.

Table 2-19: Annuity Values for Financial and Economic Assessments

Annuity Values - Financial	***NPV***	***FIRR***
0% discount rate	*$1,885*	1.26%
3% discount rate	*$1,211*	
6% discount rate	*$388*	
12% discount rate	*-$1,343*	
Annuity Values - Economic	***NPV***	***EIRR***
6% discount rate (Carbon Price #1)	*$836*	2.85%
6% discount rate (Carbon Price #2)	*$5,725*	19.67%
6% discount rate (Carbon Price #3)	*$10,002*	35.90%
6% discount rate (Carbon Price #4)	*$16,112*	62.04%

With a total area of 1,296 ha allocated for the solution measures, the total investment cost was calculated to equalling around $ 31 million; of which the following CAPEX were considered:

- Rehousing and resettlement costs with a total of around 11,582 $/ha
- Ecological restoration 157 $/ha and initial planting of 1,996 $/ha for revegetated land allocated to 1,221 ha
- Construction of toe protection gullies, retention ponds and the rehabilitation of the drainage system resulting in a total of $ 10,193.

The financial and economic benefits accumulated over the period of 50 years for the total number of hectares of the study area (1,296 ha) were calculated at a 6% discount rate. The following table summarize the results:

Table 2-20: Financial and Economic Net Present Values of Solution Measures per Hectare at a 6% Discount Rate

USD Per Hectare at 6 % discount rate	
Scenario:	***Solution measures***
Financial Net Benefits	$6,121
Financial Annualized Value	$388
$0 Carbon Price	
Economic Net Benefits	$13,184
Economic Annualized Value	$836
$8 Carbon Price	
Economic Net Benefits	$90,229
Economic Annualized Value	$5,725
$15 Carbon Price	
Economic Net Benefits	$157,643
Economic Annualized Value	$10,002
$25 Carbon Price	
Economic Net Benefits	$253,948
Economic Annualized Value	$16,112

Table 2-21: Financial and Economic Net Present Values of Solution Measures at a 6% Discount Rate

Total Value in USD for 1,296 hectares at 6 % discount rate	
Scenario:	***Solution measures***
Financial Net Benefits	$7,932,270
Financial Annualized Value	$503,262
$0 Carbon Price	
Economic Net Benefits	$17,087,108
Economic Annualized Value	$1,084,084
$8 Carbon Price	
Economic Net Benefits	$116,936,556
Economic Annualized Value	$7,418,961
$15 Carbon Price	
Economic Net Benefits	$204,304,823
Economic Annualized Value	$12,961,978
$25 Carbon Price	
Economic Net Benefits	$329,116,632
Economic Annualized Value	$20,880,574

The results show that both the economic benefits and the financial benefits have a positive result with the financial benefits reaching around$ 7.9 million and the economic benefits equalling around $ 17 million at $0 carbon price. The Consultant calculated the financial internal rate of return (FIRR) and it showed that with a discount rate of 1.26% can achieve breakeven.

2.5 SENSITIVITY ANALYSIS

The Consultant considered a sensitivity analysis to assess the changes in the net present values as key assumptions were modified. The factors that had the largest impact in the analysis were the survival rate of the plants and resettlement cost. The models also demonstrated that there is an indirect impact between plant survival rate and resettlement cost. Integrating further information in the model on the correlation of plant survival rate and storm intensity and frequency could provide for clearer correlations. Additionally, further information on the impact of plant survival rates and urban survival rates on resettlement costs would allow for improvement of the model as well. The table below presents the assumptions used in the base scenario and modified for a low and high sensitivity analysis.

Table 2-22: Assumptions Modified in the Sensitivity Analyses

Parameters	Base Scenario	Low Scenario	High Scenario
Time horizon [years]	50	50	50
Discount rates [%]	0%, 3%, 6%, 12%	0%, 3%, 6%, 12%	0%, 3%, 6%, 12%
Plant survival rate after maturity [%]	80%	50%	100%
Seedling survival rate [%]	90%	50%	100%
Carbon price	n.a	n.a	n.a
Agricultural production level– Urban gardening [%]	90%	50%	100%
Resettelment cost [USD]	$13,000	$12,000	$14,000

The tables provide the sensitivity analysis results for the lower and higher bound scenarios.

Summary results (NPV) for overall low sensitivity analysis:

Table 2-23: Low Sensitivity Financial and Economic Net Present Values of Solution Measures per Hectare at a 6% Discount Rate

USD Per Hectare at 6 % discount rate	
Scenario:	***Solution measures***
Financial Net Benefits	-$27,525
Financial Annualized Value	-$1,746
$0 Carbon Price	
Economic Net Benefits	-$20,463
Economic Annualized Value	-$1,298
$8 Carbon Price	
Economic Net Benefits	$22,316
Economic Annualized Value	$1,416
$15 Carbon Price	
Economic Net Benefits	$59,747
Economic Annualized Value	$3,791
$25 Carbon Price	
Economic Net Benefits	$113,220
Economic Annualized Value	$7,183

Table 2-24: Low Sensitivity Financial and Economic Net Present Values of Solution Measures at a 6% Discount Rate

Total Value in USD for 1,296 hectares at 6 % discount rate	
Scenario:	***Solution measures***
Financial Net Benefits	-$35,671,878
Financial Annualized Value	-$2,263,172
$0 Carbon Price	
Economic Net Benefits	-$26,519,719
Economic Annualized Value	-$1,682,520
$8 Carbon Price	
Economic Net Benefits	$28,921,334
Economic Annualized Value	$1,834,898
$15 Carbon Price	
Economic Net Benefits	$77,432,256
Economic Annualized Value	$4,912,639
$25 Carbon Price	
Economic Net Benefits	$146,733,573
Economic Annualized Value	$9,309,411

Summary results (NPV) for overall high sensitivity analysis:

Table 2-25: High Sensitivity Financial and Economic Net Present Values of Solution Measures per Hectare at a 6% Discount Rate

USD Per Hectare at 6 % discount rate	
Scenario:	***Solution measures***
Financial Net Benefits	$13,394
Financial Annualized Value	$850
$0 Carbon Price	
Economic Net Benefits	$20,460
Economic Annualized Value	$1,298
$8 Carbon Price	
Economic Net Benefits	$106,092
Economic Annualized Value	$6,731
$15 Carbon Price	
Economic Net Benefits	$181,021
Economic Annualized Value	$11,485
$25 Carbon Price	
Economic Net Benefits	$288,061
Economic Annualized Value	$18,276

Table 2-26: High Sensitivity Financial and Economic Net Present Values of Solution Measures at a 6% Discount Rate

Total Value in USD for 1,296 hectares at 6 % discount rate	
Scenario:	***Solution measures***
Financial Net Benefits	$17,358,521
Financial Annualized Value	$1,101,303
$0 Carbon Price	
Economic Net Benefits	$26,516,039
Economic Annualized Value	$1,682,296
$8 Carbon Price	
Economic Net Benefits	$137,495,541
Economic Annualized Value	$8,723,311
$15 Carbon Price	
Economic Net Benefits	$234,602,605
Economic Annualized Value	$14,884,199
$25 Carbon Price	
Economic Net Benefits	$373,326,982
Economic Annualized Value	$23,685,468

3 QUELIMANE

3.1 SCOPE AND METHODS OF THE COST BENEFIT ANALYSIS

The CBA for Quelimane assessed the cost and benefits accrued from its nature based and hybrid solutions that includes the vegetation of land and a combined measure that includes the construction of retention ponds, drainage channels, rehabilitation of existing drainage channels, outlets and flap gates, green revetment, dike with green revetment, constructions of protection of bridge abutment and a certain area allocated for the protection and re-growing of mangroves.

W&H conducted the CBA in a Microsoft Excel workbook that serves as a companion to this report.

The vegetation of land option in this analysis covers a total of 95 ha; the construction measures are covers a total of 80 ha.

In regards to the nature and hybrid based solutions recommended for Quelimane City, based on IL study and assumption, the following table summarizes the total land area size in each catchment area and the corresponding allocated land for the nature based solutions aforementioned: (IL Survey, 2019)

Table 3-1: Total Land Area in Hectares Allocated for Solution Measures in Catchment Areas

Location	Total area of catchment sites [ha]	Area used for Grass community [ha]	Area used for Wetland plant mix [ha]	Area used for Mangroves [ha]	Area used for Construction Measures [ha]	Total area used for solution measures [ha]
Whole area of Quelimane	**3,009**					
Site 1	214	11	11	0	11	32
Site 2	34	0	0	0	2	2
Site 3&4	509	8	5	0	25	38
Site 5	158	3	0	13	8	24
Site 6	64	3	0	13	6	22
Site 7	29	1	0	0	1	3
Site 8	288	0	0	7	14	22
Site 9	293	0	15	0	7	22
Site 10	50	1	0	0	2	4
Site 12	47	2	2	0	2	7
Sum (Sites 1 to 12)	**1,686**	**30**	**33**	**33**	**80**	**175**

The vegetated land includes a range of grass and mangroves species that will act as a filter strip between the residential areas and the excess water along the watercourse. These plants include 12 different species: (IL Survey, 2019)

1. Vetiver grass
2. Elephant grass
3. Buffalo grass
4. LM grass
5. Common Crowfoot
6. Basket grass
7. Miniature Papyrus
8. Papyrus
9. Common Reed
10. Red grass
11. Alkali Bulrush
12. Mangroves

The combined measures include; the construction of 5 retention ponds, 11,619 m of drainage channels, rehabilitation of existing 14,260 m of drainage channels, 9 outlets and flap gates, 3,149 m of green revetment, a total of 3,720 m of dike with green revetment, 6 constructions of protection of bridge abutment and 1,053,227 m² allocated for the protection and re-growing of mangroves. (IL Survey, 2019)

Potential damages in the catchment areas were defined by the expected storm to hit Mozambique, and two types of storms were regarded; medium storm event and heavy storm events. For each scenario, the consultant estimated costs and benefits using primary data from field studies and secondary data from a literature review.

