

## Annex 3 – Economic and Financial Analysis

### 1. Introduction

As described in the funding proposal the aim of the project “Increasing resilience to the health risks of climate change in the Federated States of Micronesia” builds upon previous activities such as the development of the National Climate Change Health Action Plan, and projects under implementation that are focusing on Water Sanitation and Hygiene (WASH) and disease surveillance. Furthermore, the project is adopting a multilevel (national, state and community approach) addressing key barriers (see below).

The project contributes to the Federated States of Micronesia (FSM) regulatory framework and policies strengthening the climate-resilient development pathways consistent with FSM’s climate change adaptation strategies. It supports the development of a proactive, climate responsive health system, with the enhancement of necessary capacities for the surveillance of and response to climate-sensitive diseases by the relevant health authorities. Finally, it builds collaboration between government stakeholders, adopting a comprehensive approach with a good potential for replication in other Pacific Island Countries which suffer from similar climate induced threats to public health.

The project states substantial adaptation needs regarding improving public health and addressing climate sensitive diseases threats, including water-, food- and vector-borne diseases. The project is fully aligned with the national policies and legislations and has been fully co-develop with the NDA and the DHSA, alongside with other stakeholders (see B2.1 and Annex 23 Stakeholder Engagement Plan), which full country-ownership. By addressing increasing risks and impacts from climate change on public health and by implementing tangible interventions in vulnerable rural communities (incl. climate adaptation interventions to prevent the spread of food-borne diseases (FDBs), vector-borne diseases (VBDs) and water-borne disease (WBDs).

The project will increase the adaptive capacity of the country to better cope with the additional burden of climate change on public health, by improving preparedness and response to climate sensitive FDBs, VBDs and WBDs, providing explicit capacity building, and fostering adaptation actions through improved national, state and local level management practices and resilient small scale WASH interventions. The project will have 78,048 direct beneficiaries (75.5% of the total population) among the most vulnerable communities (inter alia, through direct access to HIEWS alerts, environmental clean ups of areas subjected to flooding and mosquito breeding sites, clean water issues or with limited access to health services) and 102,843 indirect beneficiaries (100% of the FSM population).

The project will contribute to ARA 1 “Direct and indirect beneficiaries reached” and in particular “Beneficiaries (female/male) covered by new or improved early warning systems” that will receive targeted support and will have a measurable adaptation benefit are estimated to be Direct beneficiaries: 78,048 or 75.9% of the total population. Indirect beneficiaries, that will receive a measurable adaptation benefit, but not targeted support will be equal to the whole population of FSM i.e., 102,843 (50,650 of which women). The number

of direct beneficiaries (female/male) covered by new or improved early warning systems is expected to be Direct beneficiaries: 61,706 (30,390 women).

The project will moreover contribute to the ARA2 Health, well-being, food and water security (i) by reducing future increases in illnesses and deaths from climate-sensitive health outcomes through increased awareness of the population and (iii) by implementing tangible actions in vulnerable communities to better cope with VDBD, WBD and FBD as the main climate-sensitive health risks under component 3. ARA2 Health, well-being, food and water security beneficiaries will include 27,997 (13,788 women). In particular “Supplementary 2.3: Beneficiaries (female/male) with more climate-resilient water security” will be 16,342 (8,048 of which women). The interventions will not have additional indirect beneficiaries.

**In terms of climate projections, the Annex – pre-Feasibility study states the following: There is very high confidence in the direction of long-term change in a number of key climate variables, specifically increases in mean and extreme air and sea temperatures, sea level rise and ocean acidification.**

Temperature, annual precipitation, and sea-level rise are projected to increase in FSM by 2090. Tropical cyclones and droughts are significantly impacted by ENSO (El Niño-Southern Oscillation) events, for which changes remain uncertain. However, there is medium confidence that cyclones and droughts will decrease with climate change. A summary of the climate change observations from 1950 and projections for RCP4.5 emissions scenario using CMIP5 models for the Federated States of Micronesia is provided below, before each category is discussed in detail.

<b>Temperature</b>	<ul style="list-style-type: none"> <li>Positive seasonal and annual trends have been observed of 0.18 °C per decade in Pohnpei.</li> <li>Projections show that further warming of 1.5°C is expected by 2090.</li> </ul>
<b>Precipitation</b>	<ul style="list-style-type: none"> <li>Shows a significant decreasing trend in May–October rainfall, decreasing by 56.6mm per decade in Pohnpei. ENSO has a significant impact on interannual variability.</li> <li>Total annual rainfall is projected to increase by 6% by 2090, increasing in frequency and intensity.</li> </ul>
<b>Extreme Events</b>	<ul style="list-style-type: none"> <li>Extreme Temperature – there has been an increase of 7.86 warm days per decade, and 5.12 warm nights per decade. The frequency of extremely hot days is projected to rise.</li> <li>Extreme rainfall – Very Wet Day rainfall has been following a decreasing trend of 66.66mm per decade at Pohnpei and an increasing trend of 5.55mm per decade in Yap. The frequency and intensity of extreme rainfall events is projected to increase.</li> <li>Drought – ENSO has a significant impact on FSM’s climate. The country typically experiences drought during El Nino years. There is medium confidence that drought frequency will decrease.</li> <li>Tropical Cyclones – the region is one of the most active cyclone regions in the world, with FSM experiencing on average of 71 cyclones per decade. Projections show that, with medium confidence, the frequency of tropical cyclones globally is likely to decrease by 6%-35% by 2100.</li> </ul>

