Annex 3 – Economic and Financial Analysis

1. Introduction

As described in the funding proposal the aim of the Vanuatu Enhancing Adaptation and Community Resilience by Improving Water Security project is to achieve a paradigm shift towards climate resilient water security for rural communities across Vanuatu, by enhancing community-based planning and adaptation for climate-resilient water management, developing climate-resilient rural water infrastructure, and creating an enabling environment at provincial and national level to better address climate risks associated with water security.

The project states substantial adaptation needs in regard to improving the water sector and access to safe and quality drinking water. This project is listed as the number 1 priority in the Vanuatu's draft GCF country programme and is being fully co-developed with the NDA, the DOWR and UNICEF, alongside other stakeholders (see section B4), which guarantees full country-ownership. By addressing increasing risks and impacts from climate change on water resource management, and by working directly with vulnerable rural communities (incl. community-based adaptation activities), the project is fully aligned with the Government of Vanuatu's climate change strategies and policies, including the Climate Change and Disaster Risk Reduction Policy 2016-2030

The project will increase the adaptive capacity of rural communities to better cope with the additional burden of climate change on water security and safety, by improving climate-resilient water management community-based planning, providing explicit capacity building, and fostering adaptation actions through improved local management practices and resilient infrastructures. Water safety and security is indeed particularly vital for community long-term resilience and in the immediate aftermath of climate-induced disasters. 600 communities will be direct beneficiaries as part of component 1 (improved planning and community-based activities on climate-resilient water management), of which 220 will also benefit from improved climate-resilient water infrastructure as part of component 2. An additional 50 communities with existing DWSSPs will be targeted under component 2 during the first year of the project. This makes a total of 650 communities directly benefiting from component 1 and 2. A preliminary estimate36, which will be refined in the full funding proposal, of direct beneficiaries is therefore 74,230.

The country's population of approximately 272,000 (2016 mini census) is spread over 68 islands and 75% of people live in rural and often remote communities. With 94% of the population living within 5 km of the coast and 60% living within 1 km of the coast, coastal environments and natural resources play a vital role in the subsistence and commercial life of ni-Vanuatu. This project will address some of the vital needs of rural communities in Vanuatu. Over 24,000 households across the country are reliant on either rainwater or surface water for their primary drinking water supply. Also, one third of households have no alternative source of drinking water. These issues have been, and will continue to be, exacerbated by climate change. This project will address the fundamental human right to safe drinking water. Through an already existing prioritization process that the project will also improve, those communities that have elevated levels of vulnerability, low access to WASH services and are exposed to climate risks will be targeted first.

In terms of climate projections, the Annex – 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.

Vanuatu was ranked as being at the highest risk level in the 2019 World Risk Index for disaster exposure, and has consistently featured among the top 10 most climate-impacted countries in the world. The islands of the archipelago are primarily mountainous volcanic islands with steep catchments leading to narrow coastal plains vulnerable to flooding and sea-level rise. It is prone to various disasters, ranging from tropical cyclones to earthquakes, coupled with underlying social and economic vulnerabilities. Since Vanuatu's population is also concentrated along the coasts, the balance of freshwater and saltwater (coastal) ecosystems plays a vital role in the subsistence and commercial life of the population. The islands have uniquely fragile water resources due to its small scale, lack of storage and limited freshwater reserves – which are increasingly exposed to climate impacts. Climate impacts particularly destabilise natural resource-dependent livelihoods of rural communities (pegged estimated at 75% of the population) , who continue to rely on subsistence farming in the different islands. Such climate-induced hazards also exacerbate the current Water, Sanitation and Hygiene (WASH) baseline in Vanuatu, which is inadequate and often inaccessible for many vulnerable communities.

In terms of expected climate change related impacts the feasibility study concludes the following:

- Increases in daily ***air temperatures*** are projected across all of Vanuatu for minimum, mean and maximum daily temperatures. Compared to 1995, temperature will be higher by 1.2°C (global 1.9°C) by 2040, and 2.3°C (global 3.6°C) by 2070 (high confidence).
- ***Extreme air temperatures*** (e.g. heatwaves) will reach higher levels and become more frequent. By 2040, the current 1-day maximum occurring once every 20 years will occur every 2 years (high confidence).
- Increases in ***sea surface temperature***s will mean reefs around Vanuatu will experience conditions that exceed thermal thresholds known to cause coral bleaching (above 29.5°C) more often, but impacts will be spatially and temporally variable (high confidence).
- ***Extreme sea surface temperatures*** (marine heatwaves) will occur more often, increasing from 10% of the time currently to 25% of the time by 2040 (high confidence).
- Projections of ***rainfall changes*** are low confidence, and trends are unclear given the very high climate variability in Vanuatu. There are a range of possible future trajectories, from wetter to drier, largely determined by future changes in the South Pacific Convergence Zone (SPCZ). This will pose challenges to planning and policy development, and therefore planning should consider both a wetter and a drier future.
- ***Extreme rainfall*** will become more frequent and intense (high confidence). By 2040, the 1 in 100-year event intensity will increase to 10-11%. This change is the same across all islands. Frequencies of current extreme events will increase by 1.2-2.5%.
- The duration of ***dry periods (droughts)*** will become longer (low confidence). The 1 in 5-year event will lengthen from 19 days to 28 days.
- ***Tropical cyclones*** are projected to be less frequent (decrease in cyclone formation) but more intense (medium confidence).
- ***Sea level*** is estimated to be currently increasing by 6mm/year since 1960 or 4mm/year since 1993. Models simulate an increase of up to 18 cm by 2030, with increases of up to 89 cm indicated by 2090 (high confidence). Information on local vertical land movement is crucial. For example, in Port Vila, a sea level rise of 159 cm is projected for 2100, when the observed sinking of 4.8 mm/year is taken into account.
- In 20 years', it is projected that continued ***ocean acidification*** will result in seawater chemistry that is only marginal for calcification, affecting reef accretion and structure on 80% of coral reefs around the world, including those in Vanuatu.

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

1. **Sea-level rise**
2. **Increased intensity of precipitation events**
3. **Tropical cyclones** (increased intensity, not frequency, predicted including severe wind and waves, and intense rainfall and flooding).
4. **Drought and decreased precipitation volumes, seasonal patterns changes**
5. **Increased air and water**

In addition to addressing these specified sectors and climate risks, the community adaptation actions implemented through the project will provide co-benefits that will increase resilience to climate impacts out of scope, such as water insecurity and health outcomes (see Table 5). These co-benefits will be achieved through the capacity and resilience building activities conducted with communities, as well as through partnerships and collaboration with complementary projects, such as the Vanuatu Department of Water projects.

Project activities are designed to respond to the needs and gaps identified through the vulnerability assessment, including: increasing local capacity to plan and manage climate-resilient water resources, to increase provincial and national institutions capacity in order to address strengthened to address climate risks associated with water security, and to implement climate resilient water infrastructure that will ensure supply of sanitary safe drinking water currently and in the future. These three components are outlined below.

- **Component 1: Evidence-based planning and decision-making for climate-resilient water management at the community level**
- **Component 2: Climate-resilient rural water infrastructure**
- **Component 3: Institutional strengthening at provincial and national level to better address climate risks associated with water security**

Component 1 - aims to improve and scale up the existing technical assistance programme (TAP) in water resource management at the community level to make it more climate-resilient. It also envisages to improve DWSSP process to better account for climate change, gender and social inclusion and target 600 additional most vulnerable communities (see Annex 6 for the selection process and an indicative list of locations) through enhanced planning and community-based adaptation activities. DWSSP is deemed the best vehicle for integrating climate change and water considerations at the community level given its well-proven methodology, its legal status in Vanuatu, and its current successful implementation by DoWR.

