# Annex 3 – Economic and Financial Analysis

## 1. Introduction

As described in the funding proposal, the aim of the proposed EDA programme "Climate change adaptation solutions for Local Authorities in the Federated States of Micronesia" is to shift the status quo from a pathway of climate vulnerability and limited socioeconomic development for vulnerable communities in the Federated States of Micronesia (FSM) to one of improved food and water security, enhanced disaster risk reduction and recovery, and improved socioeconomic development by building local adaptive capacity to respond to climate change.

As of 2020, FSM's estimated population is 115,021, with a GDP of USD 408 million and a GDP per capita of almost USD 3,550. The majority of the country's population live in the coastal regions of the high islands, with more than half the population living in rural areas. According to the Household Income and Expenditure Survey (HIES), one requires an average of USD 1.84 per adult per day to meet basic caloric needs in FSM and USD 4.34 per adult per day to meet all basic needs. Across FSM, approximately 10% of the population falls below the food poverty line and approximately 41% of the population falls below the total basic needs poverty line.

Sea level rise and extreme weather events such as typhoons and storms are important risks for communities and infrastructure throughout FSM. These storms can have devastating impacts on both communities and infrastructure. Lower-lying atolls are especially vulnerable to inundation events and the loss of arable land from projected sea level rise and extreme tide events, which would severely impact the food security of local communities as a large share of the population relies on subsistence agriculture for their livelihoods. With projections of increased sea level rise under all climate scenarios and an increase in extreme high tide events due to climate change, resources and livelihoods will become more vulnerable in the future. Sea level rise and tidal surges and consequent seawater inundation along with extreme climate events are particular threat to the FSM as approximately 60% of households in FSM live within 180 meters of the shoreline.

Furthermore, extreme precipitation events and the intensity of typhoons and tropical storms are expected to increase in the future due to climate change. Lastly, climate projections suggest that the frequency and occurrence of higher maximum daily temperatures will dramatically increase for Pohnpei and FSM as a whole. Projections under all emissions scenarios indicate that the annual average air temperature and sea-surface temperature will increase in the future in FSM.

Therefore, all of the FSM states are susceptible to acute climate risks such as extreme rainfall events, drought, high sea levels, strong winds and extreme high air temperatures. FSM is particularly vulnerable to climate change and likely to suffer serious, adverse environmental, social and economic consequences. Limited infrastructure, geographic remoteness and dependence on US aid exacerbate the country's vulnerability.

According to the Notre Dame Global Adaptation Initiative (ND-GAIN), FSM is the fourth most vulnerable country to climate change and the 78th least ready country in the world (FSM scored 0.640 on the vulnerability scale and 0.360 on the readiness scale). The FSM GCF Country Programme concluded that at present, none of the FSM States have a ‘high’ level of adaptive capacity required to ensure adaptation to the effects of climate change.

The proposed programme will overcome critical barriers to strengthen the resilience of vulnerable communities to the impacts of extreme climate events as well as long term water and food insecurity as a result of predicted climate change. GCF resources will be critical in strengthening climate resilience to improve disaster risk reduction and coastal management, food and water security for FSM’s most vulnerable populations. Annex 2 and the Funding Proposal clearly present significant adaptation needs due to the high level of vulnerability to climate impacts. To address the identified barriers, the programme will work to systematically build the capacity of local authorities (LAs) in FSM to effectively understand and respond to climate change and empower them to develop localized projects for disaster risk response, food security, and water security tailored to their unique priorities and needs.

The programme will be implemented over a 7-year period and consists of two main components:

- **Component 1: Local authorities empowered to deliver climate change adaptation services to their populations**
- **Component 2: Priority project implementation-EDA Facility for strengthening local community resilience**

Component 1 is oriented towards assessing the capacity of LAs and providing technical assistance to enable access to the RCGF resources. More specifically, it is aiming at building the capacity of LAs to identify climate risks on their communities, and subsequently to design, plan and develop adaptation projects. This increased capacity would ensure a greater level of community ownership of chosen adaptation interventions which in turn will respond adequately to the significant adaptation needs of FSM communities. Additionally, knowledge sharing mechanisms are envisaged under component 1.

Component 2 is designed to provide financial support for the implementation of identified adaptation priorities. The core of the component is the establishment of a Resilient Communities Grant Facility (RCGF). The RCGF will provide sub-grants for sub-projects prioritized, developed, and submitted under Component 1. The RCGF will award grants and provide targeted technical assistance to LAs and State governments across all four FSM States, including outer atolls, to support them in the implementation of the sub-projects. It will support 30–40 sub-grants in the range of USD 75,000–1,000,000 for sub-projects relating to the food security, water security and disaster risk reduction (coastal management) adaptation areas.

During the stakeholders’ consultations 10 priority areas of interventions were identified. The priority adaptation actions were identified by municipalities and communities in FSM through direct outreach to municipalities as well as through a review of Local Early Action Plans (LEAPs) that were completed for one community per State as part of the International Climate Initiative. The combined results of the stakeholder consultations and the LEAPs review narrowed down the sectoral focus to priority adaptation actions 1 to 3 i.e. DRR (coastal management), food security and water security. The following table 1 present the full list of identified priorities.