<b>Sea level</b>	<ul style="list-style-type: none"> <li>Sea levels have risen 10mm per year against 1993 levels, compared to 3mm per year globally. During La Nina years, sea levels are elevated. By 2090, 46-47cm of sea level rise is projected under RCP4.5 emissions scenario, relative to 1986-2005.</li> </ul>
------------------	--

Current available evidence indicates the climate change challenges facing communities in FSM are due to increasing frequency and/or intensity of extreme events:

1. Decreased very wet day rainfall
2. Tropical cyclones (increased intensity, not frequency, predicted including severe wind and waves, and intense rainfall and flooding)
3. Seasonal patterns changes
4. Increased air and water temperature
5. Sea-level rise

Project activities are designed to respond to the needs and gaps identified through the vulnerability assessment, including: increasing capacity to manage climate related public health events, through coordinated surveillance and response, as well as tangible intervention to improved public health through vector population control and improved resilient WASH infrastructure that will supply of sanitary safe drinking water currently and in the future. These three components are outlined below:

- Outcome 1: Capacity building, policy strengthening and cross-sectoral collaboration to manage climate-related vector-, water- and food-borne diseases are enhanced
- Outcome 2: Surveillance of and response to climate-related food-, vector-, and water-borne diseases are established and improved
- Outcome 3: Communities have increased resilience to climate-related FBDs, WBDs and VBDs as well as capacity to manage associated health burdens

**Outcome 1** - focuses on addressing the policy gaps related to both climate change and health factors in FSM. In doing so, the component will take a two-pronged approach. It will ensure that VCAs will remain up to date to support intervention planning and implementation by improving the current vulnerability and capacity assessment processes (output 1.1). VCA processes will be improved at the national and state level and piloted to ensure their applicability under FSM specificities. It will improve and mobilise policy instruments such as the existing National Climate Change and Health Action Plan (NCCHAP 2012). The work will involve a comprehensive, context-specific vulnerability and adaptation assessment of the health sector, mainstreamed into the NAP process to ensure informed and whole-of-government planning, and it will lay the groundwork for revising the NCCHAP to become the Health National Adaptation Plan (HNAP). This outcome will also include a robust training output (1.2) to develop the capacity for, (i) implementing and monitoring the improved policies, (ii) enabling ongoing intersectoral coordination, and, (iii) ensuring public health adaptation aspects are mainstreamed in national and state-level policies.

**Outcome 2** focuses on establishing a health information and early warning system (HIEWS), overlaying health data to existing climate information early warning systems (CIEWS) and

processes. The core elements of the climate-informed HIEWS envisioned for FSM through this Outcome, will be to: (i) monitor environmental conditions; (ii) forecast high-risk conditions, initiate active surveillance; (iii) send alerts and communication; and (iv) establish a mechanism for early response. The component will focus on all the different elements of the HIEWS including:

- the introduction of improved health data collection techniques through improved testing facilities,
- the development of the structural, statistical and operational features of the HIEWS that will allow data input, data analysis, and reporting through an accessible and consolidated platform, including the overlay of historical health data with climate and weather data,
- provision of training to key personnel concerning (i) data reporting, (ii) operation and maintenance of the HIEWS (iii) response actions including active surveillance, interpretation of alerts and communication, and early response mechanism processes.

This effort will include the integration of community-level data and laboratory data to support a more efficient early warning system (EWS). A probabilistic health information system will be critical for early health planning, disease prevention and epidemic management in all states of FSM. In tandem with establishing a pioneering HIEWS in the Pacific Islands, the tools and training of this outcome will ensure the HIEWS is operational and sustained, and can increase the effectiveness of disease control by intervening before or at the beginning of the epidemic curve.

**Outcome 3** focuses on implementing specific adaptation interventions in selected vulnerable communities to better address FBDs, VBDs and WBDs as major climate-sensitive health risks. Working in tandem with the previous two outcomes, outcome 3 will provision for concrete prevention measures to be taken at the community, household and individual levels. These measures derive from a policy framework set at national level and serve to pilot the approach for validation.