Component 2 - focuses on strengthening water systems in prioritized rural communities to address climate variability and change risks and impacts through the existing capital assistance programme (CAP). At least 270 prioritized communities schools or healthcare facilities will be targeted as part of component 2. GCF funding and co-financing will be mobilized to support climate-resilient infrastructures that will be developed, based on needs identified in DWSSPs.

This component includes the investment into adaptation measures, resilient water infrastructure. Therefore, this component is the most relevant in the context of economic and financial analysis.

Component 3 - aims to strengthen the institutional capacities, knowledge, processes and coordination mechanisms to better address climate change in integrated water management across rural communities in Vanuatu.

The envisaged GCF budget for the implementation of prioritised climate adaptation measures is USD 12,887,028 while USD 15,262,946 is expected to fund TA activities, non-investment related equipment, and travel costs. The total project budget is USD 28,149,974.

USD 23,208,993 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 the Vanuatu water sector and its infrastructure. The project envisages the implementation of several proven and efficient water technologies that would increase climate resilience of communities and livelihoods in Vanuatu. 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.

The focus of the adaptation investments is resilient and reliable water infrastructure. It will include the following:

- **M1 Community 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 Gravity Fed Systems -** Gravity Fed Systems deliver water from source, through a pipe and storage network, to demand centres. They typically collect water from reservoirs, springs, rivers and groundwater sources, and can vary is capacity and distance. Direct Gravity Fed (DGF) systems use only gravity to convey water directly from the source to demand, whilst Indirect Gravity (IG) Fed systems use pumping to elevate water before gravity conveys it to demand centre(s). DGF systems can provide large volumes of water at high pressure without on-going running costs. Their flexibility and scalability of distance and capacity is only hampered by source safe yield, and topology.
- **M3 Desalination -** Solar powered reverse osmosis desalination units are being increasingly adopted around the world due to their ability to provide excellent quality water, reliably with no greenhouse gas emissions.
- **M4 Indirect Gravity Fed (IDGF) -** Includes rehabilitation and construction of new groundwater wells systems.

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/water security measures and needs;
- Avoided loss associated with lack of supply of water during extreme climate events;
- Avoided monetary losses related to water import which is costly due to topography and remoteness characteristics of Vanuatu;
- Avoided health related costs associated with water borne diseases;
- Avoided loss of human life associated with water borne diseases;

- Avoided loss related to labour that is used for gathering water from remote, unsanitary, and non adapted water sources;
- Avoided GHG emissions – renewable energy based technologies;

3. Financial analysis

The project focuses exclusively on subsistence related beneficiaries and water infrastructure that is public good. Given that all of the interventions planned are public sector projects that use grant funding , a financial analysis is largely infeasible. In addition GCF the investment criteria for Efficiency and Effectiveness makes allowance for cases where financial analysis is not applicable, and the Investment Criteria Indicators from B.22 does not contain any financial indicators for adaptation projects. Generally, these types of investments produce outputs and outcomes that meet the classical definition of public goods (non-rivalrous and non-excludable).

Nevertheless, we have carried out a financial analysis to determine the tariff levels that would be required to make the investments financially feasible if they were commercial (without the GCF and with commercial loans), and the financial return on investment with the GCF grants, assuming that the investments were to produce a return from the equity component of the investments. This analysis is given below.

As will be seen the project is financed by grants (either from GCF or co-financing sources) and the business level perspective is not applicable (and unviable). The funds are intended for subsistence stakeholders and the interventions will not result in revenue generating activities.

3.1. Approach

For each one of the four investments we have carried out a financial analysis for a single investment, from the point of view of an investor. The approach, for each investment, was as follows:

Base case

A. Develop a cash flow analysis for an investment financed by a commercial loan (80%) and equity (20%), using a fixed monthly water tariff for all households covered by the investment.
B. Adjust water tariff to ensure that the IRR is equal to the WACC for the investor
C. Using ability to pay and income data for typical household consumers, determine the percentage of ability to pay of the estimated tariff, and the share of average household income.

Project alternative case

A. Develop a cash flow analysis for the investment financed by a grant from GCF (80%) and equity of (20%), using a fixed monthly water tariff for all households covered by the investment. Note that the equity here represents government / donor funding which does not have any real expectations of a return on investment
B. Determine a suitable tariff – either the maximum tariff based on ability to pay (665 VUV per household per month[1]) or a tariff that would be needed to to cover annual OPEX costs for the selected technology.

[1] A GGGI study on Solar PV powered water pumping systems in Vanuatu (GGGI, 2019 *Baseline Survey Report*) which covered 11 communities, 3400 people and 692 households identified that 93% of households would be willing and able to pay 665

C. Determine the IRR for the "investor" and the percentage of ability to pay of the estimated tariff and the share of average household income.

Analysis

Using the above analysis, we can determine whether the GCF grant can be justified based on financial analysis.

Inputs and assumptions

We have carried out the analysis for typical investments in each of the four measures. For each we used an equity ratio of 20%. While some of the proposed investments will be covered by GCF and some by other donors and the Government of Vanuatu, the approach allows for the simulation of commercial water provision and to identify the impact of the GCF grant.

Other data inputs and assumptions are given below:

Financial analysis universal inputs					
Equity ratio	20%	percent	*Assumption*		
Corporate income tax rate	0%	percent	https://migronis.com/blog/tax-system-of-vanuatu		
Commercial loan					
Maturity period	6	years	*Assumption*		
Grace period	0	years	*Assumption*		
Credit interest rate	15%	percent	https://www.bsp.com.vu/about-us/rates-fees/product-interest-rates		
Bank fees	1.0%	percent	*Assumption*		
Water tariffs, income & demographic data					
Tariff (low)	0.876	USD / family / month	*UNICEF, 24 June 2022*		
Tariff (high)	3.504	USD / family / month	*UNICEF, 24 June 2023*		
Tariff (max ability to pay)	5.825	USD / family / month	*GGGI Baseline Survey Report, 2019*		
Average family size	5.3	people per family	*GGGI Baseline Survey Report, 2019*		
Average monthly household income	171.17	USD / family / month	*GGGI Baseline Survey Report, 2019*		

Results of the analysis is given below.

3.2. Measure 1: Construction of community rainwater harvesters

Baseline scenario

The base case analysis used the following additional inputs:

VUV per household per month. It should be noted that tariffs in rural and remote locations are seldom this high (figures between n 100 VUV and 400 VUV are more common). Average income per person per day in the targeted rural communities was 123 VUV, which is under poverty threshold according to the World Bank (1.93 USD Person/day). Average composition of a household is 5.3 members and the monthly average income per household is around 20.000 VUV.