The consultant obtained information on the cost and benefits of plantation of land and the aforementioned combined measures from IL. This information included the results of benefits accrued from replanting over time; flood protection through filtering watercourse, and carbon sequestration and socio-economic impact of risk events and risk reduction due to implementation of proposed solution measures were also considered as key economic benefits.

The consultant prepared both a financial analysis and an economic analysis. The financial analysis included market-based benefits to the local government and community. The economic analysis also included extra market benefits of mangrove restoration, such as carbon sequestration. Both the financial and economic analyses accounted for the total costs of each option, but taxes were only included in the financial analysis.

3.1.1 Financial Analysis

The financial analysis in this study considered the capital and operation expenditures (CAPEX and OPEX) which include construction costs, planting costs, maintenance, enforcement, repair and rebuilding in addition to taxes.

The consultant used market prices, estimated the annual cash flows for benefits (including revenues and subsidies) and costs (construction investment, maintenance, and labour), as well as annuity net cash flows.

The financial analysis accounted the flood protection by measuring the reduction in storm damages to houses. It also reflected the cost of the 17 percent value-added tax on goods and services, but not the opportunity cost of unpaid community labour for plantation of land and harvesting.

3.1.2 Economic Analysis

The economic analysis took into account all financial costs and benefits within the communities studied as well as the value of the carbon sequestered by the growing vegetated land in Quelimane, in addition to the socio-economic impact of risk events. The costs included in the economic analysis were the same as in the financial analysis, except for taxes, which was omitted from the economic analysis as transfer payments

Although planted land in Quelimane could provide many other economic benefits including reduced mortality and health and safety impacts from storms, water filtration, biodiversity, due to a lack of data the consultant did not value them in monetary terms.

3.2 ASSUMPTIONS FOR QUELIMANE CITY CBA

The proposed measures for flood protection in Quelimane city cover 1,686 ha across 11 different catchment areas. 95 ha of which are allocated for plantation of unused land; 80 ha of which will include construction measures of construction of retention ponds, drainage channels, outlets and flap gates, green revetment, dike with green revetment, constructions of protection of bridge abutment and a certain area allocated for the protection and re-growing of mangroves.

The analysis did not consider possible benefit transfer of biodiversity, existence value, water purification and waste treatment resulting from vegetation of land. Considering these factors in the CBA would increase the benefits accrued from vegetation of land, in this case, the analysis is calculated at a lower bound estimated of the total benefits.

The consultant followed discount rate of 6% in the base case for the economic analysis as well as the financial analysis as per the CEADIR CBA. The Consultant also applied the range of discount rates used in the CEADIR including 0%, 3% and 12% in the sensitivity analyses for the economic analysis. This was done due to the fact that higher discount rates reduce the present value of both costs and benefits incurred in the more distant future.

The mangroves will need 10 to 15 years to reach maturity. (IL Survey, 2019) The consultant assumed that in the first year, benefits will be accrued by 31%, and gradually increases to 70% in the second year, 100% in the third year which is in proportion to the growth rate of the vegetation of land (vetiver and elephant grass)

In contrast, runoff protection benefits resulted from the combined measures will occur as soon as construction and rehabilitation is completed. The consultant assumed completion of the construction of retention ponds, drainage channels, and rehabilitation of existing drainage channels, outlets and flap gates, green revetment, dike with green revetment, constructions of protection of bridge abutment.

This analysis was done in USD since much of the cost and benefit data provided was in this currency. Therefore, the consultant used an exchange rate of 63.97 meticais per dollar (as used in Nacala estimates).

3.3 PLANTATION OF LAND ASSUMPTIONS

The benefits from vegetation of land vary with the different species of plants used since that affects the growth rate as well as the tree density over time. What also impacts the tree density are the number of seedlings and trees and their projected survival rates over time. The growth in vegetation of land and tree density affects the benefits accrued from flood protection and carbon sequestration

3.3.1 Revegetation of Land and Carbon Sequestration Assumptions

IL plans to plant two plant communities:

1. Grass Community:
    a. Vetiver Grass
    b. Elephant Grass
    c. LM Grass
    d. Red Grass
2. Wetland Plant Mix:
    a. Vetiver Grass
    b. Elephant Grass
    c. Buffalo Grass
    d. Common Crowfoot

e. Basket Grass
f. Miniature Papyrus
g. Papyrus
h. Common Reed
i. Alkali Bulrush
j. Mangroves

The consultant took to the average carbon stocks of the two plant communities provided by IL to derive the carbon stock per ha in order to result with carbon stock values per ha. These results are included the results in the CBA economic benefits resulted from carbon stock at 4 different cost prices ($0, $8, $15, $25).

The growth rate of the planted land was split between the grass species and the mangroves as both groups have two distinct growth features. The growth rate of the grass species together form an average of 3 years to reach to achieve full carbon absorption capacity as it reaches maturity, while the mangroves takes up to 10 to 15 years. (IL Survey, 2019). The Vetiver and Elephant grass take up only half a year to reach their maximum height of 1.3 meters and 2.5 meters respectively. The following table provides the growth rates assumed across the three years:

Table 3-2: Growth rate of Revegetated Land

	Year 1	Year 2	Year 3
Growth rate	31%	70%	100%
Survival rate after maturity		90%	80%

Following the survey answers provided by CES, the consultant estimated that the grass community includes 40,000 number of plants per ha and 31,000 plants of the wetland community grown per ha.

It was also assumed 90% survival rate after plants are released from the nursery and an 80% survival rate after maturity. It is also assumed that benefits of planted land will be fully accrued within three years.

According to the data provided to the consultant, the carbon storage in grass communities globally equals to 22 t C ha/year while the dry grasslands in the UK reach between 117 – 435 t C ha/year (check annex), and for the purpose of the calculations an average 276 t C ha/year was calculated for the dry grasslands. The Consultant used these values for the CBA assessment as follows:

Table 3-3: Carbon Stock per Plant Community in tons per ha per year

Plant	ton of carbon C/ha/ yr	Number of plants or trees per ha	Share of plants or trees per ha	Carbon stock per hectare [t/ ha]	Carbon stock per hectare [t/ ha] after third year (20% of trees are cut per year)	Carbon stock per plant or tree [t/plant]
Grass Community	22	40000	57%	12.57	12.57	0.00055
Wetland Plant mix	276	30000	43%	118.29	118.29	0.00920
Total		**70000**		**130.86**	**130.86**	

3.2.2 Plantation Costs

The expenditures included the costs of buying the seedlings, labour for planting, maintenance, support staff and hydrological restoration. Since it is unused land, it is necessary to restore the hydrological flow to ensure healthy vegetation. Re-establishment of the natural hydrological flows improves the likelihood of successful vegetation and increases the density of trees through natural recruitment.

The consultant provided the cost of manual labour, materials and equipments, and the costs of purchasing seedlings and maintaining the planted area under table 4-3.

The consultant did not estimate the cost for licensing since it is unused land and owned by the municipality.

The consultant estimated that the local enforcement costs would be $17 per year, based on a staff-level labour rate of 5 percent of the person's time all year. W&H estimated annual labour required after implementation and planting of land by staff level; one senior staff with a monthly salary of $ 150, three mid-level staff for $ 120 a month.

The table below summarizes the cost incurred by the vegetation of land, these costs are used to calculate the costs of ecological restoration, initial planting and maintenance of the land (see annex).

Initial planting of the land includes 6,000 seedlings; 5,000 of which are elephant and vetiver grass and the remaining 1,000 is made of mangrove trees. Taking into consideration potential harvesting and damages through the years another 200 seedlings are expected to be transported and replanted.

Table 3-4: Plantation of Land Costs

Cost	Unit	Cost/Unit [USD/Unit]	Number of units per ha	Number of months	Total project cost [USD]	Cost per ha [USD/ha]
Ecological restoration - labor	Labour	$ 60	100	24	$ 144,000	$ 1,513.67
Ecological restoration - materials and equipment	Materials & Equipments		100		$ 951	$ 10.00
Maintaince after restoration	Person-Days				$ 11,000	$ 115.63
Seedlings grass	Grass	$ 0.10	5,000		$ 47,567	$ 500
Seedlings mangroves (trees)	Trees	$ 0.50	1,000		$ 47,567	$ 500
Planting labour	Person-Days	$ 60	200	18	$ 216,000	$ 2,271
Safety equipment for implementing partners including masks, gloves, etc for 250 people		$ 15.00	300	24	$ 108,000	$ 1,135
Transport of seedings from nursery	Truck rental and operations	$ 200	4	18	$ 32,496	$ 342
Bags for grass seedlings * environmentally acceptable bags	Bags	$ 0.10	5,000		$ 47,567	$ 500
Senior staff: 6	Staff	$ 150	6	24	$ 21,600	$ 227.05
Mid-level staff	Staff	$ 120	20	24	$ 57,600	$ 605.47

3.3 COMBINED MEASURES ASSUMPTIONS

In addition to the vegetation of unused land, a combined measure including the construction of 5 retention ponds, 11,619 m of drainage channels, rehabilitation of existing 14,260 m of drainage channels, 9 outlets and flap gates, 3,149 m of green revetment, a total of 3,720 m of dike with green revetment, 6 constructions of protection of bridge abutment and 1,053,227 m² allocated for the protection and re-growing of mangroves. (IL Survey, 2019)

These combined measures together with vegetation of land are to be conducted in main flood prone areas in Quelimane.