Provision of climate resilient, safe and sanitary water management and latrines is directly related to reducing the emergence of FBDs, VBDs and WBDs. The activities envisioned under this Outcome aim to improve the resilience of households in need and at risk through the installation of climate-resilient water tanks and the construction of toilets. At the same time, awareness-raising and education activities will be carried out at the community level, with the goal of achieving an understanding of FBDs, VBDs and WBDs and the proper application of preventive measures, both at the personal and household level. Innovative methods will also be used to manage mosquito breeding sites.

The envisaged GCF budget for the implementation of prioritised climate adaptation measures is USD \$ 6,836,000 while USD \$ 11,922,372 is expected to fund Capacity building activities, non-investment related equipment, and travel costs. The total project budget is USD \$18,758,372. USD 17,856,616 of the budget is to be provided by the GCF in the form of a grant.

## 2. Project benefits

The proposed project aims to build the adaptive capacity of FSM public health response to climate change impacts. The project envisages the implementation of several proven and efficient interventions that would increase the resilience of the FSM public health system, but also the resilience of communities and livelihoods in FSM. The aim is to initiate an integrated approach that would support a transformative pathway for FSM and lay the foundations for further scaling-up beyond the programme lifetime. The focus of the adaptation investments is reducing the burden of disease due to climate sensitive diseases. It will include the following:

- **M1 Household Rainwater Harvesting (RWH) systems** – these systems are simple, modular systems consisting of roof catchment, gutters, first flush system and tank storage. The roof catchment could be household or community buildings. Storages can be linked and augmented as needed. Water can be extracted from a tap directly from the tank, a nearby tap stand, or they can have a small distribution system with several tap stands.
- **M2 Water-sealed toilet-septic tank systems** - these are water-sealed toilet-septic tank systems have been identified by FSM EPA as the preferred solution and specifications are being finalized by the Pohnpei Utilities Corporation and the Pohnpei EPA. Since these systems will be ‘off-the-shelf’ procurement, will provide minimal need for extensive civil works.
- **M3 Food lab** - the project will support the equipment of the FSM Food Safety Lab and expand its capacity to address also WBDs and VBDs. The project will support the procurement and installation of the latest testing capacity and diagnostic equipment available. The laboratory will continue to be managed by the national government - EPA in Pohnpei, but also collaborates with other officers at the national and local levels of government. To increase the number of sample collections and improve its diagnostic capability, including additional testing parameters for water- , food- and vector- borne diseases, the Food Safety lab will be fully equipped with the necessary equipment and technology. The Food lab will improve its capacity to monitor important WBD and FBD pathogens, including, *Vibrio cholera*, *Salmonella* spp, *Shigella* spp, *Campylobacter*, *Clostridium botulinum*, *Ascaris*, *Giardia*, *Schistosoma* spp, and *Trichuris* spp.
- **M4 Health Informed Early Warning System** – the intervention includes the development and deployment of early warning system including its operational aspects for the surveillance of climate sensitive FBDs, VBDs and WBDs, as well as the development of a predictive model of island-scale dengue spread based.

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:

- Avoided monetary losses related to water import which is costly due to topography and remoteness characteristics of FSM;
- Avoided health related costs associated with water borne diseases;
- Avoided health related costs associated with food borne diseases;
- Avoided health related costs associated with vector borne diseases;

## 2.1. Estimation of avoided health related costs

The estimation of avoided health related cost was based on the estimation of the monetary value of Disability Adjusted Life-Years (DALYs) avoided due to the implemented measures. DALYs for FSM and CSD diseases were extracted from the WHO database<sup>1</sup>, while GDP per capita in PPP<sup>2</sup> and health expenditure per capita in FSM<sup>3</sup> were extracted by the World bank database.