CASE 1: BASELINE WITHOUT GCF			
Income			
Tarriff at which IRR = WACC	38.30	USD / household / month	*estimated*
Opex (annual)	$ 1,000	USD / year / system	*estimated*
Annual income from water users	**5,937**	USD per year	*calculated*
Financing amounts			**Total**
Total capex	USD	*Project budget*	**20,148**
Own resources (equity)	USD	*Calculated*	**4,030**
Commercial loan	USD	*Calculated*	**16,118**
GCF grants	USD	*Calculated*	
Cost of capital			
Average cost of debt	15%		
Tax rate	0.0%		
Total debt amount	$ 16,118		
Debt as a % of total capital	**80.0%**		
After tax cost of debt	**15.0%**		
Cost of equity	**20.0%**		
WACC			
WACC	**16.0%**		

Results of the base case analysis are as follows:

FINANCIAL INDICATORS - BASELINE CASE				
Tariff required to achieve IRR = WACC	**USD / household / month**	*Estimated*	**$**	**38.30**
Percentage of monthly income	**%**	*Calculated*		**22%**
Percentage of reported ability to pay	**%**	*Calculated*		**657%**
25-year Internal Rate of Return - leveraged	**%**	*Calculated*		**16.0%**
Discount rate	**%**	*Assumption*		**12%**
Net Present Value	**USD**	*Calculated*	**$**	**7,486.04**
Payback period	**Years**	*Calculated*		**9**
WACC	**%**	*Calculated*		**16.0%**

BASELINE SCENARIO - IRR sensitivity - Tariff vs interest rate

		Commercial loan interest rate (%)				
		9%	12%	15%	18%	21%
Tariff (USD)	22.98	**6.6%**	**6.0%**	**5.5%**	**5.0%**	**4.5%**
	30.64	**12.2%**	**11.5%**	**10.8%**	**10.2%**	**9.6%**
	38.30	**17.7%**	**16.8%**	**16.0%**	**15.2%**	**14.5%**
	45.96	**23.2%**	**22.3%**	**21.3%**	**20.4%**	**19.5%**
	53.62	**29.0%**	**28.0%**	**26.9%**	**25.8%**	**24.7%**

BASELINE NPV sensitivity - Tariff vs interest rate

		Commercial loan interest rate (%)				
		9%	12%	15%	18%	21%
Tariff (USD)	22.98	**- 9,331**	**- 10,545**	**- 11,801**	**- 13,096**	**- 14,428**
	30.64	**312**	**- 902**	**- 2,157**	**- 3,452**	**- 4,785**
	38.30	**9,955**	**8,742**	**7,486**	**6,191**	**4,859**
	45.96	**19,599**	**18,385**	**17,129**	**15,834**	**14,502**
	53.62	**29,242**	**28,028**	**26,773**	**25,477**	**24,145**

Project alternative scenario results

The project alternative analysis used the following additional inputs:

CASE2: PROJECT ALTERNATIVE WITH GCF

Income			
Tarriff (Max ability to pay)	$ 5.83	USD / household / month	*GGGI Baseline Survey Repor*
Opex (annual)	$ 1,000	USD / year / system	*estimated*
Annual income from water users	**55**	USD per year	*calculated*
Financing amounts			**Total (USD)**
Total capex	USD	*Project budget*	**20,148**
Own resources (equity)	USD	*Calculated*	**4,030**
Commercial loan	USD	*Calculated*	
GCF grants	USD	*Calculated*	**16,118**
Cost of capital			
Average cost of debt	15%		
Tax rate	0.0%		
Total debt amount	$ -		
Debt as a % of total capital	**0.0%**		
After tax cost of debt	**15.0%**		
Cost of equity	**20.0%**		
WACC			
WACC	**20.0%**		

Results of the project alternative analysis are as follows:

FINANCIAL INDICATORS - PROJECT ALTERNATIVE CASE

Tariff required to achieve IRR = WACC	**USD / household / month**	*Estimated*	**$**	**5.83**
Percentage of monthly income	**%**	*Calculated*		**3%**
Percentage of ability to pay	**%**	*Calculated*		**100%**
25-year Internal Rate of Return - leveraged	**%**	*Calculated*		**-7.5%**
Discount rate	**%**	*Assumption*		**12%**
Net Present Value	**USD**	*Calculated*	**$**	**-3,214.43**
Payback period	**Years**	*Calculated*		**28**
WACC	**%**	*Calculated*		**20.0%**

PROJECT ALTERNATIVE SCENARIO - IRR sensitivity - Tariff vs "equity" contribution

		"Equity" contribution (USD)				
		2,418	3,224	4,030	4,836	5,642
Tariff (USD)	3.50					
	4.66					
	5.83	-4.2%	-6.1%	-7.4%	-8.4%	-9.3%
	7.00	9.9%	6.4%	4.1%	2.4%	1.1%
	8.16	19.5%	14.2%	10.9%	8.5%	6.7%

NOTE: the IRR cannot be determined for tariffs below the middle case.

PROJECT ALTERNATIVE NPV sensitivity - Tariff vs "equity" contribution

		"Equity" contribution (USD)				
		2,418	3,224	4,030	4,836	5,642
Tariff (USD)	3.50	- 4,706	- 5,425	- 6,145	- 6,864	- 7,584
	4.66	- 3,238	- 3,957	- 4,677	- 5,397	- 6,116
	5.83	- 1,770	- 2,489	- 3,209	- 3,929	- 4,648
	7.00	- 302	- 1,021	- 1,741	- 2,461	- 3,180
	8.16	1,166	446	- 273	- 993	- 1,712

3.3. Measure 2: Direct gravity fed water systems

Baseline scenario

The base case analysis used the following additional inputs:

CASE 1: BASELINE WITHOUT GCF			
Income			
Tarriff at which IRR = WACC	89.50	USD / household / ı	*estimated*
Opex (annual)	$ 2,000	USD / year / system	*estimated*
Annual income from water users	28,396	USD per year	*calculated*
Financing amounts			**Total**
Total capex	USD	*Project budget*	**96,360**
Own resources (equity)	USD	*Calculated*	**19,272**
Commercial loan	USD	*Calculated*	**77,088**
GCF grants	USD	*Calculated*	
Cost of capital			
Average cost of debt	15%		
Tax rate	0.0%		
Total debt amount	$ 77,088		
Debt as a % of total capital	**80.0%**		
After tax cost of debt	**15.0%**		
Cost of equity	**20.0%**		
WACC			
WACC	**16.0%**		

Results of the base case analysis are as follows:

FINANCIAL INDICATORS - BASELINE CASE				
Tariff required to achieve IRR = WACC	**USD / household / month**	*Estimated*	**$**	**89.50**
Percentage of monthly income	**%**	*Calculated*		**52%**
Percentage of reported ability to pay	**%**	*Calculated*		**1536%**
25-year Internal Rate of Return - leveraged	**%**	*Calculated*		**16.0%**
Discount rate	**%**	*Assumption*		**12%**
Net Present Value	**USD**	*Calculated*	**$**	**35,803.96**
Payback period	**Years**	*Calculated*		**9**
WACC	**%**	*Calculated*		**16.0%**

BASELINE SCENARIO - IRR sensitivity - Tariff vs interest rate

		Commercial loan interest rate (%)				
		9%	12%	15%	18%	21%
Tariff (USD)	54	**7.5%**	**7.0%**	**6.4%**	**5.9%**	**5.3%**
	72	**12.6%**	**11.9%**	**11.3%**	**10.6%**	**10.0%**
	90	**17.7%**	**16.8%**	**16.0%**	**15.2%**	**14.5%**
	107	**22.8%**	**21.8%**	**20.9%**	**20.0%**	**19.1%**
	125	**28.0%**	**27.0%**	**25.9%**	**24.9%**	**23.8%**

BASELINE NPV sensitivity - Tariff vs interest rate

		Commercial loan interest rate (%)				
		9%	12%	15%	18%	21%
Tariff (USD)	54	-36,892	-42,696	-48,701	-54,895	-61,267
	72	5,360	-443	-6,449	-12,643	-19,015
	90	47,613	41,809	35,804	29,609	23,238
	107	89,865	84,062	78,056	71,862	65,490
	125	132,118	126,314	120,309	114,114	107,743