The consultant estimated the costs of the combined measures based on values provided by (IL Survey, 2019) listed in the table below. These included; construction and maintenance costs of the three measures, taking into consideration the potential costs for repair in medium and heavy storm events.

Table 3-5: Description of Combined Measures

Construction Measures	***Value***	
Area for construction measures (ha)		80
Total Investment cost per Site US $		
Area 1 total invesment cost	$	980,073
Area 2 total invesment cost	$	750,000
Area 3/4 total invesment cost	$	724,449
Area 5 total invesment cost	$	47,235
Area 6 total invesment cost	$	3,397,991
Area 7 total invesment cost	$	1,156,829
Area 8 total invesment cost	$	742,262
Area 9 total invesment cost	$	51,000
Area 10 total invesment cost	$	596,275
Area 12 total invesment cost	$	230,652
Various areas total invesment cost	$	71,300
Maintenance cost		
Maintenance cost green revetment	$	11,000
Cost to for Quelimane	$	8,748,066
Yearly maintenance	$	11,000
Annual Repair cost after medium storm event	$	8,748
Annual Rebuilding cost after large storm event	$	218,702

3.4 BENEFITS

The consultant estimated the benefits from the reduced risk of flood damage to flood prone areas and surrounding housing with vegetation of land in combination with the construction of the aforementioned various construction measures. The consultant also included the financial and economic benefits of storm protection and carbon sequestration.

3.4.1 Storm Protection

The consultant estimated the storm protection benefits by the value of rebuilding or repairing the houses damaged or destroyed and compensation costs for potential resettlements. The main building materials used for the houses in the study area stone, cement and metal roofing, with access to water, sewage and power. The consultant estimated that the value of per household that includes 10 people in Quelimane is $ 16,000. Compensation and transportation costs are assumed to be around $ 10,000, taking this value and the value of the house, a total cost of resettlement would equal to $ 26,000.

The study area included 6,338 homes affected, if no solution measures were taken. It is assumed that in medium storm event, 50% of the houses will be damaged while 100% will be damaged by the large storm event under the without solution measure scenario. On the other hand, in the with solution measures 15% of the houses could be damaged in the medium storm event and 20% in the large storm event (excluding sever tropical storms and cyclones).

Taking into consideration the above values, the total cost of damage from large storm events with solution measures and without solution measures were calculated, following the annual damage cost for the next 15 years (from 2020-2035) with and without scenarios. Then the annual cost of damage difference between the without and with solution measures was calculated to define the benefits accrued from households saved in the with solution measures scenario.

Table 3-6: Estimated Storm Damages

Storm Scenarios	Without Solution Measures	With Solution Measures
Medium Storm Event		
Number of houses damaged	3,169	951
Heavy Storm Event		
Number of houses damaged	6,338	1,268
Total cost of damage [USD] by 2036	$164,775,000	$32,955,000
Annual cost of damage [USD/year]	$6,985,919	$587,240
Difference in cost damage under scenario forecast	$6,398,679	

The values above were then measure across 2020-2035 and divided by the number of ha in order to measure the number of houses damaged, the corresponding cost of compensation and resettlement per ha which is then used in the CBA.

The following table summarizes the results by a 5 year interval between 2020 and 2035, considering both with and without project scenarios, in addition to the corresponding difference which acts as a financial benefit to the "with project scenario". The number of houses damaged were calculated through a compounded annual growth rate (CAGR), taking into account that by 2035 a total of 6,338 houses will be damaged in the without case scenario and only 3,169 damaged houses in 2020, this results in a 4 %. Similarly in the "with project scenario" a CAGR of 1.81% was used.

Table 3-7: Estimated Storm Damage Compensations per Hectare

Storm Scenario	2019 Storm			2036 Storm
Years	2020	2025	2030	2036
Without project scenario				
Number of houses per hectare damaged without project scenario	2	2	3	4
Compensation and resettelmenent cost	**$ 48,853**	**$ 2,572**	**$ 3,194**	**$ 4,142**
With project scenario				
Number of houses per hectare damaged with project scenario	1	1	1	1
Compensation and resettelmenent cost	**$ 14,655.83**	**$ 285.72**	**$ 312.60**	**$ 348.21**
Difference (without - with) project scenarios				
Difference of number of houses per hectare (with and without scenario)	1	2	2	3
Difference in compensation and resettelmenent cost	**$ 34,196.93**	**$ 2,286.41**	**$ 2,881.62**	**$ 3,794.18**

3.4.2 Other Socio-Economically Valuable Assets

Assessment of the socio-economic impact of risk events takes into consideration additional valuable assets located in each of the studied sites. Each site comprises of various sorts of added socio-economically valuable assets such as the airport in site 1, the port in site 2 and school buildings and health care centres in site 12. The results of the assessment of such socio-economic impacts presented an annual risk value and considered the probability of such risk events.

The risk value estimated is a % share of the total socio-economic impact value of the socio-economically valuable asset in the study site. This % share is represented by the probability of a risk event occurring which changes in the "with and without project" scenario.

For example, site #1 which includes an airport has a socio-economic impact value of $3.3 million, the estimated exceedance probability, if no solution measures are taken, would equal to 20%. Therefore, the risk value would equal to $664,000. In the "with project" scenario, the exceedance probability decreases to 1% and so the risk impact value decreases as well to $33,000.

The following table summarizes the risk values of each site in the "with and without project" scenario:

Table 3-8: Estimated Risk Value (USD)

Catchment Areas	Without Project Scenario	With Project Scenario	Difference (benefit)
Area 1	$ 663,600	$ 33,180	$ 630,420
Area 2	$ 22,840	$ 11,420	$ 11,420
Area 3	$ 2,208,560	$ 110,428	$ 2,098,132
Area 4	$ 513,600	$ 25,680	$ 487,920
Area 5	$ 23,840	$ 11,920	$ 11,920
Area 6	$ 17,120	$ 8,560	$ 8,560
Area 7	$ 28,680	$ 28,680	$ -
Area 8	$ 76,920	$ 38,460	$ 38,460
Area 9	$ 22,120	$ 11,060	$ 11,060
Area 10	$ 109,140	$ 5,457	$ 103,683
Area 12	$ 508,000	$ 25,400	$ 482,600
Total	$ 4,194,420	$ 310,245	**$ 3,884,175**
Total per hectare	$ 23,927	$ 1,770	**$ 22,157**

The difference calculated is the economic benefit considered in the CBA. The sum of the differences was calculated resulting in $22,157 in reduction of risk in an annual basis. The risks would gradually increase somewhat, given gradual sea level rise. The risk values were considered for 2031 horizon. Given the uncertainty of some inputs, the risk levels were mitigated.

3.4.3 Mat Weaving

The potential for mat weaving for the locals with the study areas was regarded, as it is a relevant and highly produced among the farmers around the study area. The wetland plant mix area of 33 ha were considered as the resulting land used for mat weaving since wetland plant species are commonly used for it. Roughly 20 plants of Phragmites (common reed) are used and 50 plants of Cyperus required for one mat. It is also estimated that one mat costs roughly $1.50.

The following table summarizes the parameters and total revenue derived from mat weaving per hectare per year. This will be considered the benefit accrued from mat weaving.

The consultant is aware that the plants used for mat weaving are available at 4 plants per meter squared which is 40,000 plants per ha. It is also assumed that mat weaving is considered as an extra benefit with no additional cost since labour for harvesting the plants are covered by the sale of the mat and all revenues are given to the harvester who is also weaving the mat and selling it.

Table 3-9: Mat Weaving Costs and Benefits Parameters

Mat Weaving	*Value*	
Total area of wetland plant mix community (ha)		33
Number of plants per hectare		40,000
Number of plants requiered to weave 1 mat		70
Mats produced per ha [mat/ha]		571
Total Mats produced per ha [mat/ha/year]		450
Price of 1 mat (USD/mat]	$	1.50
Revenue [USD/ha/year]	$	22,164.98
Benefits accrued in first year		70%
Benefits accrued in second year		100%

The consultant considered that not all plants are used for mat weaving and calculated that from the 40,000 plants per ha, 571 plants per ha will be available to be used for mat weaving. 80% of which is considered to calculate the number of mats per ha per year produced and that will equal to 450 mats/ha/year. The total revenue then considering that one mat costs $1.50 across the 33 ha results in 22, 165 $/ha/year

3.4.4 Value of Carbon

The plant species appointed for the study areas in Quelimane, to be planted around the flood prone areas, include 12 types of plants; vetiver grass, elephant grass, buffalo grass, LM grass, common crowfoot, basket grass, miniature papyrus, papyrus, common reed, red grass, alkali bulrush and mangroves. All 12 of which are important carbon sinks. The sale of carbon offsets can be a potential revenue source for large scale vegetation of land. On the other hand, it would also require substantial costs to arrange transactions and meet the specific requirements for sale of carbon credits; the MVR, or measurement, reporting and verification.