*Table 1: Initial Priority Adaptation Actions*

| Rank | Priority Adaptation Action | Municipalities/communities that identified the action |
|---|---|---|
| 1 | **Coastal management projects (re-vegetation, coastal barriers, soil erosion controls etc.)** | U (Pohnpei); Sohkes (Pohnpei); Malem; Mwokilloa (Pohnpei); Pingilap (Pohnpei); LEAP (Kosrae); Walung LEAP (Kosrae); Oneisom LEAP (Chuuk); Eot (Chuuk); Lelu (Kosrae); Malem (Kosrae); Tafunsak (Kosrae); Utwe (Kosrae); Yap State; Onoun (Chuuk); Ettal (Chuuk); Polle (Chuuk); Piis Paneu (Chuuk); Fanapanges (Chuuk); Oneisomw (Chuuk); Nema (Chuuk); Satowan (Chuuk); Kuttu (Chuuk); Ta (Chuuk) |
| 2 | **Food security projects (agroforestry, home gardens, etc.)** | Madolenihmw (Pohnpei); U (Pohnpei); Sohkes (Pohnpei); Kitti (Pohnpei); Pingilap (Pohnpei); Tamil LEAP (Yap); Lelu (Kosrae); Malem (Kosrae); Tafunsak (Kosrae); Utwe (Kosrae); Yap State; Onoun (Chuuk); Polle (Chuuk); Fanapanges (Chuuk); Oneisomw (Chuuk); Nema (Chuuk); Satowan (Chuuk); Kuttu (Chuuk); Ta (Chuuk) |
| 3 | **Water security projects (water infrastructure, watershed management, etc.)** | Madolenihmw (Pohnpei); U (Pohnpei); Sohkes (Pohnpei); Kitti (Pohnpei); Nett (Pohnpei); Mwokilloa (Pohnpei); Pingilap (Pohnpei); Walung LEAP (Kosrae); Tamil LEAP (Yap); Oneisom LEAP (Chuuk); Yap State; Piis Paneu (Chuuk); Fanapanges (Chuuk); Oneisomw (Chuuk); Nema (Chuuk); Satowan (Chuuk); Kuttu (Chuuk); Ta (Chuuk) |
| 4 | **Climate resilient roads / infrastructure projects** | Madolenihmw (Pohnpei); Kitti (Pohnpei); Nett (Pohnpei); Pingilap (Pohnpei); Tamil LEAP (Yap); Eot (Chuuk); Malem (Kosrae); Onoun (Chuuk); Ettal (Chuuk); Polle (Chuuk); Piis Paneu (Chuuk); Fanapanges (Chuuk); Oneisomw (Chuuk); Nema (Chuuk); Satowan (Chuuk); Kuttu (Chuuk); Ta (Chuuk) |
| 5 | **Fisheries management / protection projects** | Sohkes (Pohnpei); Pakin LEAP (Pohnpei); Pingilap (Pohnpei); Tamil LEAP (Yap); Oneisom LEAP (Chuuk); Tafunsak (Kosrae); Utwe (Kosrae) |
| 6 | **Erosion control / landslide rehabilitation projects** | Madolenihmw (Pohnpei); U (Pohnpei); Malem (Kosrae); Yap State |
| 7 | **Waste management projects [1]** | Nett (Pohnpei); Malem LEAP (Kosrae); Utwe (Kosrae); Siis (Chuuk) |
| 8 | **Protected area restoration, management and enforcement** | Nett (Pohnpei); Malem LEAP (Kosrae); Pakin LEAP (Pohnpei) |
| 9 | **Community health projects (e.g. vector control)** | Madolenihmw (Pohnpei); Tamil LEAP (Yap) |
| 10 | **Livestock management projects (e.g. piggeries)** | Pakin LEAP (Pohnpei) |

The GCF budget for the implementation of prioritised and identified pipeline of sub-grant projects is USD 12,000,000 while USD 4,591,556 is expected to fund technical assistance activities. The total project

[1] Waste management is listed as a priority adaptation area for municipalities largely because of its impact on water and soil quality when mismanaged. While this can be an important adaptation strategy for LAs, waste management projects will not be funded by this EDA project.

budget is USD 16,591,556 all of which is to be provided by the GCF in the form of a grant. The co-financing amount is USD 3,119,081 mostly provided by the FSM government.

## 2. Project benefits

The proposed programme aims to build the adaptive capacity of vulnerable LAs and to implement a variety of adaptation interventions for the increased climate resilience of communities and livelihoods. The aim is to initiate an overarching approach that would support the identification of locally-led, most suitable interventions and in doing so lay the foundations for further scaling-up beyond the programme lifetime.