Project alternative scenario results

The project alternative analysis used the following additional inputs:

CASE2: PROJECT ALTERNATIVE WITH GCF			
Income			
Tarriff (Minimum	$ 6.00	USD / household /	*Estimated*
Opex (annual)	$ 2,000	USD / year / system	*estimated*
Annual income fro	38	USD per year	*calculated*
Financing amounts			**Total (USD)**
Total capex	USD	*Project budget*	**96,360**
Own resources (e	USD	*Calculated*	**19,272**
Commercial loan	USD	*Calculated*	
GCF grants	USD	*Calculated*	**77,088**
Cost of capital			
Average cost of	15%		
Tax rate	0.0%		
Total debt amou	$ -		
Debt as a % of to	**0.0%**		
After tax cost of del	**15.0%**		
Cost of equity	**20.0%**		
WACC			
WACC	**20.0%**		

Results of the project alternative analysis are as follows:

FINANCIAL INDICATORS - PROJECT ALTERNATIVE CASE				
Tariff	**USD / household / month**	*Estimated*	**$**	**6.00**
Percentage of monthly income	**%**	*Calculated*		**4%**
Percentage of ability to pay	**%**	*Calculated*		**103%**
25-year Internal Rate of Return - leveraged	**%**	*Calculated*		**-17.0%**
Discount rate	**%**	*Assumption*		**12%**
Net Present Value	**USD**	*Calculated*	**$**	**-16,944.87**
Payback period	**Years**	*Calculated*		**28**
WACC	**%**	*Calculated*		**20.0%**

PROJECT ALTERNATIVE SCENARIO - IRR sensitivity - Tariff vs "equity" contribution

		"Equity" contribution (USD)				
		12,643	16,858	21,072	25,286	29,501
Tariff (USD)	3.60					
	4.80					
	6.00	-15.2%	-16.4%	-17.4%	-18.2%	-18.8%
	7.20	-1.3%	-3.4%	-4.8%	-6.0%	-6.9%
	8.40	4.3%	1.6%	-0.2%	-1.6%	-2.7%

NOTE: the IRR cannot be determined for tariffs below the middle case.

PROJECT ALTERNATIVE NPV sensitivity - Tariff vs "equity" contribution

		"Equity" contribution (USD)				
		12,643	16,858	21,072	25,286	29,501
Tariff (USD)	3.60	- 16,691	- 20,454	- 24,217	- 27,980	- 31,743
	4.80	- 13,859	- 17,622	- 21,385	- 25,147	- 28,910
	6.00	- 11,026	- 14,789	- 18,552	- 22,315	- 26,078
	7.20	- 8,194	- 11,957	- 15,719	- 19,482	- 23,245
	8.40	- 5,361	- 9,124	- 12,887	- 16,650	- 20,413

3.4. Measure 3: Water desalination systems

Baseline scenario

The base case analysis used the following additional inputs:

CASE 1: BASELINE WITHOUT GCF			
Income			
Tarriff at which IRR = WACC	214.00	USD / household / month	*estimated*
Opex (annual)	$ 2,000	USD / year / system	*estimated*
Annual income from water users	27,072	USD per year	*calculated*
Financing amounts			**Total**
Total capex	USD	*Project budget*	**91,980**
Own resources (equity)	USD	*Calculated*	**18,396**
Commercial loan	USD	*Calculated*	**73,584**
GCF grants	USD	*Calculated*	
Cost of capital			
Average cost of debt	15%		
Tax rate	0.0%		
Total debt amount	$ 73,584		
Debt as a % of total capital	**80.0%**		
After tax cost of debt	**15.0%**		
Cost of equity	**20.0%**		
WACC			
WACC	**16.0%**		

Results of the base case analysis are as follows:

FINANCIAL INDICATORS - BASELINE CASE				
Tariff required to achieve IRR = WACC	**USD / household / month**	*Estimated*	**$**	**214.00**
Percentage of monthly income	**%**	*Calculated*		**125%**
Percentage of reported ability to pay	**%**	*Calculated*		**3674%**
25-year Internal Rate of Return - leveraged	**%**	*Calculated*		**16.0%**
Discount rate	**%**	*Assumption*		**12%**
Net Present Value	**USD**	*Calculated*	**$**	**33,941.65**
Payback period	**Years**	*Calculated*		**9**
WACC	**%**	*Calculated*		**16.0%**

BASELINE SCENARIO - IRR sensitivity - Tariff vs interest rate

		Commercial loan interest rate (%)				
		9%	12%	15%	18%	21%
Tariff (USD)	128	7.5%	6.9%	6.4%	5.8%	5.3%
	171	12.6%	11.9%	11.2%	10.6%	9.9%
	214	17.6%	16.8%	16.0%	15.2%	14.5%
	257	22.7%	21.8%	20.9%	20.0%	19.1%
	300	28.0%	27.0%	25.9%	24.9%	23.8%

BASELINE NPV sensitivity - Tariff vs interest rate

		Commercial loan interest rate (%)				
		9%	12%	15%	18%	21%
Tariff (USD)	128	- 35,609	- 41,149	- 46,881	- 52,794	- 58,876
	171	4,803	- 737	- 6,470	- 12,383	- 18,464
	214	45,214	39,674	33,942	28,029	21,947
	257	85,625	80,085	74,353	68,440	62,358
	300	126,036	120,497	114,764	108,851	102,769

Project alternative scenario results

The project alternative analysis used the following additional inputs:

CASE2: PROJECT ALTERNATIVE WITH GCF			
Income			
Tariff (Minimum required to cover OPEX)	15.00	USD / household / month	*estimated*
Opex (annual)	$ 2,000	USD / year / system	*estimated*
Annual income from water users	38	USD per year	*Calculated*
Financing amounts			**Total (USD)**
Total capex	USD	*Project budget*	**91,980**
Own resources (equity)	USD	*Calculated*	**18,396**
Commercial loan	USD	*Calculated*	
GCF grants	USD	*Calculated*	**73,584**
Cost of capital			
Average cost of debt	15%		
Tax rate	0.0%		
Total debt amount	$ -		
Debt as a % of total capital	**0.0%**		
After tax cost of debt	**15.0%**		
Cost of equity	**20.0%**		
WACC			
WACC	**20.0%**		

Results of the project alternative analysis are as follows:

FINANCIAL INDICATORS - PROJECT ALTERNATIVE CASE				
Tariff	**USD / household / month**	*Estimated*	**$**	**15.00**
Percentage of monthly income	**%**	*Calculated*		**9%**
Percentage of ability to pay	**%**	*Calculated*		**257%**
25-year Internal Rate of Return - leveraged	**%**	*Calculated*		**-16.8%**
Discount rate	**%**	*Assumption*		**12%**
Net Present Value	**USD**	*Calculated*	**$**	**-16,162.73**
Payback period	**Years**	*Calculated*		**28**
WACC	**%**	*Calculated*		**20.0%**

PROJECT ALTERNATIVE SCENARIO - IRR sensitivity - Tariff vs "equity" contribution

		"Equity" contribution (USD)				
		11,038	14,717	18,396	22,075	25,754
Tariff (USD)	9.00					
	12.00					
	15.00	**-14.6%**	**-15.8%**	**-16.8%**	**-17.6%**	**-18.2%**
	18.00	**-0.3%**	**-2.4%**	**-4.0%**	**-5.1%**	**-6.1%**
	21.00	**5.7%**	**2.8%**	**0.9%**	**-0.6%**	**-1.8%**

NOTE: the IRR cannot be determined for tariffs below the middle case.