Owed to the fact that the Consultant has regarded the USAID CEADIR CBA as a reference and guide for the CBA, the price of carbon in the sensitivity analysis was adopted in this study. This included a 4 different carbon prices in the sensitivity analysis—$0, $8, $15, and $25 per tCO2e. (Narayan, et al., 2017)

3.4.5 Other Potential Economic Benefits that were not included

Human morality and injuries reduction are an important economic benefit of flood risk management and flood protection solutions. In this year (2019), the powerful cyclone “Idia” had almost completely destroyed the city of Beira in Mozambique, leaving 90% of it wiped out. More than half a million people were affected, roads and infrastructure across Mozambique have been destroyed and floodwaters have not receded even within 10 days after the storm. (Tara John, CNN , 2019). Including these values would increase the storm protection benefits, substantially. However, it is difficult to predict the number of fatalities from a storm and the number of storm deaths that could be avoided with the solution measurements considered.

Similarly to the CEADIR CBA a benefit transfer method has been proposed to estimate the value of statistical life based on differences in income in various developed and developing countries. However, it is difficult to find studies for countries in sub-Sahara Africa; in addition, there is a dispute in using value transfer method specifically when adjusting values from developed to developing countries. These potential benefits, if calculated would have a considerable impact on the total estimated benefits, as a result, this analysis is considered at a lower bound estimate of the total benefits.

The analysis did not consider possible benefit transfer of biodiversity, existence value, water purification and waste treatment resulting from vegetation of land. Considering these factors in the CBA would increase the benefits accrued from vegetation of land, in this case, the analysis is calculated at a lower bound estimated of the total benefits.

3.5 RESULTS

The without project scenario does not consider the solution measures recommended in this study; vegetation of land in combination the construction of retention ponds, drainage channels, rehabilitation of existing drainage channels, outlets and flap gates, green revetment, dike with green revetment, constructions of protection of bridge abutment and area allocated for the protection and re-growing of mangroves. The table lists the assumptions for the without project:

Table 3-10: Without Project Scenario Assumptions

Parameter	Base Scenario Value
Time horizon	31 years
Average house value	$ 16,000

The table below lists the assumptions for the solution measures scenario that includes the plantation of land and combined measures

Table 3-11: With Project Scenario Assumptions

Parameter	Base Scenario Value
Time horizon	31 years
Plants survival after maturity	80%
Seedling survival rate	90%
Price of carbon ($/tCO2e)	$0, $8, $15, and $25

3.5.1 Financial Analysis

The table below lists the financial costs for 2019-2025 with project scenario including land vegetation in combination the construction of retention ponds, drainage channels, rehabilitation of existing drainage channels, outlets and flap gates, green revetment, dike with green revetment, constructions of protection of bridge abutment and area allocated for the protection and re-growing of mangroves. These costs include construction costs, ecological restoration, initial planting, maintenance, travel costs, rebuilding after storm events, and taxes. The values provided are based on IL estimations and provided to the consultant through IL surveying (see in annex)

This scenario considers the cost and benefits under baseline conditions, without investments in vegetation of land and combined infrastructure development measures. The study area includes 11 catchment areas in Quelimane, with a land area of 95 ha for plantation of land, 80 ha for construction measures. All values in are in USD/ ha /year.

Table 3-12: With Project Scenario Financial Costs per Hectare per Year

Year	2020	2021	2022	2023	2024	2025
Years:	1	2	3	4	5	6
Included in timeframe?	Yes	Yes	Yes	Yes	Yes	Yes
Costs						
CAPEX						
Annual house damage compensation due to storm events	$14,656	$586	$271	$276	$281	$286
Ecological restoration	$758	$758	$0	$0	$0	$0
Initial planting	$2,512	$3,546	$0	$0	$0	$0
Construction of combined measures across all areas	$49,774	$0	$0	$0	$0	$0
OPEX						
Maintenance/replacement of non-surviving plantings	$0	$115	$115	$0	$0	$0
Enforcement	$17	$17	$17	$17	$17	$17
Travel costs for support	$10	$10	$10	$10	$10	$10
Annual maintenance for combined measures	$137	$137	$137	$137	$137	$137
Repair and rebuilding of combined measures after storm events of current 2019 rainfall	$109	$109	$109	$109	$109	$109
Taxes - Revegetation of land	$277	$449	$0	$0	$0	$0
Taxes - Combined measures	$8,503	$42	$42	$42	$42	$42
Total Financial Costs	$76,754	$5,770	$701	$591	$596	$601

What can be noted from the table above is the following:

5. Annual house damage compensation due to storm events

The annual house damage compensation calculated per ha per year considers the total resettlement cost of $26,000 and the probable number of movements/resettlements per year in the “with project scenario”. And it is seen that the compensation is bound to decrease as the benefits of the solution measures are activated.

It is important to note that the household damage compensation costs are calculated annually in a decreasing rate since the solution measures provide damage prevention. However, it was clarified to the consultant that by 2036 a bigger storm would hit the area compared to the annual expected storms. For this reason, the compensation cost of resettlement and house damage needs re-investing and so the cost in 2037 returns back to the initial 2020 costs and continues to decrease as investment in the reconstructions and replantation take place and benefits will be re-accrued.

6. Ecological restoration and Initial planting

These values were taken from the “Plantation Land Cost” Table previously stating the total cost of each activity in USD per hectare. The total capital costs represented by the one time activities or capital activities were divided in two years, to be paid off in two years.

7. Construction of combined measures across all areas

This includes the total investment cost for all the sites regarding the construction of drainage channels, retention basins, shore protections, dikes, etc. The total cost is $8.7 million for the total 175 ha which equals to $49,774 per hectare.

8. The Operational Expenditures (OPEX)

The OPEX includes maintenance costs, repairs and taxes costs on revegetated land and combined grey infrastructure measures. The costs are calculated per ha per year and are assumed to be consistent throughout the years.

The total financial costs include all CAPEX and OPEX in addition to the tax rates.

The table below presents the financial benefits accrued from taking the solution measures. The benefit stream was provided by the storm protection of houses calculated by the difference in compensation and resettlement cost between the “with and without project scenario” as aforementioned.

The financial benefits include benefits accrued from mat weaving and avoided household damages.

Table 3-13: With Project Scenario Financial Benefits per Hectare per Year

Year	2020	2021	2022	2023	2024	2025
Years:	1	2	3	4	5	6
Included in timeframe?	Yes	Yes	Yes	Yes	Yes	Yes
Financial Benefits						
Mat Weaving	$15,515	$22,165	$22,165	$22,165	$22,165	$22,165
House damage prevention with solution measures	$34,197	$1,368	$1,988	$2,083	$2,182	$2,286
Total Financial Benefits	$49,712	$23,533	$24,153	$24,248	$24,347	$24,451

What can be noted from the table above is the following:

3. Mat Weaving

The total revenue then considering that one mat costs $1.50 across the 33 ha results in 22,165 $/ha/year. Further explanation on this benefit is aforementioned above.

4. House damage prevention with solution measures

The values represent the difference in cost of household compensation in the “without project” scenario. Details of this benefit are explained in the chapters above.

After calculating the financial net present value (FNPV) and discounting it at 6% for 31 years, the total sum NPV for the proposed measures was 189,384 $/ha.

3.5.2 Economic Analysis

The economic analysis, in regards to the economic costs, adjusts the financial costs by calculating the sum of all costs considered (not including transfer payments such as taxes). The economic benefits include the carbon sequestration benefits as well as the socio-economic benefit by reduced risk. As aforementioned in sub section 3.3.4 Value of Carbon, the following lists the assumptions taken:

1. Assume that the 4 carbon prices were net of transaction and measurement, reporting and verification (MRV) costs and would not increase over time with climate change
2. Assume that the benefits of carbon sequestration could not be sold due to the limited involvement of Mozambique in the carbon offset market, in addition to lack of information on the transaction and MRV costs. Therefore, carbon benefits are considered in the economic analysis.
3. The Consultant therefore did not include marketable carbon sequestration benefits in the financial and economic analysis as a benefit to the communities or government nor as an extra market value to society.
4. The sum of the differences of the socio-economic risk value differences, in the “with and without project” scenario, was calculated resulting in $22,157 in reduction of risk in an annual basis. The risks would gradually increase somewhat, given gradual sea level rise. The risk values were considered for 2031 horizon. Given the uncertainty of some inputs, the risk levels were mitigated.

The table below lists the costs considered for the economic costs including the capital and operational costs of green revetment activities, construction activities, enforcement, maintenance and repair and rebuilding after storm events. The only difference between the financial and economic costs is the inclusion of taxes, where the economic cost does not include transfer payments such as taxes.

