DRAFT

COST BENEFIT ANALYSIS

of the

TUVALU PACC PROJECT

Ministry of Finance & Economic Development

Government of Tuvalu

July 2012

CONTENTS:

ACRONYMS

CBA – Cost Benefit Analysis

GIZ - Deutsche Gesellschaft für Technische Zusammenarbeit

NPV – Net Present Value

PACC – Pacific Adaptation to Climate Change

PWD – Public Works Department

SPC- Secretariat of the Pacific Commission

EXECUTIVE SUMMARY

At the request of the Tuvalu Pacific Adaptation to Climate Change (PACC) project with assistance from SPREP and SPC, the Department of Planning and Budget was tasked to conduct a cost benefit analysis (CBA) of the Tuvalu PACC Project from February to May 2012. The main purpose of the CBA was to weigh the total aggregate costs and benefits of the PACC pilot project which is the construction of a new water cistern for the Lofeagai community on the main capitol island, Funafuti.

Upon the request for a CBA, a staff from the Ministry of Finance and Economic Development (DPB) and the national PACC Project coordinator underwent CBA training in Nauru in November 2011. One outcome of the CBA training was the formulation of the PACC CBA work plan which guided the different stages of the Tuvalu PACC CBA. Descriptions of the specific steps taken in the CBA are included in methodology section of the report (Section 3). The CBA noted that the PACC pilot project has commenced prior to the CBA, but a analysis was necessary to capture the true cost implications of such projects compared to its intended and unintended benefits.

Technical mission from GIZ/SPC was in country in early April 2012 to assist the PACC Project coordinator and DPB staff to finalize the PACC CBA. During this mission visit, data were reviewed and analysed in depth for more accurate assumptions and projections. Two half day trainings sessions were conducted by the GIZ/SPC staff for the staff of the Department of Planning and Budget and the Office of the Auditor General. The purpose of the training was to build the capacity and knowledge of both agency staff in carrying out CBAs and also to enable them to review CBAs. At the end of the GIZ/SPC mission, a first draft of the PACC CBA was compiled for further inputs from DPB and the national PACC Project Coordinator.

This report contains the main steps, analysis and conclusions of the PACC CBA, together with its recommendations and suggestions for continuing improvements of similar projects.
The Department of Planning and Budget, Ministry of Finance and Economic Development would like to thank the national PACC Project Coordinator, staff of the Public Works Department (PWD), the Meteorological Department, for their commitment and assistance in providing the data for the analysis and to the GIZ/SPC and SPREP for providing the technical assistance in finalizing this report.

1 INTRODUCTION

1.1 Problem statement

The physical location and topography of Tuvalu makes it especially vulnerable to climate change related risk including sea level rise and changes in rainfall patterns which could exacerbate the existing vulnerability to drought. Sea level rise and the associated unusually high King Tides have plagued Tuvalu for a number of years causing flooding of dwellings and intrusion of salt water into the freshwater lens. These events impact adversely on food security, water, health and general living conditions of Tuvaluans.

Tuvalu does not have above-ground water sources and relies largely on precipitation, desalinisation and underground water to a certain degree. It is critical that Tuvalu institutes a climate change resilient water management programme and searches for alternative ways of managing pressures particularly given the high cost of fuel expenses from desalinisation. The choice of which combination of methods to use will depend on local conditions, but a strong program of conservation is essential. Vulnerability and adaptation assessments using climate information are essential to inform the adaptation measures chosen. These include the design and demonstration of approaches to increase the climate resiliency of the water supply systems, and demonstrate ways to improve water retention capacity as a long term strategy and a means of 'climate proofing'.

According to the National Adaptation Programmme of Action (NAPA, 2007) for Tuvalu, drought is on the increase and it is closely associated with the frequency of ENSO, which brings periods of erratic and low rainfall to Tuvalu. This climate related risk, coupled with human-induced stresses due to over-consumption and increase in population, has impacted severely on Tuvalu's ability to maintain a quality water supply for its population. Efforts are needed to be put in place now to address these risks and the activities to being demonstrated under PACC will go some way to address some of the many vulnerabilities facing Tuvalu.

The quantity of (daily) water supply in Lofeagai village, which is the site chosen for this PACC pilot project on Funafuti, is inadequate at the end of the dry season and drought periods. Household rainwater tanks are dry for around 120-150 days (4-5 months) during a typical year. During these times households must purchase their water from expensive desalination (AUD$5.94/500 litres and $AUD3.52/1000 litres) and very limited quantities of bottled water. During severe drought periods the government also rations two buckets (around 20 litres each) per day per household to poorer households (78% of community population). There are long delays and waiting costs for each of these back-up supply options.