PROJECT ALTERNATIVE NPV sensitivity - Tariff vs "equity" contribution

		"Equity" contribution (USD)				
		11,038	14,717	18,396	22,075	25,754
Tariff (USD)	9.00	**- 15,258**	**- 18,543**	**- 21,828**	**- 25,113**	**- 28,398**
	12.00	**- 12,425**	**- 15,710**	**- 18,995**	**- 22,280**	**- 25,565**
	15.00	**- 9,593**	**- 12,878**	**- 16,163**	**- 19,448**	**- 22,733**
	18.00	**- 6,760**	**- 10,045**	**- 13,330**	**- 16,615**	**- 19,900**
	21.00	**- 3,928**	**- 7,213**	**- 10,498**	**- 13,783**	**- 17,068**

3.5. Measure 4: IDGF - systems

Baseline scenario

The base case analysis used the following additional inputs:

CASE 1: BASELINE WITHOUT GCF			
Income			
Tarriff at which IRR = WACC	104.50	USD / household / month	*estimated*
Opex (annual)	$ 2,000	USD / year / system	*estimated*
Annual income from water users	15,745	USD per year	*calculated*
Financing amounts			**Total**
Total capex	USD	*Project budget*	**53,436**
Own resources (equity)	USD	*Calculated*	**10,687**
Commercial loan	USD	*Calculated*	**42,749**
GCF grants	USD	*Calculated*	
Cost of capital			
Average cost of debt	15%		
Tax rate	0.0%		
Total debt amount	$ 42,749		
Debt as a % of total capital	**80.0%**		
After tax cost of debt	**15.0%**		
Cost of equity	**20.0%**		
WACC			
WACC	**16.0%**		

Results of the base case analysis are as follows:

FINANCIAL INDICATORS - BASELINE CASE				
Tariff required to achieve IRR = WACC	**USD / household / month**	*Estimated*	**$**	**104.50**
Percentage of monthly income	**%**	*Calculated*		**61%**
Percentage of reported ability to pay	**%**	*Calculated*		**1794%**
25-year Internal Rate of Return - leveraged	**%**	*Calculated*		**16.0%**
Discount rate	**%**	*Assumption*		**12%**
Net Present Value	**USD**	*Calculated*	**$**	**19,843.00**
Payback period	**Years**	*Calculated*		**9**
WACC	**%**	*Calculated*		**16.0%**

BASELINE SCENARIO - IRR sensitivity - Tariff vs interest rate

		Commercial loan interest rate (%)				
		9%	12%	15%	18%	21%
Tariff (USD)	62.70	**7.0%**	**6.4%**	**5.9%**	**5.3%**	**4.8%**
	83.60	**12.4%**	**11.7%**	**11.0%**	**10.4%**	**9.7%**
	104.50	**17.7%**	**16.8%**	**16.0%**	**15.2%**	**14.5%**
	125.40	**23.0%**	**22.1%**	**21.1%**	**20.2%**	**19.3%**
	146.30	**28.6%**	**27.5%**	**26.5%**	**25.4%**	**24.4%**

BASELINE NPV sensitivity - Tariff vs interest rate

		Commercial loan interest rate (%)				
		9%	12%	15%	18%	21%
Tariff (USD)	62.70	**- 22,942**	**- 26,161**	**- 29,491**	**- 32,926**	**- 36,459**
	83.60	**1,725**	**- 1,494**	**- 4,824**	**- 8,259**	**- 11,792**
	104.50	**26,392**	**23,173**	**19,843**	**16,408**	**12,875**
	125.40	**51,059**	**47,840**	**44,510**	**41,075**	**37,542**
	146.30	**75,725**	**72,507**	**69,177**	**65,742**	**62,208**

Project alternative scenario results

The project alternative analysis used the following additional inputs:

CASE2: PROJECT ALTERNATIVE WITH GCF			
Income			
Tarriff (Minimum required to cover OPEX)	$ 12.00	USD / household / month	*estimated*
Opex (annual)	$ 2,000	USD / year / system	*estimated*
Annual income from water users	38	USD per year	*Calculated*
Financing amounts			**Total (USD)**
Total capex	USD	*Project budget*	**53,436**
Own resources (equity)	USD	*Calculated*	**10,687**
Commercial loan	USD	*Calculated*	
GCF grants	USD	*Calculated*	**42,749**
Cost of capital			
Average cost of debt	15%		
Tax rate	0.0%		
Total debt amount	$ -		
Debt as a % of total capital	**0.0%**		
After tax cost of debt	**15.0%**		
Cost of equity	**20.0%**		
WACC			
WACC	**20.0%**		

Results of the project alternative analysis are as follows:

FINANCIAL INDICATORS - PROJECT ALTERNATIVE CASE				
Tariff	**USD / household / month**	*Estimated*	**$**	**12.00**
Percentage of monthly income	**%**	*Calculated*		**7%**
Percentage of ability to pay	**%**	*Calculated*		**206%**
25-year Internal Rate of Return - leveraged	**%**	*Calculated*		**-14.4%**
Discount rate	**%**	*Assumption*		**12%**
Net Present Value	**USD**	*Calculated*	**$**	**-9,279.87**
Payback period	**Years**	*Calculated*		**28**
WACC	**%**	*Calculated*		**20.0%**

PROJECT ALTERNATIVE SCENARIO - IRR sensitivity - Tariff vs "equity" contribution

		"Equity" contribution (USD)				
		6,412	8,550	10,687	12,824	14,962
Tariff (USD)	7.20					
	9.60					
	12.00	**-12.0%**	**-13.4%**	**-14.4%**	**-15.2%**	**-15.9%**
	14.40	**4.6%**	**1.9%**	**0.0%**	**-1.4%**	**-2.5%**
	16.80	**12.5%**	**8.6%**	**6.0%**	**4.1%**	**2.7%**

NOTE: the IRR cannot be determined for tariffs below the middle case.

PROJECT ALTERNATIVE NPV sensitivity - Tariff vs "equity" contribution

		"Equity" contribution (USD)				
		6,412	8,550	10,687	12,824	14,962
Tariff (USD)	7.20	- **11,128**	- **13,036**	- **14,945**	- **16,853**	- **18,762**
	9.60	- **8,295**	- **10,204**	- **12,112**	- **14,021**	- **15,929**
	12.00	- **5,463**	- **7,371**	- **9,280**	- **11,188**	- **13,096**
	14.40	- **2,630**	- **4,539**	- **6,447**	- **8,356**	- **10,264**
	16.80	- **202**	- **1,706**	- **3,615**	- **5,523**	- **7,431**

3.6. Conclusion

We have simulated a cash flow analysis for each of the four measures. We calculated the IRR and NPV for two cases: 1) finance provided by commercial sources including a loan (80%) and equity (20%) from the developer and 2) finance provided through a grant from the GCF and "equity" from an investor (donor or government). We adjusted the tariff to produce, in the first case, an IRR equal to the WACC, and, in the second case, either a tariff set at the maximum ability to pay (665 VUV/month/household) or a tariff that would be sufficient to cover the OPEX for the technology in question. The results are summarized below:

Measure	**Baseline**			**Project alternative**		
	Tariff required to achieve IRR=WACC	% monthly income	% ability to pay	Minimum tariff (= ability to pay or OPEX coverage)	% monthly income	% ability to pay
M1 - Rainwater harvesters	$ 38.30	22%	657%	$ 5.83	3%	100%
M2 - Direct gravity fed system	$ 89.50	52%	1,536%	$ 6.00	4%	103%
M3 - Water desalination systems	$ 214.00	125%	3,674%	$ 15.00	9%	257%
M4 -IDGF systems	$ 104.50	61%	1794%	$ 12.00	7%	206%

It is clear that in all cases the monthly household tariff that would be required for a commercial loan-based investment would be many orders of magnitude beyond what household can pay. In the project alternative, with GCF grant funding, the necessary tariffs (to, at a minimum, cover OPEX costs) are higher than the reported ability to pay for M2, M3 and M4. Since these investments are seen as a public good these additional costs will be covered by public funds.