Table 3-14: With Project Scenario Economic Costs per Hectare per Year

Year	2020	2021	2022	2023	2024	2025
Years:	1	2	3	4	5	6
Included in timeframe?	Yes	Yes	Yes	Yes	Yes	Yes
Costs						
CAPEX						
Annual house damage compensation due to storm events	$14,656	$586	$271	$276	$281	$286
Ecological restoration	$758	$758	$0	$0	$0	$0
Initial planting	$2,512	$3,546	$0	$0	$0	$0
Construction of combined measures across all areas	$49,774	$0	$0	$0	$0	$0
OPEX						
Maintenance/replacement of non-surviving plantings	$0	$115	$115	$0	$0	$0
Enforcement	$17	$17	$17	$17	$17	$17
Travel costs for support	$10	$10	$10	$10	$10	$10
Annual maintenance for combined measures	$137	$137	$137	$137	$137	$137
Repair and rebuilding of combined measures after storm events of current 2019 rainfall	$109	$109	$109	$109	$109	$109
Total Economic Costs	$67,974	$5,279	$660	$549	$554	$560

The table below presents the economic benefits of revegetation of land at four different carbon values in addition to the socio-economic benefits by reduced risks:

Table 3-15: Incremental Economic Benefits from Plantation of Land per Hectare

Year	2020	2021	2022	2023	2024	2025
Years:	1	2	3	4	5	6
Included in timeframe?	Yes	Yes	Yes	Yes	Yes	Yes
Total Financial Benefits	$49,712	$23,533	$24,153	$24,248	$24,347	$24,451
Economic Benefits						
Socio-economic benefit by reduced risk		*$ 22,100*	*$ 22,100*	*$ 22,100*	*$ 22,100*	*$ 22,100*
Carbon stocks (Carbon Price #1)	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
Carbon stocks (Carbon Price #2)	$17,397.35	$18,948.85	$22,089.31	$30,145.68	$41,831.29	$67,296.32
Carbon stocks (Carbon Price #3)	$32,620.03	$35,529.10	$41,417.46	$56,523.15	$78,433.68	$126,180.61
Carbon stocks (Carbon Price #4)	$54,366.72	$59,215.17	$69,029.10	$94,205.25	$130,722.79	$210,301.01

As aforementioned above, the sum of the socio-economic risk value differences, in the “with and without project” scenario, was calculated resulting in $22,100 in reduction of risk in an annual basis. The risks would gradually increase somewhat, given gradual sea level rise. The risk values were considered for 2031 horizon. Given the uncertainty of some inputs, the risk levels were mitigated.

As for the benefits accrued from the carbon sequestration; it included 4 different carbon prices in the sensitivity analysis—price #1 ($0), price #2 ($8), price #3 ($15), and price #4 ($25) per tCO2e

The table below presents the economic EPV per ha for the four carbon prices over the 31 year time horizon at a 6% discount rate. The economic NPV ranged from of 201,586 $/ha min at a carbon price 0$/tCO2e to 1,861,651 $/ha at a carbon price of 25$/tCO2e.

Table 3-16: Economic Net Present Value of Revegetated Land by Carbon Prices at 6% discount rate

Carbon Price [$/tCO2e]	Economic Net Benefit [$/ha]	Economic Net Benefit [$]
$ -	$ 201,586	$ 35,430,210
$ 8.00	$ 732,807	$ 128,795,971
$ 15.00	$ 1,197,625	$ 210,491,011
$ 25.00	$ 1,861,651	$ 327,198,212

3.6 RESULTS OF THE BASE CASE SCENARIO

The economic net present values (NPV) of solution measures exceeded those of the financial NPV with a financial rate of return of 19.08% at a 6 % discount rate and an economic internal rate of return of 573.15% at 6% discount rate at carbon price #4; 25 $/tCO2e. In addition to the economic benefit accrued from carbon sequestration, the socio-economic benefits realized by reduction in risk levels subject to willingness for funding of mitigation measures estimates an EIRR of 52.64%.

Table 3-17: Annuity Values for Financial and Economic Assessments

Annuity Values - Financial	*NPV*	*FIRR*
0% discount rate	*$17,407*	19.08%
3% discount rate	*$15,584*	
6% discount rate	*$13,596*	
12% discount rate	*$9,409*	
Annuity Values - Economic	***NPV***	***EIRR***
6% discount rate (socio-economic benefit by reduced risk)	$35,075	52.64%
6% discount rate (Carbon Price #1)	$14,472	22.48%
6% discount rate (Carbon Price #2)	$52,610	81.11%
6% discount rate (Carbon Price #3)	$85,980	158.17%
6% discount rate (Carbon Price #4)	$133,652	573.15%

With a total area of 175 ha allocated for the solution measures, the total investment cost was calculated to equalling around $ 8.7 million; of which the following CAPEX per site were considered:

Site No.	Total Investment cost per SiteUS $
Site 1	$ 980,073
Site 2	$ 750,000
Site 3&4	$ 724,449
Site 5	$ 47,235
Site 6	$ 3,397,991
Site 7	$ 1,156,829
Site 8	$ 742,262
Site 9	$ 51,000
Site 10	$ 596,275
Site 12	$ 230,652
various	$ 71,300
Total	**$ 8,748,066**

The financial and economic benefits accumulated over the period of 50 years for the total number of hectares of the study area (175 ha) were calculated at a 6% discount rate. The following table summarize the results. Although results are sensitive to the carbon price assumption, the solution measures will still have a positive NPV at carbon price of zero.

The financial and economic benefits accumulated over the period of 31 years for the total number of hectares of the study area (175 ha) were calculated at a 6% discount rate. The following table summarize the results:

Table 3-17: Base Sensitivity Financial and Economic Net Present Values of Solution Measures per Hectare at a 6% Discount Rate

USD Per Hectare at 6 % discount rate	
Scenario:	***Solution measures***
Financial Net Benefits	$189,384
Financial Annualized Value	$13,596
Socio-economic benefit by reduced risk	$488,566
$0 Carbon Price	
Economic Net Benefits	$201,586
Economic Annualized Value	$14,472
$8 Carbon Price	
Economic Net Benefits	$732,807
Economic Annualized Value	$52,610
$15 Carbon Price	
Economic Net Benefits	$1,197,625
Economic Annualized Value	$85,980
$25 Carbon Price	
Economic Net Benefits	$1,861,651
Economic Annualized Value	$133,652

Table 3-18: Base Sensitivity Financial and Economic Net Present Values of Solution Measures at a 6% Discount Rate

Total Value in USD for 175 ha at 6% discount rate	
Scenario:	***Solution measures***
Financial Net Benefits	$33,285,526
Financial Annualized Value	$2,389,644
Socio-economic benefit by reduced risk	$85,868,901
$0 Carbon Price	
Economic Net Benefits	$35,430,210
Economic Annualized Value	$2,543,615
$8 Carbon Price	
Economic Net Benefits	$128,795,971
Economic Annualized Value	$9,246,551
$15 Carbon Price	
Economic Net Benefits	$210,491,011
Economic Annualized Value	$15,111,619
$25 Carbon Price	
Economic Net Benefits	$327,198,212
Economic Annualized Value	$23,490,288

The results show that both the economic benefits and the financial benefits have a positive result with the financial benefits reaching around$ 33 million and the socio-economic benefits by risk reduction equalling around $ 85 million, in addition to carbon sequestrated economic benefit reaching $35 million at $0 carbon price. The Consultant calculated the financial internal rate of return (FIRR), as previously calculated, and it showed that with a discount rate of 19.08% can achieve breakeven.

3.7 SENSITIVITY ANALYSIS

W&H considered a sensitivity analysis to assess the changes in the net present values as key assumptions were modified. The factors that had the largest impact in the analysis were the survival rate of the plants and resettlement cost. The models also demonstrated that there is an indirect impact between plant survival rate and resettlement cost. Integrating further information in the model on the correlation of plant survival rate and storm intensity and frequency could provide for clearer correlations. Additionally, further information on the impact of plant survival rates and urban survival rates on resettlement costs would allow for improvement of the model as well. The table below presents the assumptions used in the base scenario and modified for a low and high sensitivity analysis.

Table 3-19: Assumptions Modified in the Sensitivity Analyses

Parameters	Base Scenario	Low Scenario	High Scenario
Time horizon [years]	31	31	31
Discount rates [%]	0%, 3%, 6%, 12%	0%, 3%, 6%, 12%	0%, 3%, 6%, 12%
Mangrove survival rate after maturity [%]	80%	50%	100%
Seedling survival rate [%]	90%	50%	100%
Carbon price	n.a	n.a	n.a
Green Revetment	100%	50%	100%
Average resettelment cost [USD]	26,000	13,000	26,000
Mat weaving benefits accrued [%]	70 % first year 100% second year	40 % first year 50% second year	80 % first year 100% second year
Socio-economic risk probability with scenario	1%	2%	1%
Socio-economic risk probability without scenario*			
Catchment areas 1,3,4,10,12	20%	30%	20%
Catchment areas 2,5,6,8,9	2%	3%	2%
Catchment area 7	1%	2%	1%

The tables provide the sensitivity analysis results for the lower and higher bound scenarios.