Estimation of monetary value of DALYs			
Parameter	Sources and assumptions elaboration	Unit	Value
Input data			
GDP per capita PPP (USD)	<a href="https://data.worldbank.org/indicator/NY.GDP.PCAP.PP.CD?locations=FM">https://data.worldbank.org/indicator/NY.GDP.PCAP.PP.CD?locations=FM</a>	USD	3544
Health expenditure per capita (USD)	<a href="https://data.worldbank.org/indicator/SH.XPD.CHEX.PC.CD?locations=FM">https://data.worldbank.org/indicator/SH.XPD.CHEX.PC.CD?locations=FM</a>	USD	415
Total Population of FSM	2010 FSM Census	#	102,843
National average DALYs 200-2019 / 100.000 for WBD	WHO <a href="https://www.who.int/data/gho/data/themes/mortality-and-global-health-estimates/global-health-estimates-leading-causes-of-dalys#:~:text=States%2C%202015%20%C2%A6-,WHO%20Member%20States%2C%202019,-YLL%20estimates%2C%202000">https://www.who.int/data/gho/data/themes/mortality-and-global-health-estimates/global-health-estimates-leading-causes-of-dalys#:~:text=States%2C%202015%20%C2%A6-,WHO%20Member%20States%2C%202019,-YLL%20estimates%2C%202000</a>	DALY	844.7
National average DALYs 200-2019 / 100.000 for VBD	WHO <a href="https://www.who.int/data/gho/data/themes/mortality-and-global-health-estimates/global-health-estimates-leading-causes-of-dalys#:~:text=States%2C%202015%20%C2%A6-,WHO%20Member%20States%2C%202019,-YLL%20estimates%2C%202001">https://www.who.int/data/gho/data/themes/mortality-and-global-health-estimates/global-health-estimates-leading-causes-of-dalys#:~:text=States%2C%202015%20%C2%A6-,WHO%20Member%20States%2C%202019,-YLL%20estimates%2C%202001</a>	DALY	122.7
National average DALYs 200-2019 / 100.000 for FBD	WHO <a href="https://www.who.int/data/gho/data/themes/mortality-and-global-health-estimates/global-health-estimates-leading-causes-of-dalys#:~:text=States%2C%202015%20%C2%A6-,WHO%20Member%20States%2C%202019,-YLL%20estimates%2C%202002">https://www.who.int/data/gho/data/themes/mortality-and-global-health-estimates/global-health-estimates-leading-causes-of-dalys#:~:text=States%2C%202015%20%C2%A6-,WHO%20Member%20States%2C%202019,-YLL%20estimates%2C%202002</a>	DALY	846.0

<sup>1</sup> WHO <https://www.who.int/data/gho/data/themes/mortality-and-global-health-estimates/global-health-estimates-leading-causes-of-dalys#:~:text=States%2C%202015%20%C2%A6-,WHO%20Member%20States%2C%202019,-YLL%20estimates%2C%202000>

<sup>2</sup> <https://data.worldbank.org/indicator/NY.GDP.PCAP.PP.CD?locations=FM>

<sup>3</sup> <https://data.worldbank.org/indicator/SH.XPD.CHEX.PC.CD?locations=FM>

DALYs 200-2019 / 100.000 for WBD adjusted to outer islands	ASSUMPTION	DALY	1,267.08
DALYs 200-2019 / 100.000 for VBD adjusted to outer islands	ASSUMPTION	DALY	184.06
DALYs 200-2019 / 100.000 for FBD adjusted to outer islands	ASSUMPTION	DALY	1,268.95
Monetary value of DALY	WHO-CHOICE (3xGDP per capita) <a href="https://www.valueinhealthjournal.com/article/S1098-3015(15)00574-4/fulltext#:~:text=World%20Health%20Organisation%20(WHO)%2D,cost%2Deffectiveness%20of%20health%20interventions.">https://www.valueinhealthjournal.com/article/S1098-3015(15)00574-4/fulltext#:~:text=World%20Health%20Organisation%20(WHO)%2D,cost%2Deffectiveness%20of%20health%20interventions.</a>	USD	\$10,633
Per capita monetary value of DALY's from WBD in 2019 (National)	Calculated	USD	\$90
Per capita monetary value of DALY's from VBD in 2019 (National)	Calculated	USD	\$13
Per capita monetary value of DALY's from FBD in 2019 (National)	Calculated	USD	\$90
Per capita monetary value of DALY's from WBD in 2019 (Outer Islands)	Calculated	USD	\$135
Per capita monetary value of DALY's from VBD in 2019 (Outer Islands)	Calculated	USD	\$20
Per capita monetary value of DALY's from FBD in 2019 (Outer Islands)	Calculated	USD	\$135

### 3. Financial analysis

The project focuses exclusively on subsistence related beneficiaries and public goods (health, water and hygiene infrastructure). Given that all 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. Therefore, 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 (from GCF) and the business level perspective is not applicable. The funds are intended for subsistence stakeholders and the interventions will not result in revenue generating activities. It is noteworthy that this applies also to agriculture and fishery 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 for all envisaged adaptation measures. This period includes 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 in the funding proposal and Annex 2 – prefeasibility study, there is a significant lack of capacity related to climate adaptation on all levels and among all stakeholders relevant the public health sector in FSM. The project envisages variety of possible adaptation intervention within the above-mentioned focal areas covered by the scope of the project.

For the purpose of the economic analysis, the above-mentioned interventions were identified – each one tested with economic analysis. The measures were selected based on the FSM climate rationale, project design, the outcomes of stakeholder consultations, the literature review, and discussions with the AE – The Pacific Community (SPC). The following measures were tested by the economic analysis:

- Measure 1: Household Rainwater Harvesting (RWH) systems
- Measure 2: Water-sealed toilet-septic tank systems
- Measure 3 Food lab improvements
- Measure 4: Health Informed Early Warning System

##### 4.2. Measure 1: Household Rainwater Harvesting (RWH) systems

Measure 1 would include the construction of rainwater harvesters. Reliable access to water is one of the major issues in 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 avoided loss of human life and avoided health costs from WBDs. Additionally, avoided costs associated with 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 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 20-year period was conducted for the implementation of rainwater harvesters.