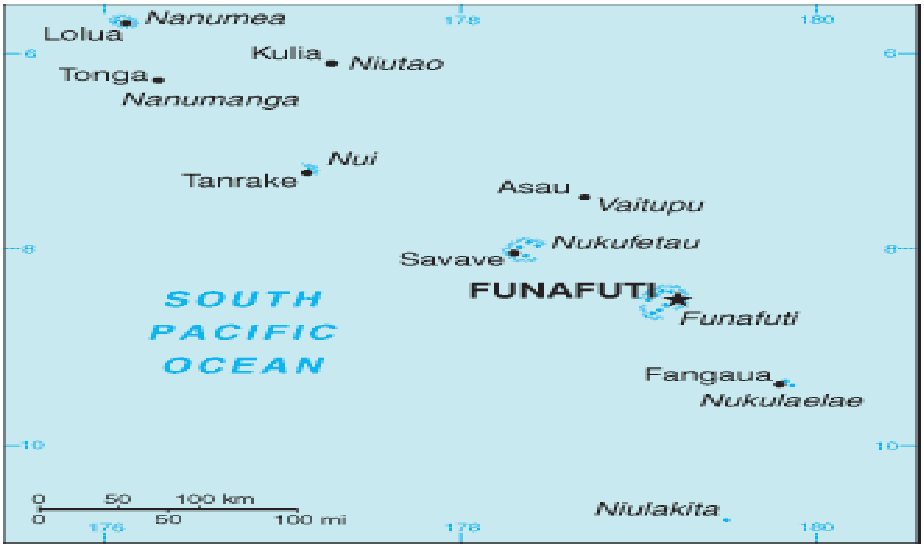
1.2 Objective in this study, expected outcomes

A cost-benefit analysis was conducted to examine the benefits and costs of the proposed solution to the problem – building a community water cistern in Lofeagai village that will use the newly built church roof as a catchment area. Once built the community are planning on building a community hall on top of the cistern and using the roof from the hall to also feed into the cistern.

This proposed option is compared to the alternative of having additional rainwater tanks that could supply the same volume of water to the community during the dry season.

2 BACKGROUND

2.1 Country context



Map of Tuvalu

The islands of Tuvalu are generally composed of very coarse coral gravels and sands. The coarse sediments cannot sustain substantial fresh groundwater lenses to the extent that exists in other atoll countries in the region. In Tuvalu the primary freshwater source is from stored household and communal rainwater. The overall available water resources are only partly known, and in most of the outer islands the available groundwater and its quality is largely unknown. The estimated demand for freshwater in the main population centre of Funafuti is close to the estimated sustainable freshwater yields indicating vulnerability to variations in climate.

Groundwater salinity levels vary, but it is historically a non-potable secondary source in areas where salinity levels are not prohibitive. In times of prolonged drought it has also been a source of drinking water on some islands. Its use as a secondary source has been severely compromised by pollution from inadequate sanitation systems on Funafuti, and there is an increasing threat that this could also occur on the outer islands. Waterborne diseases are common and exact a significant toll on the health, wellbeing and productivity of the population. The coastal areas of Funafuti are a major source of livelihood and also contain marine biodiversity of conservation value. These areas are also under threat from poor solid and liquid waste management.

Tuvalu PACC have identified high priority in the water sector that need particular attention when addressing challenges of climate change related disaster risks. Currently, there is a number of adaptation measures have been implemented in the country, ranging from plans, policies, and on the ground projects targeting vulnerable communities. However, there is a great need to refurbish or supplement fresh water resources by repairing rainwater harvesting systems, increasing household and community rainwater storage and investigating and expanding the use of groundwater resources.

2.2 Water Supply Issues.

The quantity of (daily) water supply in Lofeagai village, Funafuti, is inadequate at the end of the dry season and drought periods. Household rainwater tanks are dry for around 120-150 days (4-5 months) during a typical year. During these times households must purchase their water from expensive desalination (AUD$5.94/500 litres and $AUD3.52/1000 litres) and some limited bottled water. During severe drought periods the government also rations two buckets (around 20 litres each) per day per household to poorer households (78% of community population). There are long delays and waiting costs for each of these back-up supply options.

Cause(s) of problem

- Poor household rainwater catchment management[1]
- Limited catchment available on certain houses in Lofeagai
- Population growth and migration from outer islands (driver)
- Economic growth (driver)
- Climate change-related impacts on rainfall
- Lack of awareness how to manage use of water
- No community storage reserve

3 METHODOLOGY

3.1 Cost benefit analysis

A cost-benefit analysis was conducted to examine the costs and benefits of the community cistern, when compared to an alternative of providing additional rainwater tanks for households that would supply the same volume of water during the dry season.

Cost-benefit analysis is an economic framework that evaluates the benefits and costs of a project to support effective decision making and resource use. The technical sections of this economic study will follow the following main 3 steps.

- Measuring the nominal gains and losses over a given time period to the Lofeagai community.
- Aggregating these nominal gains and losses and expressing them as social benefits and present social costs.
- Determining the overall net present gain or loss.