Based on stakeholder consultations and the FSM context, the following set of potential interventions was identified. The specific locations and technical aspects of interventions will be chosen as part of the process during project implementation.:

*Table 2 Thematic areas and indicative adaptation interventions*

| Thematic area description | Indicative adaptation interventions |
|---|---|
| **Climate-induced Disaster Risk Reduction (DRR) and Coastal Protection:** | |
| **Climate impacts:** Including interrelated coastal erosion, sea level rise, storm surges associated with typhoons and tropical storms as well as flooding and landslides due to extreme rainfall and storm events.<br>**DRR sub-projects:** Community-led, that can safeguard lives, livelihoods and infrastructure. Depending on the climate change projections for the area, such projects could prepare for extremes ranging from flash floods to typhons.<br>**Coastal protection sub-projects:** Ecological infrastructure can in some cases play a role in buffering extremes, and as such be incorporated as part of climate-proof small infrastructure projects. Such interventions will need to be linked to projected climate change related impacts on communities being reduced or prevented as a result of healthy and functioning ecosystems. | • Retrofitting existing buildings to climate-proof against increased storm incidents (e.g. cyclone proofing, solar panels, rainwater tanks)<br>• Watershed reforestation for landslide protection and flooding control<br>• Small-scale coastal infrastructure constructed that will reduce the risk of losses and damages caused by climate-induced disaster events (as appropriate, use of endemic species planting, wave breakers, man-made channels)<br>• Restoration, rehabilitation or substitution of ecosystems relevant for adaptation (e.g. mangrove restoration, re-vegetation, sea-grass beds)<br>• Equipping municipalities with necessary tools to respond to climate-induced disaster, including emergency plans, building shelter, medical and other supplies |
| **Food Security** | |
| **Climate impacts:** Climate change–induced extreme weather events and sea-level as well as the projected impacts of warmer atmospheric and open water temperatures, erratic rainfall intensity and distribution, more frequent and more intense tropical cyclones etc and their effect on land, soil and water resources, agricultural production systems (including those of livestock and fisheries), infrastructure, and social (community) systems.<br>**Food security sub-projects**: Address the management of cropland, livestock, forests and fisheries. Sub-projects that aim to support food security under the new realities of climate change through sustainable and equitable transitions for agricultural systems and livelihoods as well as access to markets and value chains. Specifically, to target increased productivity (i.e., produce more food and boost local incomes) and enhanced ability of communities to adapt to climate change and weather extremes. In FSM, it is important to also support benefits to coastal ecosystem (e.g., by reducing sediment into the coastal zone through taro | • Development and use of climate-resilient crop species and varieties (resilient to drought, waterlogging, saltwater, pests), including techniques for their consistent supply (germplasm collections, nurseries)<br>• Farming and land use techniques facilitating soil and water conservation (e.g. mulching, organic farming, mixed cropping, drainage)<br>• Small scale aquaculture<br>• Fisheries and coastal resources management<br>• Livestock management<br>• Watershed management<br>• Establishment of agroforestry demonstration sites integrated with livestock<br>• Building value chains for crops, fisheries, and livestock protecting |

| | |
|---|---|
| swamps, reducing pressure on wild-caught fisheries, reducing pollutants from fertilizers). | |
| **Water Security** | |
| **Climate impacts:** Climate-induced disturbances in water supply and security including reduced aquifer recharge from hydrological disturbances, salinization and contamination of aquifers from sea-level rise and flooding<br>**Water security sub-projects:** interventions that address increased impacts of droughts in Yap and Chuuk; shortages in freshwater supplies, especially in the outer-islands; increased incidence of lowland flooding and seawater inundation, especially in the steep topographies of Chuuk, Pohnpei and Kosrae. | • Water infrastructure (e.g. water tanks, solar water pumps)<br>• Procurement and distribution of rainwater collection tanks<br>• Capturing and storage of rain and groundwater resources (individual household and community storage capacities)<br>• Reducing leakage of reticulated systems and water storage facilities<br>• Water saving (e.g. introducing compost toilets, demand management through awareness raising)<br>• Water quality enhancement and assurance<br>• Solar water purifiers |

Based on above, the project has the potential to generate a broad range of environmental, social, and economic benefits and co-benefits, some of which include:

- Increased capacity of relevant stakeholders to identify, develop, and implement tailored and focused adaptation measures and needs;
- Increased resilience of buildings and infrastructure to severe climate impacts, especially those resulting from climate extremes;
- Reduced flooding and seawater intrusion due to coastal management interventions;
- Reduced erosion and loss of coast, and loss of infrastructure such as roads;
- Avoided loss of biodiversity due to, for example, mangrove planting:
- Avoided crop losses and overall increased food security due to implementation of climate resilient crops/varieties such as saltwater resistant yam;
- Avoided cost resulting from erosion and soil damage due to implementation of soil and water conservation techniques;
- Increased water security and water subsistence due to implementation of water infrastructure such as rainwater harvesters;
- Increased productivity and avoided crop losses as a result of investing into water storage and irrigation systems;
- Health benefits resulting from increased water security.

## 3. Financial analysis

Given that most of the interventions planned are public sector projects that use grant funding and therefore do not generate any revenues, a financial analysis is largely infeasible. Given this, a focus has been put on the economic analysis of the project. Generally, these types of investments produce outputs and outcomes that meet the classical definition of public goods (non-rivalrous and non-excludable).