*Table 1 Assumptions for measure 1.*

Cost calculations on a per investment basis			
Parameter	Sources and assumptions elaboration	Unit	Value
<b>Input data</b>			
Discount rate	Assumption based on a general range of social discount rate for developing countries (8-12%)	%	12%
Equipment costs per rainwater harvester tank	<a href="#">Adaptation fund</a>	USD	\$1,120
Construction cost per rainwater harvester	<a href="#">Adaptation fund proposal</a>	USD	\$5,000
Lifetime of investment	<a href="#">Assumption based on “Life-cycle costs of rainwater harvesting systems”</a>	Years	20
Opex costs for one rainwater harvester	Assumption: 20 % of Annualized Equipment CapEx <a href="#">“Life-cycle costs of rainwater harvesting systems”</a>	USD/year/per harvester	\$224
Investment costs per one rainwater harvester investment	Calculated	USD/per sub-project	\$6,120
# of projects (investments) for household investments	Pre-feasibility study	#	500
Total # of beneficiaries	Pre-feasibility study	#	16,342
<b>Benefits calculations on a per investment basis</b>			
Volume of one rainwater tank	RENI Project	l	10,000

Annual water volume savings by rainwater - per harvester	<a href="https://terranoa.org.au/repository/paccsap-collection/pacific-adaptation-scenarios-costs-and-benefits-water-security-in-tuvalu-technical-report/cba-tuvalu-water-security-technical-report.pdf">https://terranoa.org.au/repository/paccsap-collection/pacific-adaptation-scenarios-costs-and-benefits-water-security-in-tuvalu-technical-report/cba-tuvalu-water-security-technical-report.pdf</a>	Litres per annum	90,000
Total annual saving per investment	Calculated	Litres per annum	90,000
Import price of water per litre	Assumption based on need for water demand during droughts and seawater intrusion	USD/l	\$0.01
Monetary benefits of avoided cost of accessing drinkable water per investment (per households)	Calculated	USD/year	\$900
Per capita monetary value of DALYs from WBD in 2019	Calculated		\$135
Effectiveness of the Measure on disease burden %	ASSUMPTION	%	55%
Health costs avoided due to M1	Calculated	USD/ year	\$2,422
<b>Total benefits per one rainwater harvester investment</b>	<b>Calculated</b>	<b>USD/per sub-project</b>	<b>\$3,322</b>

## Results

The benefits were calculated on the basis of implementing 500 rainwater harvesters and 2 community Rainwater Harvesting (RWH). The following table presents the results of Key Performance Indicators (KPIs):

*Table 2 KPIs for measure 1.*

Net costs / benefits	USD	Calculated	\$ 24,045,873
EIRR	%	Calculated	103%
ENPV	USD	Calculated	\$ 6,388,488
Net costs / benefits per year	USD / year	Calculated	\$ 1,265,572

The results show that all KPIs are positive in terms of the economic feasibility of the proposed project. The ENPV is USD \$ 24,045,873 and the EIRR is at 103%, higher than the used discount rate of 12% making this measure, under presented assumptions, economically viable.

## Sensitivity analysis

Various scenarios were tested to establish the economic viability of measure 1 based on either changes in the costs of investment, changes in the level of benefits, changes in the

effectiveness of the measure to avoided loss of human life and avoided health costs, or changes in the discount rate. It must be noted that the benefits sensitivity analysis includes changes both in terms of health-related benefits and water savings, while the measure effectiveness sensitivity analysis includes only changes in health benefits. The results are presented in the following table.

*Table 3 Sensitivity analysis for measure 1.*

Investment costs	ENPV of the investment	EIRR of the investment
60%	\$7,463,119	658%
80%	\$6,925,804	179%
100%	\$6,388,488	103%
120%	\$5,851,173	71%
140%	\$5,313,857	54%

Benefits	ENPV of the investment	EIRR of the investment
60%	\$2,758,462	41%
80%	\$4,573,475	66%
100%	\$6,388,488	103%
120%	\$8,203,501	160%
140%	\$10,018,514	261%

Effectiveness of intervention	ENPV of the investment	EIRR of the investment
60%	\$3,741,968	53%
75%	\$4,734,413	69%
100%	\$6,388,488	103%
120%	\$7,711,748	141%
140%	\$9,035,008	198%

Discount rate	ENPV of the investment
60%	\$10,373,209
75%	\$8,594,400
100%	\$6,388,488
120%	\$5,109,129
140%	\$4,131,195

The results show a positive ENPV and EIRR in all scenarios with alternating level of costs and income, respectively. Based on the assumptions described above, measure 1 can be justified on economic grounds.