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 25-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 – feasibility study, there is a significant lack of capacity related to climate adaptation on all levels and among all stakeholders relevant for water sector in Vanuatu. The project envisages variety of possible adaptation intervention within the above mentioned focal areas covered by the scope of the project.

The economic analysis covers the interventions for which the scale is know to some extent. Due to nature of variety and number of possible adaptation interventions, it was not possible and feasible to test every single possible intervention. Furthermore, the identification of the scale of interventions is significantly hindered due to the great diversity of relevant parameters. Indeed, Vanuatu is extremely diverse in terms of population distribution, geographical morphology, distribution of climate impacts and corresponding adaptation needs.

As already stated, the proposed programme is aiming at three main types of technologies – **Community Rainwater harvesting systems, Gravity fed systems, and desalination systems.** For the purpose of the economic analysis, above mentioned four types of technologies were identified – each one tested with economic analysis. The measures were selected based on the Vanuatu 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: Construction of community rainwater harvesters**
- **Measure 2: Direct gravity fed water systems**
- **Measure 3: Water desalination systems**
- **Measure 4: IDGF - systems**

4.2. Measure 1: Construction of community rainwater harvesters

Measure 1 would include the construction of rainwater harvesters. Reliable access to water is one of the major issues in Vanuatu. 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. 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 Vanuatu 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 25-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**
Input data			

Discount rate	Assumption based on a general range of social discount rate for developing countries (8-12%)	%	12%
Investment costs per rainwater harvester tank	1 x 50^2 shelter with 2 x 10,000L tank - including costs for shipping and labour	USD	$20,148
Rainwater harvester costs per investment	Calculated	USD/investment	$20,148
# of beneficiaries per investment	Estimation based on http://www.bibalex.org/Search4Dev/files/419439/442767.pdf	#	80
Lifetime of investment	https://terranova.org.au/repository/paccsap-collection/pacific-adaptation-scenarios-costs-and-benefits-water-security-in-tuvalu-technical-report/cba-tuvalu-water-security-technical-report.pdf	Years	25
Opex costs for one rainwater harvester	**Based on https://www.mdpi.com/2073-4441/6/4/945/pdf**	**USD/year/per harvester**	**$1,000**
Investment costs per one rainwater harvester investment	**Calculated**	**USD/per sub-project**	**$20,148**

Benefits calculations on a per investment basis			
Volume of one rainwater tank	Supply and Installation Cost (Full Cost) of Rainwater Harvesting System in FSM - RENI Project	l	10,000
Annual water volume savings by rainwater - per harvester	https://terranova.org.au/repository/paccsap-collection/pacific-adaptation-scenarios-costs-and-benefits-water-security-in-tuvalu-technical-report/cba-tuvalu-water-security-technical-report.pdf	Litres per annum	90,000
Total annual saving per investment	Calculated	Litres per annum	90,000
Benefits			
Import price of water per litre	Assumption based on need for water demand during droughts and seawater intrusion	USD/l	$0.01
Benefits resulting in access to water per investment	Calculated	USD/year	$900
Value of Statistical Life (VSL) in Vanuatu	Conservative assumption based on https://gh.bmj.com/content/bmjgh/5/1/e001535/DC1/embed/inline-supplementary-material-1.pdf?download=true	USD	$100,000
Annual health costs per capita in Vanuatu	https://documents1.worldbank.org/curated/en/393851528813168114/pdf/12-6-2018-17-10-35-VanuatuSpendBetterHealthFinancingSystemAssessmentfinal.pdf	USD/year	$160
Number of water borne disease related deaths per 100,000 people in Vanuatu	https://vizhub.healthdata.org/gbd-compare/	People per year	25

Number of people suffering of water borne diseases per 100,000 people in Vanuatu	https://vizhub.healthdata.org/gbd-compare/	People per year	300
Number of people suffering of water borne diseases - project potential	Based on https://vizhub.healthdata.org/gbd-compare/	People per year	150
Number of deaths avoided on a project level - based on approximated number of beneficiaries (approx. 30k)	Assumption	People per year	10
% measure potential against split project ratio	Assumption	%	55%
Number of deaths avoided by M1 - based on the number of beneficiaries	Assumption	#/year	5
Amount of people avoiding health costs due to M1	Assumption	#/year	82
VSL costs avoided due to M1 - on a per investment basis	Calculated	USD/year	$3,704
Health costs avoided due to M1	Calculated	USD/year	$89
Total benefits per one rainwater harvester investment	**Calculated**	**USD/per sub-project**	**$4,693**

Results

The benefits were calculated on the basis of implementing 148 rainwater harvesters. The following table presents the results of Key Performance Indicators (KPIs):

Table 2 KPIs for measure 1.

Net costs / benefits	**USD**	**Calculated**	$12,644,429
EIRR	**%**	**Calculated**	30%
ENPV	**USD**	**Calculated**	$2,032,576
Net costs / benefits per year	**USD / year**	**Calculated**	$505,777

The results show that all KPIs are positive in terms of the economic feasibility of the proposed project. The ENPV is USD $2,032,567 and the EIRR is at 30%, 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 or changes in the level of benefits. The results are presented in the following table.

Table 3 Sensitivity analysis for measure 1.

Project costs	ENPV of the investment	EIRR of the investment
60%	$2,841,244	63%

80%	$2,436,910	41%
100%	$2,032,576	30%
120%	$1,628,242	24%
140%	$1,223,908	20%
Benefits	**ENPV of the investment**	**EIRR of the investment**
60%	$410,877	16%
80%	$1,221,727	23%
100%	$2,032,576	30%
120%	$2,843,425	39%
140%	$3,654,275	48%

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: Direct gravity fed water systems

Measure 2. would include the implementation of gravity fed 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. 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 Vanuatu 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 25-year period was conducted for the implementation 69 gravity fed systems.

Without the project - Baseline scenario:

Table 4 Assumptions for measure 2.