The project is financed by grants (either from GCF or cofinancing sources) and the business level perspective is not applicable. The RCGF is intended for public stakeholders and the interventions will not result in revenue generating activities. It is noteworthy that this applies also to agriculture as a vast majority of it is subsistence production.

## 4. Economic analysis

An economic analysis of the project has been performed to assess the incremental adaptation benefits to climate change for communities. The economic cost-benefit analysis uses a cash flow model over a 20-year period, and a 50-year period for coastal management. These periods include all investment and operational costs of the project, as well as the monetised revenues from resulting externalities such as avoided losses.

### 4.1. Approach

As already described, FSM is still identifying specific adaptation interventions which are envisaged to be addressed with the proposed project and its dedicated grant facility – the RCGF. It was not possible to determine the scale of proposed interventions as this will be known only when sub-grant projects are identified (Component 1) and implemented (Component 2). Furthermore, the identification of the scale of interventions is significantly hindered due to the great diversity of relevant parameters. Indeed, FSM is extremely diverse in terms of population distribution, geographical morphology, distribution of climate impacts and corresponding adaptation needs.

Therefore, the approach undertaken was based on identifying the most **probable** interventions that would reflect the most pressing adaptation needs. As already stated, the proposed programme is aiming at three main thematic areas – DRR, water security, and food security. For the purpose of the economic analysis, the three most representative measures were identified - one for each thematic area. The measures were selected based on the FSM climate rationale, the outcomes of stakeholder consultations, the literature review, and discussions with the AE's Regional Office. The following exemplary measures were tested by the economic analysis:

- **Example Measure 1. Construction of rainwater harvesters – Water security**
- **Example Measure 2. Coastal management (Combination of rock revetment and mangrove planting) – Disaster Risk Reduction**
- **Example Measure 3. Climate resilient crops – Introduction of salt and drought tolerant varieties – Food security**

### 4.2. Example Measure 1: Construction of rainwater harvesters

Example Measure 1 would include the construction of rainwater harvesters. Reliable access to water is one of the major issues in the FSM. Watersheds are often polluted due to inundation while droughts can cause shortage of available water. Rainwater harvesters are a proven solution to address these issues and were tested with cost-benefit analysis.

The main benefit used for calculating the economic feasibility of the measure is the price of imported water due to inability to meet water demand during climate-based impacts to local water sources. More specifically, there is a need to deliver drinking and sanitary water over a very large area of the FSM islands. This practice increases the price of water significantly due to high transport costs.

**Counterfactual analysis**

The counterfactual analysis for this measure is based on the estimated ongoing costs of the system during climate-impact events. In the absence of the project, investment would most likely not occur and so benefits per unit of investment are based on the comparison of the current situation and the "with project" situation.

**Assumptions**

The economic cost-benefit analysis, over 20-year period was conducted for the implementation of rainwater harvesters based on following assumptions.

*Table 3 Assumptions for Example Measure 1*

| Cost calculations on a per investment basis | | Unit | Cost |
|---|---|---|---|
| Discount rate | Based on http://documents1.worldbank.org/curated/en/164231557713145805/pdf/Micronesia-Maritime-Investment-Project.pdf | % | 6 |
| Investment costs per rainwater harvester tanks | Supply and Installation Cost (Full Cost) of Rainwater Harvesting System in FSM - RENI Project | USD | 3,000 |
| Transportation costs of equipment for rainwater harvester | Supply and Installation Cost (Full Cost) of Rainwater Harvesting System in FSM - RENI Project | USD | 5,800 |
| Average number of tanks per building | Supply and Installation Cost (Full Cost) of Rainwater Harvesting System in FSM - RENI Project | # | 2 |
| Rainwater harvester costs per one investment | Calculated | USD/ investment | 17,600 |
| # of beneficiaries per investment | Estimation based on http://www.bibalex.org/Search4Dev/files/419439/442767.pdf | # | 40 |
| # of investment under one grant mechanism sub-project | Assumption | # | 10 |
| **Investment costs per one grant mechanism sub-project** | **Calculated** | **USD/per sub-project** | **176,000** |
| **Benefits calculations on a per investment basis** | | **Unit** | **Cost** |
| Volume of the rainwater tank | Supply and Installation Cost (Full Cost) of Rainwater Harvesting System in FSM - RENI Project | l | 5,700 |
| # of beneficiaries per investment | Estimation based on http://www.bibalex.org/Search4Dev/files/419439/442767.pdf | # | 40 |

| | | | |
|---|---|---|---|
| Annual water volume savings due to rainwater per harvester | https://www.clarktanks.com.au/wp-content/uploads/2018/02/socio-economic-benefits-to-rainwater-harvesting-councils-community-and-individuals.pdf | Liters per annum | 90,000 |
| Total annual saving per investment | Calculated | Liters per annum | 180,000 |
| Benefits | | | |
| Import price of water per litre | Assumption based on need for water demand during droughts and seawater intrusion | USD/l | 0.02 |
| Benefits resulting in access to water per investment | Calculated | USD/year | 3,600 |
| **Total benefits per one grant mechanism sub-project** | **Calculated** | **USD/per sub-project** | **36,000** |