### 4.3. Measure 2: Water-sealed toilet-septic tank systems

Measure 2. would include the installation of water-sealed toilet-septic tank systems. Like rainwater harvesters, the main benefit used for calculating the economic feasibility of the measure is the avoided loss of human life and avoided health costs. Avoided health costs related to this measure include reduced prevalence of WBDs and FBDs.

### 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 20-year period was conducted for the implementation of 500 latrines installed.

*Table 4 Assumptions for measure 2.*

Cost calculations on a per investment basis			
Parameter	Sources and assumptions elaboration	Unit	Value
<b>Input data</b>			
Discount rate	Assumption based on a general range of social discount rate for developing countries (8-12%)	%	12%
Equipment cost for water-sealed toilet in main islands (Type 2)	Consultation with Pohnpei EPA office.	USD	\$5,000
Installation cost for water-sealed toilet with septic tank / cesspool in main islands	Consultation with Pohnpei EPA office.  Cost incurred by the users based on agreement with EPA	USD	\$500
Lifetime of investment	FSM Input	Years	20
Opex costs for one latrine pit	Assumption based on <a href="https://www.unicef.org/india/media/1206/file/Financial-and-Economic-Impacts.pdf">https://www.unicef.org/india/media/1206/file/Financial-and-Economic-Impacts.pdf</a>	USD/investment	\$1,100
Investment costs per one latrine pit type 2	Calculated	USD/per sub-project	\$5,500
# of projects (investments) Type 2	Pre-Feasibility study	#	500
Total # of beneficiaries in main islands	Pre-Feasibility study (Census 2010)	#	11,635

Benefits calculations on a per investment basis			
Benefits			

Per capita monetary value of DALYs from WBD in 2019	Calculated	USD	\$135
Per capita monetary value of DALYs from FBD in 2019	Calculated	USD	\$135
Per capita monetary value of DALYs from WBD in 2019	Calculated	USD	\$90
Per capita monetary value of DALYs from FBD in 2019	Calculated	USD	\$90
Effectiveness of the Measure on disease burden for WBD %	<u>ASSUMPTION</u>	%	55%
Effectiveness of the Measure on disease burden for FBD %	<u>ASSUMPTION</u>	%	55%
Health costs avoided due to M2	Calculated	USD/year	\$2,301
<b>Total benefits per one Type 2 latrine</b>	<b>Calculated</b>	<b>USD/per sub-project</b>	<b>\$2,301</b>

### Results

The benefits were calculated on the basis of implementing 500 gravity fed systems. The following table presents the results of Key Performance Indicators (KPIs):

*Table 5 KPIs for measure 2*

Net costs / benefits	USD	Calculated	\$ 7,624,182
EIRR	%	Calculated	27%
ENPV	USD	Calculated	\$ 1,390,416
Net costs / benefits per year	USD / year	Calculated	\$ 401,273

The results show that all KPIs are positive in terms of the economic feasibility of the proposed project. The ENPV is USD 5,794,074 and the EIRR is at 21%, higher than the used discount rate of 12% making this measure, under presented assumptions, economically viable.

### Sensitivity analysis

Various scenarios were tested to establish the economic viability of measure 2 based on either changes in the costs of investment, changes in the level of benefits, or changes in the discount rate. No additional sensitivity analysis on the effectiveness of the measure was conducted since all benefits derive from health benefits. The results are presented in the following table.

*Table 6 Sensitivity analysis for measure 2*

Investment costs	ENPV of the investment	EIRR of the investment
60%	\$3,348,425	99%

80%	\$2,369,420	48%
100%	\$1,390,416	27%
120%	\$411,411	16%
140%	\$(567,594)	7%

Benefits	ENPV of the investment	EIRR of the investment
60%	\$(1,123,760)	-2%
80%	\$133,328	13%
100%	\$1,390,416	27%
120%	\$2,647,504	43%
140%	\$3,904,591	63%

Effectiveness of intervention	ENPV of the investment	EIRR of the investment
60%	\$(1,123,760)	-2%
75%	\$(180,944)	10%
100%	\$1,390,416	27%
120%	\$2,647,504	43%
140%	\$3,904,591	63%

Discount rate	ENPV of the investment
60%	\$2,743,787
75%	\$2,131,990
100%	\$1,390,416
120%	\$973,491
140%	\$664,812

#### 4.4. Measure 3 Surveillance lab

The measure aims at the implementation of increasing the capacity of the FSM food lab for the surveillance of climate-sensitive WBDs, FBDs and VBDs. Like measures 1 and 2, the main benefit used for calculating the economic feasibility of the measure is the avoided loss of human life and avoided health 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 20-year period was conducted for the implementation of surveillance lab.