Summary results (NPV) for overall low sensitivity analysis:

Table 3-20: Low Sensitivity Financial and Economic Net Present Values of Solution Measures per

Hectare at a 6% Discount Rate

USD Per Hectare at 6 % discount rate	
Scenario:	***Solution measures***
Financial Net Benefits	$51,079
Financial Annualized Value	$3,667
Socio-economic benefit by reduced risk	$506,272
$0 Carbon Price	
Economic Net Benefits	$63,281
Economic Annualized Value	$4,543
$8 Carbon Price	
Economic Net Benefits	$478,400
Economic Annualized Value	$34,345
$15 Carbon Price	
Economic Net Benefits	$841,630
Economic Annualized Value	$60,422
$25 Carbon Price	
Economic Net Benefits	$1,360,529
Economic Annualized Value	$97,675

Table 3-21: Low Sensitivity Financial and Economic Net Present Values of Solution Measures at a 6% Discount Rate

Total Value in USD for 175 ha at 6% discount rate	
Scenario:	***Solution measures***
Financial Net Benefits	$8,977,461
Financial Annualized Value	$644,514
Socio-economic benefit by reduced risk	$88,980,769
$0 Carbon Price	
Economic Net Benefits	$11,122,145
Economic Annualized Value	$798,486
$8 Carbon Price	
Economic Net Benefits	$84,082,233
Economic Annualized Value	$6,036,452
$15 Carbon Price	
Economic Net Benefits	$147,922,310
Economic Annualized Value	$10,619,673
$25 Carbon Price	
Economic Net Benefits	$239,122,421
Economic Annualized Value	$17,167,131

Summary results (NPV) for overall high sensitivity analysis:

Table 3-22: High Sensitivity Financial and Economic Net Present Values of Solution Measures per Hectare at a 6% Discount Rate

USD Per Hectare at 6 % discount rate	
Scenario:	***Solution measures***
Financial Net Benefits	$192,251
Financial Annualized Value	$13,802
Socio-economic benefit by reduced risk	$491,434
$0 Carbon Price	
Economic Net Benefits	$204,454
Economic Annualized Value	$14,678
$8 Carbon Price	
Economic Net Benefits	$1,178,621
Economic Annualized Value	$84,616
$15 Carbon Price	
Economic Net Benefits	$2,031,017
Economic Annualized Value	$145,811
$25 Carbon Price	
Economic Net Benefits	$3,248,726
Economic Annualized Value	$233,233

Table 3-23: High Sensitivity Financial and Economic Net Present Values of Solution Measures at a 6% Discount Rate

Total Value in USD for 175 ha at 6% discount rate	
Scenario:	***Solution measures***
Financial Net Benefits	$33,789,522
Financial Annualized Value	$2,425,827
Socio-economic benefit by reduced risk	$86,372,897
$0 Carbon Price	
Economic Net Benefits	$35,934,206
Economic Annualized Value	$2,579,798
$8 Carbon Price	
Economic Net Benefits	$207,150,882
Economic Annualized Value	$14,871,824
$15 Carbon Price	
Economic Net Benefits	$356,965,474
Economic Annualized Value	$25,627,346
$25 Carbon Price	
Economic Net Benefits	$570,986,319
Economic Annualized Value	$40,992,377

4 CONCLUSIONS

NACALA

The CBA assessed the financial and economic viability of the flood management solution measures considered by the Consultant for Nacala City. A study area across 11 catchment areas and 1,296 ha were allocated for the solution measures where 977 ha was used for revegetation of land, 244 ha used for urban gardening and 75 ha used for combined measures (rehabilitation of drainage system, toe protection of gullies and retention ponds).

The solution measures had a positive economic net present value which exceeded that of the financial net present value in the base scenario. For the project to reach financial breakeven the discount rate should be 1.26%. It could have resulted with a higher bound estimate of the total financial and economic viability if the value of human health and safety and other benefits were considered. More research would be required to help estimate benefits that were not included in this analysis, including reduced human health and safety risks as well as water filtration, biodiversity, and existence values for the revegetated land.

QUELIMANE

The CBA for Quelimane assessed the financial and economic viability of the storm management solution measures considered by the Consultant for Quelimane City. A study area across 11 catchment areas and 175 ha were allocated for the solution measures which included:

- Green revetment with a total area of 95 ha which includes
  - 31 ha for grass communities such as Vetiver grass, elephant grass, LM grass and red grass
  - 33 ha for wetland plant mix including multiple cyperus species, common reed and more
  - 33 ha for mangroves
- Combined measures solution across 80 ha including construction of drainage systems, shore protections, retention basins and protection bridges.

The solution measures had a positive economic and financial net present value. For the project to reach financial breakeven the discount rate should be 19.08%. Similarly to Nacala, it could have resulted with a higher bound estimate of the total financial and economic viability if the value of human health and safety and other benefits were considered. More research would be required to help estimate benefits that were not included in this analysis, including reduced human health and safety risks as well as water filtration, biodiversity, and existence values for the revegetated land

RECOMMENDATIONS

It is recommended that further investigation should be taken regarding topics such as; market price developments and market demand for housing plots, agricultural products or straw mats or woods, and possibly fishery / aquaculture and population development, social structures.

It is also recommended that further investigation should be taken regarding risk prevention measures to be adopted in the cities. This includes organization for defence and combat against heavy storms to cater for protective measures in safe places. This would require organized communicative interaction with the public, shelter, food stock, facilities, and potable water. Establishment of such an organizational means could benefit from such assistance measures.

5 REFERENCES

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6 ANNEX 1: NACALA

CES SURVEY 2018 AND 2019

The following section is divided as per the CEADIR CBA structure. It includes questions regarding certain parameters and values needed to complete the CBA for Nacala.

1. What is the project life (years) for sensitivity analysis?

50 years

2. What is the survival rate of revegetated land?

90%

3. How can the locals benefit from the revegetated land? Economically, what does it give back to the society?

Urban Gardening will be proposed as part of the revegetated land (assumption for the moment: 20% of the area proposed for revegetation will be used for urban gardening)

4. What is the number of hectares of in each catchment area?

Catchment Area	Total land area [ha]	Land area allocated for revegetation of land [ha]	Land area allocated for combined measures [ha]	% share of land area allocated for the solution measures
Area 1	929	650	0	70% To be Revegetated
Area 2	75	53	0	70% To be Revegetated
Area 3	108	75	0	70% To be Revegetated
Area 4	175	122	0	70% To be Revegetated
Area 5	351	246	0	70% To be Revegetated
Area 6	164	8	8	5% To be Revegetated, 5% for Combined Measures
Area 7	275	14	14	5% To be Revegetated, 5% for Combined Measures
Area 8	76	4	4	5% To be Revegetated, 5% for Combined Measures
Area 9	533	27	27	5% To be Revegetated, 5% for Combined Measures
Area 10	154	8	8	5% To be Revegetated, 5% for Combined Measures
Area 11	301	15	15	5% To be Revegetated, 5% for Combined Measures
Area 12	5,257	-	0	-
Area 13	10,121	-	0	-
Total	**18,519**	**1,221**	**75**	

5. What is the total number of households/Industrial buildings in all catchment areas and what is the number of households per hectare? (regardless of whether affected or not by the rainfall)

Parameter	Value
Total number of households Nacala (estimated)	50,760
Total number of households - affected	5,401
Number of households per hectare	3

6. What is the total affected population in all catchment areas?

Parameter	Value
Total population in catchment areas	249,602
Total population affected	27,005

7. What is the percentage of homes/industrial buildings damaged in medium and large events, considering proposed measures taken (nature based and combined measures)?

Parameter	Value
Base line	
Number of homes damaged in current event	2,701
Number of homes damaged in 2036	5,401
Solution measures	
Number of homes damaged in current event	842
Number of homes damaged in 2036	1,137

8. What is the total area dedicated to revegetation of unused land?

Parameter	Catchment Areas	Total Area [ha]
Revegetation around gullies (vetiver grass, elephant grass and Moringa trees)	n.a.	977
Urban Gardening	n.a.	244
Total Revegetation area	Areas 1 to 11	1,221

9. How many years will it take for the land to be fully revegetated? And how many years will it take for the benefits of revegetated land to be accrued?

Parameter	Years
Year to full revegetated land	Year 1: 20% Effectiveness Year 2: 70% Effectiveness

	Year 3: 100% Effectiveness

10. What is the licensing cost for concessions of land that have been issued so far?

Utilized land is owned by municipality and according to available information currently unused.

11. What are the economic and financial benefits that come with revegetation of land
    a. Financial Benefits of Revegetation of land
        i. Erosion protection
        ii. Agriculture production – urban gardening
    b. Economic Benefits of Revegetation of land:
        i. CO2 sequestration

12. What is the annual probability of an extreme event?

In addition: extreme event = critical flow in gullies. Event happens regularly in rainy season in case of heavy rainfall events, basic assumption: 10 times per year

13. What are the costs that come with the combined measures used in this study?

Combined Measures	
Area for combined measures (ha)	75
Retention pond cost	Retention pond
Total cost of retention pond [USD]	$396,000
Cost of construction of retention pond [USD/pond]	$4,000
Number of retention ponds	99
Annual Maintenance cost [USD/year]	$500
Total Repair cost after current rainfall 2019 [USD]	$200
Total Rebuilding cost after heavy rainfall 2036 [USD]	$400
Toe protected gullies cost	Toe protection
Total cost of toe protection [USD]	$248,441
Cost of construction of toe protection within gullies [USD/m]	$5.50
Length of toe protection [meters]	45,171
Annual Maintenance cost [USD/m/year]	$1.00
Annual Maintenance cost [USD/year]	$45,171
Repair cost after current rainfall 2019 [USD/m]	$0.20
Total Repair cost after current rainfall 2019 [USD]	$9,034.20
Rebuilding cost after heavy rainfall 2036 [USD/m]	$0.40
Total Rebuilding cost after heavy rainfall 2036 [USD]	$18,068.40
Rehabilitation of Drainage System [USD]	Drainage System
Total Cost of rehabilitating drainage system [USD]	$120,000
Rehabiltation cost per meter	$4.43
Rehabilitation of Drainage System [meters]	27,118
Annual Maintenance cost [USD/year]	$90,000
Total Repair cost after current rainfall 2019 [USD]	$0.00
Total Rebuilding cost after heavy rainfall 2036 [USD]	$0.00

14. What is the price of different crops / vegetables per kg?

Parameter – Price in USD/kg	Value
Maize	0.18
Cassava	0.23
Sorghum	0.28
Rice	0.433
Beans	0.42
Sweet Potatoes	0.32

15. What is the rate of production different crops / vegetables in kg per hectare and year?

Parameter – Production in kg/year*ha	Value
Maize	850
Cassava	4,500
Sorghum	450
Rice	1,200
Beans	450
Sweet Potatoes	1,500

16. What is the rate of production different crops / vegetables in kg per hectare and year?

Crop Produced	Share of Crop per Hectare
Maize	45%
Cassava	45%
Sorghum	2%
Rice	0%
Beans	5%
Sweet Potatoes	3%

17. How would the measures described for this study impact on agricultural production in Nacala? And when will we see an increase in agriculture production i.e. 5 years after revegetation of land or as a result of the combined measures?