Cost calculations on a per investment basis			
Parameter	**Sources and assumptions elaboration**	**Unit**	**Value**
Input data			
Discount rate	Assumption based on a general range of social discount rate for developing countries (8-12%)	%	12%

Investment costs per one gravity fed system	1-2 x 10,000L tank and 1 break pressure tank, supplied water is 100 l/person/day from a spring or stream - including shipping and labour costs	USD	$96,360
Number of people benefiting from one investment	Calculated	#	150
Volume of tank of water per investment	Project technical data	l	10,000
Lifetime of investment	Expert's assumption	Years	25
Annual opex costs for one direct gravity fed system	**Assumption**	**USD/year/per system**	**$2,000**
Investment costs per one gravity fed system	**Calculated**	**USD/per investment**	**$96,360**

Benefits calculations on a per investment basis			
Volume of one investment tank	Calculated	l	10,000
Water supply per person/day	Project technical data	l/day	100
Number of people covered by one investment	Project technical data	# people	150
Annual water supply per investment	l/year	Calculated	4,500,000
Number of days per year - system operating	Assumption	Days	300
Daily water supply per investment	l/year	Calculated	15,000
Benefits			
Import price of water per litre	Assumption based on need for water demand during droughts	USD/l	$0.01
Benefits resulting in access to water per investment	Calculated	USD/year	$45,000
Social cost of avoided GHG emissions	**Calculated**	**$/year**	**227.5**
Value of Statistical Life (VSL) in Vanuatu	Conservative assumption based on https://gh.bmj.com/content/bmjgh/5/1/e001535/DC1/embed/inline-supplementary-material-1.pdf?download=true	USD	$100,000
Annual health costs per capita in Vanuatu	https://documents1.worldbank.org/curated/en/393851528813168114/pdf/12-6-2018-17-10-35-VanuatuSpendBetterHealthFinancingSystemAssessmentfinal.pdf	USD/year	$160
Number of water borne disease related deaths per 100,000 people in Vanuatu	https://vizhub.healthdata.org/gbd-compare/	People per year	25
Number of people suffering of water borne diseases - project potential	Based on https://vizhub.healthdata.org/gbd-compare/	People per year	150
Number of people suffering of water borne diseases - per 100,000 people	https://vizhub.healthdata.org/gbd-compare/	People per year	300

Number of deaths avoided on a project level - based on approximated number of beneficiaries (approx. 30k)	Assumption	People per year	10
% measure potential against split project ratio	Assumption	%	26%
Total measure potential against number of beneficiaries	Assumption	%	26%
Number of deaths avoided by M2 - based on the number of beneficiaries	Assumption	#/year	3
Amount of people avoiding health costs due to M2	Assumption	#/year	38
VSL costs avoided due to M2 - on a per investment basis	Calculated	USD/year	$3,704
Health costs avoided due to M2	Calculated	USD/year	$89
Total benefits per one direct gravity fed investment	**Calculated**	**USD/per sub-project**	**$48,793**

Results

The benefits were calculated on the basis of implementing 69 gravity fed systems. The following table presents the results of Key Performance Indicators (KPIs):

Table 5 KPIs for measure 2 – Gravity fed systems

Net costs / benefits	**USD**	**Calculated**	$69,101,660
EIRR	**%**	**Calculated**	103%
ENPV	**USD**	**Calculated**	$15,145,661
Net costs / benefits per year	**USD / year**	**Calculated**	$2,764,066

The results show that all KPIs are positive in terms of the economic feasibility of the proposed project. The ENPV is substantial USD 15,145,661 and the EIRR is at 103%, higher than the used discount rate of 12% making this measure, under presented assumptions, economically viable.

Table 6 Sensitivity analysis for measure 2

Project costs	ENPV of the investment	EIRR of the investment
60%	$16,948,773	541%
80%	$16,047,217	172%
100%	$15,145,661	103%
120%	$14,244,105	73%
140%	$13,342,549	57%
Benefits	**ENPV of the investment**	**EIRR of the investment**
60%	$7,284,285	44%
80%	$11,214,973	68%
100%	$15,145,661	103%

120%	$19,076,349	155%
140%	$23,007,037	244%

4.4. Measure 3: Water desalination systems

The measure aims at the implementation of water desalination systems. The technology is based on solar powered reverse osmosis with desalination units.

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. 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 Vanuatu 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 25-year period was conducted for the implementation of water desalination systems.

Table 7 Assumptions for measure 3.

Cost calculations on a per investment basis			
Parameter	**Sources and assumptions elaboration**	**Unit**	**Value**
Input data			
Discount rate	Assumption based on a general range of social discount rate for developing countries (8-12%)	%	12%
Investment cost per one desalination system	Project technical data - Materials and works for one Desalination system - 250l/hr (approx 250 people)	USD	$91,980
Water production capacity	Project technical data - Based on average community size 50-100 people with 1 x 3,000L tank water supplied is only for drinking and cooking (5-10 liter/person/day)	Litres per day	600
Days operated per year	Assumption	Days	300
Annual water production capacity	Calculated	Litres per year	180,000
Lifetime of investment	https://terranova.org.au/repository/paccsap-collection/pacific-adaptation-scenarios-costs-and-benefits-water-security-in-tuvalu-technical-report/cba-tuvalu-water-security-technical-report.pdf	Years	25
Cost of batteries per desalination plant	Assumption based on https://www.igs.com/energy-resource-center/energy-101/solar-panel-batteries#:~:text=Solar%20batteries%20range	USD/per system	$5,000

	%20from%20%245%2C000,and%20price%20per%20relative%20capacity.		
Opex costs per desalination plant	Assumption	USD/system	$2,000
Investment costs per one desalination system investment	**Calculated**	**USD/per sub-project**	**$91,980**

Benefits calculations on a per investment basis			
Annual water production capacity	Calculated	Litres per year	180,000
Energy required to desalinate 1m3 water	https://www.elementalwatermakers.com/solutions/plug-play-solar-desalination/	kWh/m3	10
Annual energy consumption per one desalination system	Calculated	kWh/year	1,800
Benefits			
Import price of water per litre	Assumption based on need for water demand during droughts and seawater intrusion	USD/l	$0.01
Benefits resulting in access to water per investment	Calculated	USD/year	$1,800
Vanuatu energy grid emission factor	https://procurement-notices.undp.org/view_file.cfm?doc_id=41770	kgCO2/kWh	1.3
Total GHG emission reductions per year	Calculated	kgCO2/year	2,340
Social price of carbon	https://www.oecd.org/env/cc/37321411.pdf	USD/tCO2e	35
Social cost of avoided GHG emissions	Calculated	USD/year	81.9
Benefits resulting in access to water per investment	Calculated	USD/year	$18
Value of Statistical Life (VSL) in Vanuatu	Conservative assumption based on https://gh.bmj.com/content/bmjgh/5/1/e001535/DC1/embed/inline-supplementary-material-1.pdf?download=true	USD	$100,000
Annual health costs per capita in Vanuatu	https://documents1.worldbank.org/curated/en/393851528813168114/pdf/12-6-2018-17-10-35-VanuatuSpendBetterHealthFinancingSystemAssessmentfinal.pdf	USD/year	$160
Number of water borne disease related deaths per 100,000 people in Vanuatu	https://vizhub.healthdata.org/gbd-compare/	People per year	25
Number of people suffering of water borne diseases - project potential	Based on https://vizhub.healthdata.org/gbd-compare/	People per year	150
Number of people suffering of water borne diseases per 100,000 people in Vanuatu	https://vizhub.healthdata.org/gbd-compare/	People per year	300
Number of deaths avoided on a project level - based on	Assumption	People per year	15

approximated number of beneficiaries (approx. 30k)			
% measure potential against split project ratio	Assumption	%	1%
Number of deaths avoided by M3 - based on the number of beneficiaries	Assumption	#/year	0
Amount of people avoiding health costs due to M3	Assumption	#/year	2
VSL costs avoided due to M3 - on a per investment basis	Calculated	USD/year	$5,556
Health costs avoided due to M3	Calculated	USD/year	$89
Total benefits per one desalination system investment	**Calculated**	**USD/per sub-project**	**$7,526**

Results

The benefits were calculated on the basis of implementing 4 individual desalination systems. The following table presents the results of Key Performance Indicators (KPIs):

Table 8 KPIs for measure 3.