**Table 7 Assumptions for measure 3.**

#### **Cost calculations on a per investment basis**

Parameter	Sources and assumptions elaboration	Unit	Value
<b>Input data</b>			
Discount rate	Assumption based on a general range of social discount rate for developing countries (8-12%)	%	12%
Investment costs per one surveillance Laboratory	FSM input	USD	\$1,405,820
Number of people benefiting from one investment	Total Population of FSM	#	102,843
Lifetime of investment	FSM input	Years	20
Annual opex costs	FSM input	USD/year	\$133,722
Investment costs per one Lab	Calculated	USD/per investment	\$1,405,820
# of projects (investments)	Project information	#	1
Total # of beneficiaries	Pre-Feasibility study	#	\$102,843
<b>Investment costs per one Lab</b>	<b>Calculated</b>	<b>USD/per investment</b>	<b>\$1,405,820</b>

### Results

The benefits were calculated on the basis of implementing one surveillance laboratory. The following table presents the results of Key Performance Indicators (KPIs):

*Table 8 KPIs for measure 3.*

Net costs / benefits	USD	Calculated	\$ 11,123,661
EIRR	%	Calculated	88%
ENPV	USD	Calculated	\$ 3,216,195
Net costs / benefits per year	USD / year	Calculated	\$ 585,456

The results show that all KPIs are positive in terms of the economic feasibility of the proposed project. The ENPV is substantial USD 3,216,195 and the EIRR is at 88%

### Sensitivity analysis

Various scenarios were tested to establish the economic viability of measure 3 based on either changes in the costs of investment, changes in the level of benefits, or changes in the discount rate. No additional sensitivity analysis on the effectiveness of the measure was conducted since all benefits derive from health benefits. The results are presented in the following table.

*Table 9 Sensitivity analysis for measure 3.*

Investment costs	ENPV of the investment	EIRR of the investment
60%	\$4,016,253	546%
80%	\$3,616,224	156%
100%	\$3,216,195	88%
120%	\$2,816,166	60%
140%	\$2,416,137	44%

Benefits	ENPV of the investment	EIRR of the investment
60%	\$1,129,659	32%
80%	\$2,172,927	55%
100%	\$3,216,195	88%
120%	\$4,259,463	139%
140%	\$5,302,731	228%

Discount rate	ENPV of the investment
60%	\$5,040,416
75%	\$4,231,539
100%	\$3,216,195
120%	\$2,618,200
140%	\$2,154,393

#### 4.5. Measure 4: Health Informed Early Warning System

The measure aims at the implementation of a complete operational Health Informed Early Warning System. The measure would involve the development of fit-for-use HIEWS including the structural, statistical and operational features of the system. Like all the above measures, the main benefit used for calculating the economic feasibility of the measure is the avoided loss of human life and avoided health 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 20-year period was conducted for the implementation of the HIEWS.

*Table 10 Assumptions for measure 4.*

##### **Cost calculations on a per investment basis**

Parameter	Sources and assumptions elaboration	Unit	Value
<b>Input data</b>			
Discount rate	Assumption based on a general range of social discount rate for developing countries (8-12%)	%	12%
Investment costs per one HIEWS	FSM input (Includes 2.1.2 procurement and staff costs)	USD	\$556,000
Number of people benefiting from investment	Total Population of FSM	#	61,706
Lifetime of investment	FSM input	Years	20
Annual opex costs	FSM input	USD/year	\$50,000
Investment costs per one HIEWS	Calculated	USD/per investment	\$556,000
# of projects (investments)	Project information	#	1
Total # of beneficiaries	Calculated	#	61,706
<b>Investment costs per one HIEWS</b>	<b>Calculated</b>	<b>USD/per investment</b>	<b>\$556,000</b>

Benefits calculations on a per investment basis			
Benefits			
Per capita monetary value of DALYs from WBD in 2019	Calculated	USD	\$90
Per capita monetary value of DALYs from VBD in 2019	Calculated	USD	\$13
Per capita monetary value of DALYs from FBD in 2019	Calculated	USD	\$90
Effectiveness of the Measure on disease burden %	ASSUMPTION	%	4%
Health costs avoided due to M4	Calculated	USD/year	\$793,168
<b>Total benefits per one HIEWS</b>	<b>Calculated</b>	<b>USD/per sub-project</b>	<b>\$793,168</b>

## Results

The benefits were calculated on the basis of implementing one HIEWS. The following table presents the results of Key Performance Indicators (KPIs):

*Table 11 KPIs for measure 1.*

Net costs / benefits	USD	Calculated	\$6,734,344
EIRR	%	Calculated	532%
ENPV	USD	Calculated	\$1,836,737
Net costs / benefits per year	USD / year	Calculated	\$336,717

The results show that all KPIs are positive in terms of the economic feasibility of the proposed project. The ENPV is substantial USD 12,127,862 and the EIRR is at 81%, higher than the used discount rate of 12% making this measure, under presented assumptions, economically viable.