1-3 years

18. What is the dimension of a retention pond, (size)?

Size of Construction (AVG.): 100 m³
Retention Volume: ~ 2,000 m³

19. The table below lists the different costs related to revegetation of land considered in the CBA, please fill in the table:

Cost	Unit	Cost/Unit [USD/Unit]	Number of units per month or ha	Number of months
Ecological restoration - labor	Labour	$ 60	100	24
Ecological restoration - materials and equipment	Materials & Equipments		100	
Maintaince after restoration	Person-Days	$ 60.00	10	12
Maintenance after restoration - materials and equipment			10	
Seedlings grass	Grass	$ 0.10	5,000	
Seedlings trees	Trees	$ 0.50	1,000	
Seedling maintainance	Person-Days	$ 60.00	10	24
Planting labor	Person-Days	$ 60	200	18
Safety equipment for implementing partners including masks, gloves, etc for 250 people		$ 15.00	300	24
Transport of seedings from nursery	Truck rental and operations	$ 200	4	18
Bags for grass seedlings * environmentally acceptable bags	Bags	$ 0.10	5,000	
Ropes and stropes for moringa tree seedlings	Ropes and stropes	$ 0.05	1,000	
Replanting moringa trees (once 200 have been harvested every year)	Plants	$ 0.50	200	
Transport of 200 seedings to be replanted from nursery	Truck rental and operations	$ 200	1	12
Ropes and stropes for 200 seedlings	Ropes and stropes	$ 0.05	200	
During Implementation				
Senior staff: 6	Staff	$ 150	6	24
Mid-level staff for each 15 workers 1 foreman (20)	Staff	$ 120	20	24
After Implementation				
Senior staff: 1	Staff	$ 150	1	12
Mid-level staff for each 15 workers 1 foreman (3)	Staff	$ 120	3	12
Junior staff / workers and guards: 45	Staff	$ 60	45	12

20. The table below lists the different costs related to the urban gardening, anticipated as a result of revegetation of land, please fill in the table:

Benefits	Cost	Value [MZN/unit]	Quantity
Agricultural production gardening	Plants/seeds	5.0	20,000
Agricultural production gardening	Water for plants	10	20,000
Agricultural production gardening	Tools and accessories	700	200
Agricultural production gardening	Labour (per hour)	25.0	48,000

21. What is the number of trees/plants grown per hectare?

Vetiver / Elephant Grass: 5,000

Moringa: 1,000

22. What is the initial number of seedlings used for the complete area allocated for the revegetation of land?

100,000

23. What is the harvest rate expected (number of trees per hectare per year)?

200

7 ANNEX 2: QUELIMANE

CES SURVEY RESULTS

The total investment cost per site in US Dollars

Site No.	Total Investment cost per SiteUS $	
Site 1	$	980,073
Site 2	$	750,000
Site 3&4	$	724,449
Site 5	$	47,235
Site 6	$	3,397,991
Site 7	$	1,156,829
Site 8	$	742,262
Site 9	$	51,000
Site 10	$	596,275
Site 12	$	230,652
various	$	71,300
Total	**$**	**8,748,066**

Total areas of solution measures in squared meters, converted then to hectares for calculations

Location	Area [m²]	Area	Grass community	Wetland plant mix	Mangroves	Area for Construction Measures [m²]
Whole area of Quelimane	**30,086,737**					
Site 1	2,141,930	214,190	107,100	107,100		107,100
Site 2	337,510					16,880
Site 3&4	5,094,020	127,350	76,410	50,940		254,700
Site 5	1,577,200	157,720	31,540		126,180	78,860
Site 6	635,990	159,000	31,800		127,200	63,600
Site 7	291,460	14,570	14,570			14,570
Site 8	2,882,810	72,070			72,070	144,140
Site 9	2,933,340	146,670		146,670		73,330
Site 10	497,070	12,430	12,430			24,850
Site 12	473,120	47,310	23,660	23,660		23,660
Sum (Sites 1 to 12)	**16,864,450**	**951,310**	**297,510**	**328,370**	**325,450**	**801,690**

Number of Houses in Quelimane and number of inhabitants within the site areas

Location	Area [m²]	Area with houses [m²]	Numbers of houses [-]	Number of inhabitants (5 / house)	Number of inhabitants (10 / house)
Whole area of Quelimane	**30,086,737**	**30,086,737**	**34,152**	**170,760**	**341,520**
Site 1	2,141,932	255,418	660	3,300	6,600
Site 2	337,505	127,423	72	360	720
Site 3&4	5,094,018	5,094,018	9,636	48,180	96,360
Site 5	1,577,203	479,436	511	2,555	5,110
Site 6	635,988	319,622	516	2,580	5,160
Site 7	291,464	167,316	421	2,105	4,210
Site 8	2,882,806	1,653,645	1,681	8,405	16,810
Site 9	2,933,343	678,775	93	465	930
Site 10	497,066	330,640	84	420	840
Site 12	473,118	149,227	145	725	1,450
Sum (Sites 1 to 12)	**16,864,443**	**9,255,519**	**13,819**	**69,095**	**138,190**

General description of study site areas and affected population and number of house-holds

General Parameters	
Meticais per US D	63.97
Value-added Tax Rate	17%
Area of location site m²	
Catchment Area 1	2,141,930
Catchment Area 2	337,510
Catchment Area 3 and 4	5,094,020
Catchment Area 5	1,577,200
Catchment Area 6	635,990
Catchment Area 7	291,460
Catchment Area 8	2,882,810
Catchment Area 9	2,933,340
Catchment Area 10	497,070
Catchment Area 12	473,120
Total	16,864,450
Number of m² for solution measurements	16,864,450
Whole area of Quelimane m²	30,086,737
Total Number of Households in catchment area	100,540
Number of people per household	10
Total population in catchment areas (10/house)	138,190
Total population affected	63,375

The table below lists the multiple solution measures considered and their corresponding costs

Site No.	Description	Position	Site No.	Qty.	Unit	Total Price US $	Total Investment cost per Site US $ Considered as CAPEX per Site/area
1	Construction of drainage channel/ pipes (airport)	D1	1	2012	m	$181,080	**$980,073**
	Construction of drainage channels/ pipes	D2	1	619	m	$37,140	
		D3	1	802	m	$48,120	
	Construction of retention basins/ ponds	R1	1	1		$295,515	
		R2	1	1		$186,609	
		R3	1	1		$186,609	
	Construction of outlets/ flap gates	O/F6	1	1	ls	$15,000	
		O/F7	1	1	ls	$15,000	
		O/F8	1	1	ls	$15,000	
2	Construction of shore protection, revetment	SP1	2	300	m	$750,000	**$750,000**
3/4	Construction of drainage channels/ pipes	D4	3/4	1382	m	$82,920	**$724,449**
		D5	3/4	633	m	$37,980	
		D6	3/4	633	m	$37,980	
		D7	3/4	1400	m	$84,000	
		D8	3/4	861	m	$51,660	
		D9	3/4	422	m	$25,320	
		D10	3/4	58	m	$3,480	
		D11	3/4	50	m	$3,000	
		D12	3/4	103	m	$6,180	
		D13	3/4	144	m	$8,640	
		D14	3/4	17	m	$1,020	
	Construction of retention basin/ ponds	R4	3/4		ls	$21,166	
		R5	3/4		ls	$24,499	
		R6	3/4		ls	$54,173	
		R7	3/4		ls	$58,368	
		R8	3/4		ls	$69,717	
		R9	3/4		ls	$99,617	
		R10	3/4		ls	$24,484	
		R11	3/4		ls	$30,245	
5	Construction of green revetment	GRS1	5	3149	m	$47,235	**$47,235**
6	Construction of drainage channel/ pipes (airport)	D15	6	1055	m	$94,950	**$3,397,991**
	Construction of drainage channels/ pipes	D16	6	168	m	$10,080	
		D17	6	478	m	$28,680	
		D18	6	490	m	$29,400	
		D19	6	292	m	$17,520	
	Construction of outlets/ flap gates	O/F1	6	1	ls	$15,000	
		O/F2	6	1	ls	$15,000	
		O/F3	6	1	ls	$15,000	
		O/F4	6	1	ls	$15,000	
		O/F5	6	1	ls	$15,000	
	Construction of dike with green revetment	DGR1	6	1980	m	$1,265,715	
	Protection and re-growing of mangroves	PM1	6	938323	m2	$1,876,646	
7	Construction of outlets/ flap gates	O/F9	7	1	ls	$15,000	**$1,156,829**
	Construction of retention basin/ ponds	R12	7	1	ls	$29,969	
	Construction of dike with green revetment	DGR2	7	1740	m	$1,111,860	