**Results**

The benefits were calculated on the assumption that 10 rainwater harvesters would be installed which would, presumably, represent one sub-grant project applied for to the RCGF. The following table 4 present the results of Key Performance Indicators (KPIs):

*Table 4 KPIs for Example Measure 1*

| | | | |
|---|---|---|---|
| **Net costs / benefits** | **USD** | **Calculated** | **8,432,000** |
| **EIRR** | **%** | **Calculated** | **25%** |
| **ENPV** | **USD** | **Calculated** | **3,402,341** |
| **Net costs / benefits per year** | **USD / year** | **Calculated** | **421,600** |

The results show that all KPIs are positive in terms of the economic feasibility of the proposed project. The ENPV is USD 3,402,341 and the EIRR is at 25%, significantly higher than the used discount rate of 6%. It is noteworthy that this calculation takes into account only one major benefit. It is expected that this type of investment will trigger other co-benefits that were not possible to be accounted for due to the lack of data. Co-benefits may include: avoided crop and livestock losses due to uninterrupted water supply, avoided occurrence of water-borne diseases and subsequent health costs due to polluted water sources, and others.

**Sensitivity analysis**

Various scenarios were tested to establish the economic viability of Example Measure 1 based on either changes in the costs of investment or changes in the level of benefits. The results are presented in the following table.

*Table 5 Sensitivity analysis for Example Measure 1*

| Investment costs | ENPV of the investment (USD) |
|---|---|
| 60% | 4,495,683 |
| 80% | 3,949,012 |

| | |
|---|---|
| 100% | 3,402,341 |
| 120% | 2,855,670 |
| 140% | 2,308,998 |
| **Benefits** | **ENPV of the investment (USD)** |
| 60% | 948,062 |
| 80% | 2,175,201 |
| 100% | 3,402,341 |
| 120% | 4,629,480 |
| 140% | 5,856,619 |

The results show positive ENPV in all scenarios with changing levels of costs and income, respectively. Based on the assumptions described above, Example Measure 1 can be justified on economic grounds.

## 4.3. Example Measure 2: Coastal management (Combination of rock revetment and mangrove planting)

Example Measure 2 would include a combination of rock revetment and mangrove planting. These interventions are commonly used as coastal management practices in the Pacific. The objective is to decrease the impacts of devastating wave energy, sea inundation, and tidal surges on coastal ecosystems and communities. More specifically:

- Rock revetments are conventional land protection structures that have been used extensively throughout the Pacific. A rock revetment is formed using a geotextile filter fabric placed on a formed backshore slope, overlain by a cushioning layer of small rock, and protected from wave energy by a suitably large rock armour.
- Mangrove planting is a coastal management practice that belongs to EbA – Ecosystem Based Adaptation. The establishment of offshore vegetation, such as mangroves, dissipates wave energy before it reaches the shoreline and traps fine sediment, while maintaining habitats for juvenile fish and other marine species. The protection and restoration of natural defences such as mangrove ecosystems can play a vital role in coastal protection and Disaster Risk Reduction (DRR). There are two main EbA functions that are relevant to coastal vegetation: reducing coastal erosion from storm surge/cyclones and protection of coastal inhabitants from loss of livelihoods and life - the 'bio shield' function.

Example Measure 2 would include the combination of investments (rock revetement and mangrove planting) under one sub-grant project applied to the RCGF. The cost-benefit analysis over a 50-year lifetime was conducted on a one per sub-grant project basis. The economic analysis envisages four sub-grant projects for this measure.

The calculations were based on putting investment costs against identified benefits that would result under this measure. More specifically, co-benefits that would occur are following:

- Rock revetment - Avoided cost of damaged road infrastructure and avoided costs for reconstruction/replacement of flooded buildings.
- Mangrove planting - Avoided costs for reconstruction/replacement of flooded buildings and biodiversity related co-benefits of mangrove protection area.

As in the case of Example Measure 1, there are other benefits that would result under this type of investment. The major and most significant one is reduction of coastal erosion. However, it was not possible to determine or assume the value of avoided erosion costs.

## Counterfactual analysis

The counterfactual analysis for this measure is based on the estimated negative impacts of climate-related events. In the absence of the project, investment would most likely not occur and so benefits per unit of investment are based on the comparison of the "climate change impact" situation and the "with project" situation.

## Assumptions

The economic cost-benefit analysis, over a 50-year period was conducted for the implementation of coastal management investments.