### *Sensitivity analysis*

Various scenarios were tested to establish the economic viability of measure 4 based on either changes in the costs of investment, changes in the level of benefits, or changes in the discount rate. No additional sensitivity analysis on the effectiveness of the measure was conducted since all benefits derive from health benefits. The results are presented in the following table.

*Table 12 Sensitivity analysis for measure 4.*

Investment costs	ENPV of the investment	EIRR of the investment
60%	\$2,066,718	#NUM!
80%	\$1,951,728	#NUM!
100%	\$1,836,737	532%
120%	\$1,721,746	217%
140%	\$1,606,756	134%

Benefits	ENPV of the investment	EIRR of the investment
60%	\$872,061	87%
80%	\$1,354,399	189%
100%	\$1,836,737	532%
120%	\$2,319,075	#NUM!
140%	\$2,801,413	#NUM!

Discount rate	ENPV of the investment
60%	\$2,945,939
75%	\$2,451,323
100%	\$1,836,737
120%	\$1,479,398
140%	\$1,205,588

The results show a positive ENPV and EIRR in all scenarios with alternating level of costs, benefits and discount rate respectively. Based on the assumptions described above, measure 4 can be justified on economic grounds.

#### 4.6. 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 four measures. 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.

##### Results

The following table presents the project level cost-benefit analysis that consolidates all four previously elaborated adaptation measures and includes the non-investment part of the project budget. The discount rate of 12% used was the same as throughout the entire analysis.

**Table 13 Consolidated economic analysis – entire project**

Label	Unit	Source of information	Total
Costs - (OPEX costs - leveraged co-finance)			
M1 - CAPEX costs	USD	M1 - Rainwater harvesters	\$3,060,000
M1 - OPEX costs		M1 - Rainwater harvesters	\$1,848,000
M2 - CAPEX costs	USD	M2 - Climate resilient latrines	\$2,750,000
M2 - OPEX costs		M2 - Climate resilient latrines	\$9,190,500
M3 - CAPEX costs	USD	M3 - Surveillance laboratory	\$1,405,820
M3 - OPEX costs		M3 - Surveillance laboratory	\$2,406,996
M4 - CAPEX costs	USD	M4 - HIEWS	\$556,000
M4 - OPEX costs		M4 - HIEWS	\$800,000
<b>Total</b>	<b>USD</b>	<b>Calculated</b>	<b>\$22,017,320</b>

Other project costs			
Total non-investment project costs	USD	Project proposal	\$7,620,891
<b>Total non-investment project costs</b>	<b>USD</b>	<b>Calculated</b>	<b>\$7,620,891</b>

<b>Total investment costs</b>	<b>USD</b>	<b>Calculated</b>	<b>\$7,771,820</b>
<b>Total project costs</b>	<b>USD</b>	<b>Calculated</b>	<b>\$15,392,711</b>
<b>Total costs (with OPEX)</b>	<b>USD</b>	<b>Calculated</b>	<b>\$29,638,211</b>

Benefits			
M1 - benefits	USD	M1 - Rainwater harvesters	\$29,065,873
M2 - benefits	USD	M2 - SCT Toilets	\$20,131,182

Label	Unit	Source of information	Total
M3 - benefits	USD	M3 - Surveillance laboratory	\$15,070,199
M4 - benefits	USD	M4 - HIEWS	\$8,090,344
<b>Total benefits</b>	<b>USD</b>	<b>Calculated</b>	<b>\$72,000,000</b>

*Table 14 KPIs - Project level*

Net costs / benefits	USD	Calculated	\$42,719,390
EIRR	%	Calculated	25%
ENPV	USD	Calculated	\$7,707,178
Net costs / benefits per year	USD / year	Calculated	\$2,135,970

The results clearly show that the programme-level ENPV is positive, **USD 42,719,390** and the programme-level **EIRR is 25%**. The conclusion is that the proposed programme is economically viable and can be justified on economic grounds, even with substantial non-investment budget costs. 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.

### *Sensitivity analysis*

Various scenarios were tested to establish the economic viability of the project based on either changes in the costs of investment, changes in the level of benefits, or changes in the discount rate. The results are presented in the following table.

*Table 15 Sensitivity analysis for measure 3.*

Investment costs	ENPV of the investment	EIRR of the investment
60%	\$54,574,673	52%
80%	\$48,647,032	35%
100%	\$42,719,390	25%
120%	\$36,791,749	19%
140%	\$30,864,108	14%

Benefits	ENPV of the investment	EIRR of the investment
60%	\$13,776,351	9%
80%	\$28,247,871	17%
100%	\$42,719,390	25%
120%	\$57,190,910	33%
140%	\$71,662,429	41%

Discount rate	ENPV of the investment
60%	\$15,405,128
75%	\$11,939,297
100%	\$7,707,178

120%	\$5,303,908
140%	\$3,506,349