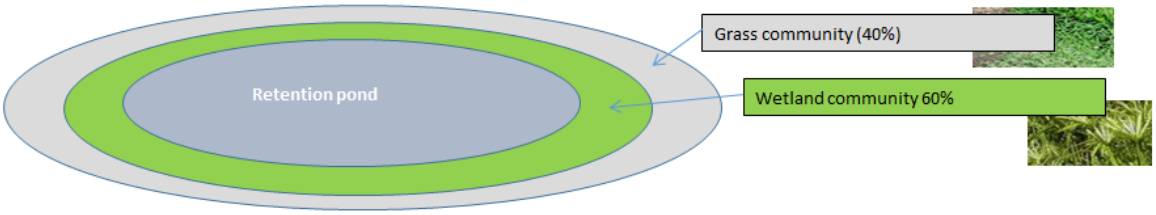
Site No.	Description	Position	Site No.	Qty.	Unit	Total Price US $	Total Investment cost per Site US $ Considered as CAPEX per Site/area
8	Protection and re-growing of mangroves	PM2	8	114904	m2	$284,962	**$742,262**
	Construction of revetment	RV1	8	836	m	$355,300	
	Construction of protection of bridge abutment (revetment)	PB1	8	1	ls	$25,500	
		PB2	8	1	ls	$25,500	
		PB3	8	1	ls	$25,500	
		PB4	8	1	ls	$25,500	
9	Construction of protection of bridge abutment (revetment)	PB5	9	1	ls	$25,500	**$51,000**
		PB6	9	1	ls	$25,500	
10	Construction of revetment	RV2	10	1403	m	$596,275	**$596,275**
12	Construction of retention basin/ ponds	R13	12	1	ls	$230,652	**$230,652**
various	Rehabilitation of existing drainage channels	EC1		817	m	$4,085	**$71,300**
		EC2		1130	m	$5,650	
		EC3		1709	m	$8,545	
		EC4		2619	m	$13,095	
		EC5		2664	m	$13,320	
		EC6		1378	m	$6,890	
		EC7		1362	m	$6,810	
		EC8		1517	m	$7,585	
		EC9		268	m	$1,340	
		EC10		380	m	$1,900	
		EC11		238	m	$1,190	
		EC12		178	m	$890	
in general	maintenance cost green revetment (1.5 years)			1	ls	$11,000	**$11,000**
							$8,748,066

Assumptions and Propositions regarding Plant Based Measures:

1 Proposed plant mix

1.1 Retention ponds

It was assumed that one fifth of the area of each retention pond would be planted, around the outside edge of the pond. It is proposed that within the planted area, approximately 40% of the area should be planted with low, ground-cover grass species ("grass community"), with these species planted on the outer margin of the planted area. The remaining 60% should be a mix of taller wetland plants ("wetland community"), planted along the inner edge of the planted area.



1.2 Slopes

The slopes should be planted with low, ground-cover grass species only.

2 Ecosystem services (benefits) provided by the two communities

2.1 Grass community:

- Erosion control
- Grazing / foraging (goats, chickens, cattle)
- Carbon accumulation (mostly in the soils)

o Dry grasslands (UK): 117 – 435 t C ha^{-1} (different soils – podsols, calcareous, gley soils)

- Biodiversity

2.2 Wetland community

- Harvesting for building materials
- Harvesting for basket or mat weaving (especially the *Cyperus* species, reed (Phragmites) and elephant grass) - SEE BELOW FOR COSTING OF THIS BENEFIT
- Medicinal purposes (bulbs/leaves, roots of some wetland plants)
- Carbon accumulation (Alonso et al., 2012):
  - Peatlands (globally): 0.1 - 0.46 t C ha^{-1} yr^{-1}
  - Grassed wetlands (globally): 3.05 t C ha^{-1} yr^{-1},
  - Rivers (globally): 1.6 - 2.2 t C ha^{-1} yr^{-1}
  - Constructed wetlands (globally): 22 t C ha^{-1} yr^{-1}
- Erosion control
- Water quality improvement
- Flood attenuation

COSTING OF BENEFIT FROM BASKET AND MAT WEAVING
Species that are (can be) used for basket and mat weaving:
All *Cyperus* species
Phragmites australis (common reed)

One mat costs 100 meticais (roughly $1.50). For Phragmites (common reed), probably 20 plants would be required for one mat. For Cyperus, it would be roughly 50 plants.
Mat woven out of common reed (Phragmites australis) which is seen growing in the background (sells for 100 meticais)

Description of Plantations used for Green Revetment:

Vetiver grass [Chrysopogon zizanioides]						
No of plants per m²	Plantation cost per plant (US $) [CAPEX]	Carbon absorbtion per plant in mg per year	Year of plantation	term to achieve foll carbon absortion capacity	re-plantation in percent of no of plants	Recurrent cost for cultivation and re-plantation (OPEX) in US$ p.Year and plant
4	1	n/a - see Carbon sequestration	2020	2	25	0.28

Elephant grass [Pennisetum purpureum]						
No of plants per m²	Plantation cost per plant (US $) [CAPEX]	Carbon absorbtion per plant in mg per year	Year of plantation	term to achieve foll carbon absortion capacity	re-plantation in percent of no of plants	Recurrent cost for cultivation and re-plantation (OPEX) in US$ p.Year and plant
4	1	n/a - see Carbon sequestration	2020	3	25	0.28

Buffalo grass [Stenotaphrum secondatum]						
No of plants per m²	Plantation cost per plant (US $) [CAPEX]	Carbon absorbtion per plant in mg per year	Year of plantation	term to achieve foll carbon absortion capacity	re-plantation in percent of no of plants	Recurrent cost for cultivation and re-plantation (OPEX) in US$ p.Year and plant
4	1	n/a - see Carbon sequestration	2020	2	10	0.13

LM grass [Dactyloctenium austral]						
No of plants per m²	Plantation cost per plant (US $) [CAPEX]	Carbon absorbtion per plant in mg per year	Year of plantation	term to achieve foll carbon absortion capacity	re-plantation in percent of no of plants	Recurrent cost for cultivation and re-plantation (OPEX) in US$ p.Year and plant
4	1	n/a - see Carbon sequestration	2020	2	10	0.13

Common crowfoot [Dactyloctenium aegyptium]						
No of plants per m²	Plantation cost per plant (US $) [CAPEX]	Carbon absorbtion per plant in mg per year	Year of plantation	term to achieve foll carbon absortion capacity	re-plantation in percent of no of plants	Recurrent cost for cultivation and re-plantation (OPEX) in US$ p.Year and plant
4	1	n/a - see Carbon sequestration	2020	2	10	0.1

Basket grass [Cyperus textilis]						
No of plants per m²	Plantation cost per plant (US $) [CAPEX]	Carbon absorbtion per plant in mg per year	Year of plantation	term to achieve foll carbon absortion capacity	re-plantation in percent of no of plants	Recurrent cost for cultivation and re-plantation (OPEX) in US$ p.Year and plant
2	2	n/a - see Carbon sequestration	2020	3	25	0.53

Miniature papyrus [Cyperus prolifer]						
No of plants per m²	Plantation cost per plant (US $) [CAPEX]	Carbon absorbtion per plant in mg per year	Year of plantation	term to achieve foll carbon absortion capacity	re-plantation in percent of no of plants	Recurrent cost for cultivation and re-plantation (OPEX) in US$ p.Year and plant
1	4	n/a - see Carbon sequestration	2020	3	25	1.03

Papyrus [Cyperus papyrus]						
No of plants per m²	Plantation cost per plant (US $) [CAPEX]	Carbon absorbtion per plant in mg per year	Year of plantation	term to achieve foll carbon absortion capacity	re-plantation in percent of no of plants	Recurrent cost for cultivation and re-plantation (OPEX) in US$ p.Year and plant
1	4	n/a - see Carbon sequestration	2020	4	25	1.03

Common reed (Phragmites australis)						
No of plants per m²	Plantation cost per plant (US $) [CAPEX]	Carbon absorbtion per plant in mg per year	Year of plantation	term to achieve foll carbon absortion capacity	re-plantation in percent of no of plants	Recurrent cost for cultivation and re-plantation (OPEX) in US$ p.Year and plant
4	0	n/a - see Carbon sequestration	2020	2 - 3	0	0

Red grass [Themeda triandra]						
No of plants per m²	Plantation cost per plant (US $) [CAPEX]	Carbon absorbtion per plant in mg per year	Year of plantation	term to achieve foll carbon absortion capacity	re-plantation in percent of no of plants	Recurrent cost for cultivation and re-plantation (OPEX) in US$ p.Year and plant
4	1	n/a - see Carbon sequestration	2020	2	10	0.13