Net costs / benefits	**USD**	**Calculated**	$309,451
EIRR	**%**	**Calculated**	7%
ENPV	**USD**	**Calculated**	$(73,699)
Net costs / benefits per year	**USD / year**	**Calculated**	$12,378

The results show that all KPIs are positive in terms of the economic feasibility of the proposed project. The ENPV is slightly negative USD (73,699) and the EIRR is at 7%.

Sensitivity analysis

Various scenarios were tested to establish the economic viability of measure 3 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 9 Sensitivity analysis for measure 3.

Project costs	ENPV of the investment	EIRR of the investment
60%	$26,078	15%
80%	$(23,810)	10%
100%	$(73,699)	7%
120%	$(123,587)	4%
140%	$(173,476)	3%
Benefits	**ENPV of the investment**	**EIRR of the investment**
60%	$(143,996)	1%
80%	$(108,847)	4%
100%	$(73,699)	7%

120%	$(38,550)	9%
140%	$(3,401)	12%

Based on the assumptions described above, measure 3. Can't be justified on economic terms.

Only 4 desalination projects will be supported by the project, and the economic case of each desalination project will need to be examined carefully. In the experience of the project team desalination is applicable in exceptional cases where community needs and environmental conditions justify this technology.

4.5. Measure 4: IDGF - systems

The measure aims at the implementation of shallow groundwater systems. The measure would involve the rehabilitation and construction of new shallow groundwater systems. Due to data limitations, the analysis considered only construction of new shallow groundwater systems. We believe that this approach is sufficient to demonstrate the economic viability of the proposed measure within Vanuatu context.

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. 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 Vanuatu 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 25-year period was conducted for the implementation of rainwater harvesters.

Table 10 Assumptions for measure 4.

Cost calculations on a per investment basis			
Parameter	**Sources and assumptions elaboration**	**Unit**	**Value**
Input data			
Discount rate	Assumption based on a general range of social discount rate for developing countries (8-12%)	%	12%
Investment cost per one IDGF system	Average community size 50-100 people with 1 x 10,000L tank, supplied water is 50-100 l/person/day generally from a borehole though sometimes from a water source that is below the community - includes labour and shipping	USD	$53,436

Water volume of one IDGF system	Assumption	Litters	5,000
Lifetime of investment	Assumption	Years	25
Annual opex costs for one direct gravity fed system	**Assumption**	**USD/year/per system**	**$2,000**
Investment costs per one IDGF system	**Calculated**	**USD/per sub-project**	**$53,436**
Benefits calculations on a per investment basis			
Annual water savings potential per one IDGF system	Assumption	Litres per year	1,687,500
People covered by one investment	Project technical data	# People	75
Daily water supply	Project technical data	l/day/person	75
Days operated per year	Assumption	Days	300
Volume of tank	Project technical data	l	10,000
Benefits			
Import price of water per litre	Assumption based on need for water demand during droughts and seawater intrusion	USD/l	$0.01
Benefits resulting in access to water per investment	Calculated	USD/year	$16,875
Value of Statistical Life (VSL) in Vanuatu	Conservative assumption based on https://gh.bmj.com/content/bmjgh/5/1/e001535/DC1/embed/inline-supplementary-material-1.pdf?download=true	USD	$100,000
Annual health costs per capita in Vanuatu	https://documents1.worldbank.org/curated/en/393851528813168114/pdf/12-6-2018-17-10-35-VanuatuSpendBetterHealthFinancingSystemAssessmentfinal.pdf	USD/year	$160
Number of water borne disease related deaths per 100,000 people in Vanuatu	https://vizhub.healthdata.org/gbd-compare/	People per year	25
Number of people suffering of water borne diseases - project potential	Based on https://vizhub.healthdata.org/gbd-compare/	People per year	150
Number of people suffering of water borne diseases per 100,000 people in Vanuatu	https://vizhub.healthdata.org/gbd-compare/	People per year	150
Number of deaths avoided on a project level - based on approximated number of beneficiaries (approx. 80k)	Assumption	People per year	15
% measure potential against split project ratio	Assumption	%	18%
Number of deaths avoided by M3 - based on the amount of budget allocation	Assumption	#/year	3

Amount of people avoiding health costs due to M3	Assumption	#/year	27
VSL costs avoided due to M3 - on a per investment basis	Calculated	USD/year	$5,556
Health costs avoided due to M3	Calculated	USD/year	$89
Total benefits per one IDGF system	**Calculated**	**USD/per sub-project**	**$22,519**

Results

The benefits were calculated on the basis of implementing 49 IDGF systems. The following table presents the results of Key Performance Indicators (KPIs):

Table 11 KPIs for measure 1.

Net costs / benefits	**USD**	**Calculated**	$22,209,324
EIRR	**%**	**Calculated**	73%
ENPV	**USD**	**Calculated**	$4,666,337
Net costs / benefits per year	**USD / year**	**Calculated**	$888,373

The results show that all KPIs are positive in terms of the economic feasibility of the proposed project. The ENPV is substantial USD 4,666,337 and the EIRR is at 73%, 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 or changes in the level of benefits. The results are presented in the following table.

Table 12 Sensitivity analysis for measure 4.

Project costs	ENPV of the investment	EIRR of the investment
60%	$ 5,376,416	236%
80%	$ 5,021,376	111%
100%	$ 4,666,337	73%
120%	$ 4,311,297	54%
140%	$ 3,956,258	43%
Benefits	**ENPV of the investment**	**EIRR of the investment**
60%	$ 2,089,723	34%
80%	$ 3,378,030	51%
100%	$ 4,666,337	73%
120%	$ 5,954,644	102%
140%	$ 7,242,951	144%

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 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 three measures, scaled-up to the envisaged number of sub-projects that could potentially be financed by the project. 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 three previously elaborated adaptation measures and includes the non-investment part of the programme budget. The discount rate of 5% used was the same as throughout the entire analysis.

Table 13 Consolidated economic analysis – entire project

Label	Unit	Source of information	Total
Year			
Costs			
M1 - CAPEX costs	USD	M1 - Rainwater harvesters	$ 2,981,904
M2 - CAPEX costs	USD	M2 - Direct gravity fed system	$ 6,648,840
M3 - CAPEX costs	USD	M3 - Water desalination systems	$ 367,920
M4 - CAPEX costs	USD	M4 - IDGF- systems	$ 2,618,364
Total	**USD**	**Calculated**	**$ 12,617,030**
Other project costs			
Total non-investment project costs	USD	Project proposal	$ 15,672,986
Percentage of funds utilisation - project lifetime distribution	%	Assumption	
Total non-investment project costs	**USD**	**Calculated**	$ 15,672,986
Total investment costs	**USD**	**Calculated**	$12,617,028
Total project costs	**USD**	**Calculated**	$28,209,014
Benefits			
M1 - benefits	USD	M1 - Rainwater harvesters	$ 12,153,815
M2 - benefits	USD	M2 - Direct gravity fed system	$ 58,917,056
M3 - benefits	USD	M3 - Water desalination systems	$ 526,844
M4 - benefits	USD	M4 - IDGF- systems	$ 19,310,424
Total benefits	**USD**	**Calculated**	$ 91,000,000

Table 14 KPIs - Project level

Net costs / benefits	**USD**	**Calculated**	$88,591,877
EIRR	**%**	**Calculated**	20%
ENPV	**USD**	**Calculated**	$37,150,065
Net costs / benefits per year	**USD / year**	**Calculated**	$3,543,675

The results clearly show that the programme-level ENPV is positive, **USD 37,150,065** and the programme-level **EIRR is 20%.** The conclusion is that the proposed programme is economically viable and can be justified on economic grounds, even with more than 50% 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.