*Table 6 Assumptions for Example Measure 2.*

| **Cost calculations on a per investment basis** | | | |
|---|---|---|---|
| Rock revetment | **Source** | **Unit** | **Cost** |
| Discount rate | Based on http://documents1.worldbank.org/curated/en/164231557713145805/pdf/Micronesia-Maritime-Investment-Project.pdf | % | 6 |
| Rock revetment investment costs per m | https://www.researchgate.net/publication/337884805_Affordable_coastal_protection_in_the_Pacific_Islands_-_Desktop_Review | USD/m | 2,000 |
| # of meters to be covered by one investment | Assumption | m | 500 |
| Total investment - per sub project (Rock revetment) | Calculated | USD | 1,000,000 |
| Mangrove replanting | | | |
| Investment costs for mangrove replanting | Assumption | USD/ha | 5,000 |
| # of hectares to be restored per one sub-project | Assumption based on https://www.climatelinks.org/sites/default/files/asset/document/2017_USAID%20CEADIR_Cost-Benefit%20Analysis%20of%20Mangrove%20Restoration%20for%20Coastal%20Protection%20.pdf | ha | 10 |
| Total investment per sub-project (mangrove replanting) | Calculated | USD | 50,000 |
| **Investment costs per one grant mechanism sub-project** | **Calculated** | **USD/per sub-project** | **1,050,000** |
| **Benefits calculations on a per investment basis** | | | |
| Rock revetment | | | |

| | | | |
|---|---|---|---|
| # of households/building protected by rock revetment | Assumption | # of buildings | 30 |
| # cost per building replaced | Project feasibility study | USD/buildings | 54,153 |
| Lifetime of investment | Assumption | Years | 50 |
| Total theoretical cost of building replacement cost avoided by rock revetment sub-project during the lifetime of investment | Calculated | USD | 1,624,593 |
| km of road to be protected by the rock revetment sub-project | Assumption | km | 1 |
| Cost of new road construction | Kosrae shoreline management plan | USD/m | 373 |
| Avoided cost of damaged road infrastructure due to the project | Calculated | USD | 373,000 |
| Total avoided damage costs - distributed annually over lifetime of the project | Calculated | USD/annum | 39,952 |
| **Total avoided damage costs lifetime of investment - rock revetment** | **Calculated** | **USD** | **1,997,593** |
| Mangrove planting | | | |
| # of buildings within the mangrove protection area | Assumption | # | 50 |
| Value of the building replacement covered by mangrove protection area | Calculation | USD | 2,707,655 |
| Annual percentage of buildings damage avoided due to mangrove protection | Assumption | % of value of buildings | 5% |
| Yearly avoided costs to buildings in mangrove protection area | Calculated | USD/annum | 135,383 |
| Biodiversity related co-benefits of mangrove protection area | https://www.climatelinks.org/sites/default/files/asset/document/2017_USAID%20CEADIR_Cost-Benefit%20Analysis%20of%20Mangrove%20Restoration%20for%20Coastal%20Protection%20.pdf | USD/ha/annum | 5 |

| | | | |
|---|---|---|---|
| Annual costs of biodiversity protection co-benefits | Calculated | USD/annum | 54 |
| **Annual mangrove avoided costs** | **Calculated** | **USD/annum** | **135,437** |

| | | | |
|---|---|---|---|
| **Envisaged number of coastal management grant mechanism based sub-projects** | **#** | **Assumption** | **4** |
| **Total investment envisaged for the coastal management measure packages** | **USD** | **Calculated** | **4,200,000** |

**Results**

The benefits were calculated on the basis of implementing one sub-grant project (though for the project-level EIRR calculations, 4 sub-projects are envisaged). The following table presents the results of Key Performance Indicators (KPIs):

*Table 7 KPIs for Example Measure 2*

| | | | |
|---|---|---|---|
| **Net costs / benefits** | **USD** | **Calculated** | **7,321,989** |
| **EIRR** | **%** | **Calculated** | **15%** |
| **ENPV** | **USD** | **Calculated** | **1,436,878** |
| **Net costs / benefits per year** | **USD / year** | **Calculated** | **366,099** |

The results show that all KPIs are positive in terms of the economic feasibility of the proposed project. The ENPV is substantial USD 7,321,989 and the EIRR is at 15%, higher than the used discount rate of 6% making this measure, under presented assumptions, economically viable. As noted above, this intervention would avoid costs induced by coastal erosion which were not possible to calculate. However, avoided erosion losses would further increase the ENPV and EIRR of Example Measure 2.

**Sensitivity analysis**

Various scenarios were tested to establish the economic viability of Example Measure 2 based on either changes in the costs of investment or changes in the level of benefits. The results are presented in the following table.

*Table 8 Sensitivity analysis for Example Measure 2*

| Project costs | ENPV of the investment (USD) |
|---|---|
| 60% | 1,835,059 |
| 80% | 1,635,969 |
| 100% | 1,436,878 |
| 120% | 1,237,788 |
| 140% | 1,038,697 |
| **Benefits** | **ENPV of the investment (USD)** |
| 60% | 463,946 |

| | |
|---|---|
| 80% | 950,412 |
| 100% | 1,436,878 |
| 120% | 1,923,344 |
| 140% | 2,409,811 |

The results show a positive ENPV in all scenarios with alternating level of costs and income, respectively. Based on the assumptions described above, Example Measure 2 can be justified on economic grounds.

## 4.4. Example Measure 3: Introduction of salt and drought tolerant varieties

Example Measure 3 would include the introduction of saltwater resistant and drought tolerant varieties of yam. Yam is the common name for plant species in the genus *Dioscorea* that form edible tubers. Yams are perennial herbaceous vines cultivated for the consumption of their starchy tubers. Yam is traditionally grown in the Pacific region and has varieties that are drought and salt tolerant. As such, yam could be potentially very suitable crop in the FSM. The cultivation of saltwater resistant and drought tolerant yam could result in higher productivity and increased food security when compared to other similar vulnerable crops such as taro. Note that for this measure, the results of economic analysis results would be similar to the financial analysis results. However, since most production is for subsistence (and not market consumption), it is more appropriate to refer to it as economic analysis.

Taro is a tropical plant grown primarily for its edible corms, a root vegetable. It is traditionally grown in the FSM and is subject to high damages caused primarily by inundation. Damage reports such as, the "FSM_Tidal Surge Preliminary Damage Assessment Report Final for nap", shows huge losses of taro crops due to tidal surges, at around 90%. Seawater inundation is caused by many factors where tidal surges have this highest impacts. However, seawater inundation can be caused by high level of precipitation, sea level rise, and typhoons.

The calculations were undertaken under the assumption that the project will finance, through the RCGF, 456 ha of yam production using saltwater resistant and drought tolerant varieties depending on location and identified climate impacts. The resulting benefits relate to avoided crop losses that would occur if taro was produced on the same scale or production.

**Counterfactual analysis**

The economic analysis of this measure included a comparison of baseline and alternative scenarios. This counterfactual analysis compared the production of taro versus yam under the same climate circumstances and impacts. The taro production represents the baseline while the saltwater and drought resistant yam production represents the alternative scenario.

**Assumptions**

The economic cost-benefit analysis, over a 20-year period was conducted for the production of 456 ha of saltwater and drought tolerant yam put against the baseline scenario of the 456 ha of taro production.

*Baseline scenario:*

*Table 9 Assumptions for Example Measure 3 – Baseline scenario*

| **Baseline scenario – taro production** | | | |
|---|---|---|---|
| Taro production | **Source** | **Unit** | **Cost** |
| Discount rate | Based on http://documents1.worldbank.org/curated/en/164231557713145805/pdf/Micronesia-Maritime-Investment-Project.pdf | % | 6 |
| Average yield per ha | http://www.fao.org/3/AC450E/ac450e05.htm | tonnes per ha | 6.2 |
| Value per tonne of yield | Assumption | USD/tonne | 200 |
| Marginal investment costs | Assumption | USD/ha/y | 2,400 |
| Marginal operating costs | Assumption | USD/ha/y | 250 |
| Losses per tidal surge | FSM_TidalSurge_Preliminary Damage Assessment Report-Final for nap | % | 90% |
| Gap after saltwater intrusion until next harvest | https://nca2014.globalchange.gov/report/regions/hawaii-and-pacific-islands/graphics/saltwater-intrusion-destroys-crops | Years | 5 |
| Annual losses due to sea inundation, droughts etc. | Assumption | %/year | 20% |
| Number of tidal surges | Assumption (envisaged that surge would occur in the year 10 of the project | Assumption | 1 |
| Lifetime of investment | Assumption | Years | 20 |

*Alternative scenario:*

| **Alternative project scenario – saltwater resistant yam** | | | |
|---|---|---|---|
| Yam production | **Source** | **Unit** | **Cost** |
| Discount rate | Based on http://documents1.worldbank.org/curated/en/164231557713145805/pdf/Micronesia-Maritime-Investment-Project.pdf | % | 6 |
| Average yield per ha | http://www.fao.org/3/AC450E/ac450e05.htm<br><br>https://www.spc.int/sites/default/files/resources/2018-05/Vulnerability_Pacific_agriculture_climate_change.pdf | tonnes per ha | 10 |
| Value per tonne of yield | Assumption | USD/tonne | 400 |
| Marginal investment costs | Assumption | USD/ha/y | 1,000 |
| Marginal operating costs | Assumption | USD/ha/y | 200 |
| Losses per tidal surge | FSM_TidalSurge_Preliminary Damage Assessment Report-Final for nap | % | 10% |
| Gap after saltwater intrusion until next harvest | https://nca2014.globalchange.gov/report/regions/hawaii-and-pacific- | Years | 0 |

| | | | |
|---|---|---|---|
| | islands/graphics/saltwater-intrusion-destroys-crops | | |
| Annual losses due to sea inundation, droughts etc. | Assumption | %/year | 15% |
| Number of tidal surges | Assumption (envisaged that surge would occur in the year 10 of the project | Assumption | 1 |
| Lifetime of investment | Assumption | Years | 20 |

**Results**

*Baseline scenario:*

The benefits were calculated on the basis of implementing 456 ha of taro production. The following table presents the results of Key Performance Indicators (KPIs):

*Table 10 KPIs for Example Measure 3 – Baseline scenario*

| | | | |
|---|---|---|---|
| **Net costs / benefits** | **USD** | **Calculated** | **185,638** |
| **EIRR** | **%** | **Calculated** | **6%** |
| **ENPV** | **USD** | **Calculated** | **(9,246)** |
| **Net costs / benefits per year** | **USD / year** | **Calculated** | **9,282** |

The KPIs show that the EIRR matches the discount rate while the ENPV is slightly negative. This clearly shows that if one tidal surge occurred in 20 years (a conservatively low estimate), this would result in taro production not being economically viable. The main reason behind it is a massive potential loss of 90% as a result of a tidal surge. Furthermore, there is a 5-year post-tidal surge period during which damaged soil is not suitable for taro production. Therefore, the taro production is not economically viable under baseline assumptions listed above.

*Alternative scenario:*

The alternative scenario benefits were calculated on the basis of implementing 456 ha of yam production. The following table present the results of Key Performance Indicators (KPIs):

*Table 11 KPIs for Example Measure 3 – Alternative scenario*

| | | | |
|---|---|---|---|
| **Net costs / benefits** | **USD** | **Calculated** | **9,259,308** |
| **EIRR** | **%** | **Calculated** | **41%** |
| **ENPV** | **USD** | **Calculated** | **4,228,664** |
| **Net costs / benefits per year** | **USD / year** | **Calculated** | **462,965** |

The results show that all KPIs are positive in terms of the economic feasibility of the proposed project. The ENPV is USD 4,228,664 and the EIRR is at 41%, significantly higher than the used discount rate of 6% making this measure, under presented assumptions, economically viable. The counterfactual analysis clearly shows that the introduction of saltwater and drought tolerant yam varieties is economically viable while taro production is not.

**Sensitivity analysis**

Various scenarios were tested to establish the economic viability of Example Measure 2 based on either changes in the costs of investment or changes in the level of benefits. The results are presented in the following table.

*Table 12 Sensitivity analysis for Example Measure 3*

| Investment costs | ENPV of the investment (USD) |
|---|---|
| 60% | 5,112,599 |
| 80% | 4,670,631 |
| 100% | 4,228,664 |
| 120% | 3,786,696 |
| 140% | 3,344,728 |
| **Benefits** | **ENPV of the investment** |
| 60% | 1,653,263 |
| 80% | 2,940,963 |
| 100% | 4,228,664 |
| 120% | 5,516,364 |
| 140% | 6,804,064 |

The results present positive ENPV in all scenarios. Based on the assumptions described above, Example Measure 3 can be justified on economic grounds.

## 4.5. Consolidated project level cost/benefit analysis

An economic analysis of the project as a whole has been performed to assess the incremental adaptation benefits to climate change. This analysis combines all three measures, scaled-up to the envisaged number of sub-projects that could potentially be financed by the RCGF. Additionally, the project-level analysis takes into account the entire proposed project budget including the costs of all the components (i.e. non-investment components as well) and project management costs and co-finance. Please note that all of that none of co-finance is envisaged for sub-grant projects.

**Results**

The following table presents the project level cost-benefit analysis that consolidates all three previously elaborated adaptation measures and includes the non-investment part of the programme budget. The discount rate of 6% used was the same as throughout the entire analysis.

| Label | Unit | Source of information | Total |
|---|---|---|---|
| **Costs** | | | |
| M1 - costs | USD | M1 - Rainwater harvesters | 3,520,000 |
| M2 - costs | USD | M2 - Coastal Management | 4,262,000 |
| M3 - costs | USD | M3 - Climate resilient crops | 4,223,700 |
| **Total** | **USD** | **Calculated** | **12,000,000** |
| **Other project costs** | | | |
| Total non-investment project costs+ co-finance | USD | Project proposal | 7,710,637 |
| **Total non-investment project costs** | **USD** | **Calculated** | **7,710,637** |

| | | | |
|---|---|---|---|
| **Total costs** | **USD** | **Calculated** | **19,710,637** |
| Benefits | | | |
| M1 - benefits | USD | M1 - Rainwater harvesters | 11,952,000 |
| M2 - benefits | USD | M2 - Coastal Management | 12,503,347 |
| M3 - benefits | USD | M3 - Climate resilient crops | 13,118,208 |
| **Total benefits** | **USD** | **Calculated** | **38,000,000** |

*Table 13 KPIs - Project level*

| | | | |
|---|---|---|---|
| **Net costs / benefits** | **USD** | **Calculated** | **39,268,625** |
| **EIRR** | **%** | **Calculated** | **11%** |
| **ENPV** | **USD** | **Calculated** | **39,268,625** |
| **Net costs / benefits per year** | **USD / year** | **Calculated** | **31,668** |

The results clearly show that the programme-level ENPV is positive at **USD 39,268,625** and the programme-level **EIRR is 11%.** The conclusion is that the proposed programme is economically viable and can be justified on economic grounds, even with approximately 40% of non-investment budget costs including co-finance for which no direct benefits are envisaged. It is also noteworthy that the analysis included conservative assumptions and not all benefits have been included in the economic calculations since it was not possible to estimate their monetary values, but these benefits would nonetheless occur under the proposed interventions. Some of benefits would include: avoided coastal erosion, avoided crops damage due to availability of water for irrigation, increased capacity of relevant stakeholders to identify, develop, and implement tailored and focused adaptation measures and needs, and health benefits resulting from increased water security.