[1] During the 2011 drought the majority of households thought that is was not their responsibility to clean their gutters and fix their roofs.

At a workshop in Nauru in 2011, Ms. Simalua Enele (Finance Ministry of Finance and Economic Development) and Ms Loia Tausi (PACC coordinator) developed a workplan to guide the cost benefit analysis framework. This workplan identified a "without" PACC scenario, a "with" PACC scenario and compared with the alternative of household rainwater tanks. (See 3.2).

Data was collected to compare the different scenarios identified in the workplan. The data for both the base case and household rainwater tanks were grouped into separate sets the first set being the costs and charges on the production of water both on the government and the Lofeagai community. The second set of data is the basic demographic information of Lofeagai, the amount of water consumption in the community including time spent by residents of Lofeagai on purchasing desalinated water. The amount of water the cistern and the water tanks are expected to supply and their life spans make up the fourth set of data, while the last data set is the cost information for constructing and maintaining both the community cistern and household water tanks. The data for this analysis was collected within a period of two months. A detailed description of the sources of data is provided in section 4 of this report.

The data analysis was done using excel spreadsheets with calculations done in order to show the monetary value of the total benefits as compared to estimated costs of the base case and its alternative. Assumptions made in the analysis were tested using sensitivity analysis to test the impacts of various uncertainties on the net present value and benefit/cost ratio. The section on valuing the costs and benefits will highlight the specific methods of calculating the benefits and costs of the project.

3.2 With and without analysis, expected general benefits and costs

Without scenario

The 'Without scenario' is also known to be the status quo of the community in terms of water supply. In the status quo, community members of Lofeagai village will continue to queue at the PWD office to buy desalinated water as and when needed. There is often a delay between purchasing the water at PWD and the delivery of the water to their respective home which can take sometimes for instance a week. In times of longer dry period than expected, government restricts the sales of water to public and again, people can be deprived from their right to water. During critical periods, government supplies are not for sale but are rationed amongst all resident of the island. During the recent drought in late 2011, residents of Funafuti were rationed to 2 buckets per household per day.

Lofeagai community does not have a community cistern that they can rely on as a reserve supply during times of water shortage. Unlike other communities who can access water from their community cistern members of Lofeagai are especially vulnerable as their community does not have an immediate response plan to water shortages but relies on assistance from government limited water supply at a cost. Purchase of imported bottled water is another available option but it is too costly for people to be able to supply their entire families' water needs. Underground water is not recommended as a source of drinkable water or for consumption but can be use otherwise for washing, flushing toilets, bathing etc.

With project scenario

In this scenario the community cistern (with a storage capacity of 750m3) is built to utilise the catchment available from a nearby church. Once complete the cistern will also form the foundation for a community hall and in time therefore the rainwater catchment (roof) from the community hall can also feed into the cistern. For the purposes of the analysis the base 'with project' scenario assumes that only the existing catchment of the roof of the church will be used and sensitivity analysis is done to examine the difference that including the proposed catchment from the community hall has on the results.

As the cistern is being built as a reserve for use during the dry season it is assumed that water is only extracted from the cistern between April –November (average rainfall) and May-November (if the preceding and current year has had low rainfall). The amount of water extracted during the dry season from the cistern depends on rainfall patterns and whether or not the community hall when built is also used for catchment purposes. The base 'with project' scenario assumes average rainfall patterns using average monthly rainfall data from 1933-2011. Sensitivity analysis is also conducted for the low rainfall scenario.[2]

The cistern provides additional water to the community during the dry season and additional peace of mind that they have a community back-up supply. It will help the residents of Lofeagai to avoid the total costs of consuming desalinated water including time spent on purchasing desalinated water.

A comparison is made with the purchase of rainwater tanks that would supply the same volume of additional water supply. The benefit/cost ratios for both cases show the benefits are higher than the total costs, but with the rainwater tanks having a more favourable benefit/cost ratio. This is mainly due to the lower cost of installing and maintaining rainwater tanks in each household. One disadvantage to installing rainwater tanks in each household is the large amount of space within the land; therefore, the water cistern project design is a more practical approach towards using the limited land for water storage.

3.3 Valuing benefits and costs

This section discusses the valuation of costs and benefits and in particular those values that could not easily be gleaned from market prices.

Costs

[2] The low rainfall scenario was developed based on the standard deviation (95% confidence interval) around the mean monthly rainfall. This standard deviation was then deducted from the mean to provide a low monthly rainfall figure. This can be interpreted as 95% of the time rainfall in a given month was no lower than this. The low rainfall scenario therefore represents a conservative estimate of rainfall. It is also worth noting that the latest climate change projections indicate that the length of droughts in Tuvalu may become shorter in the coming decades (Pacific Climate Change Science Programme Report).

In general all cost data was available using market prices for actual purchases made. The exceptions included the following costs.

Rental rate for cement mixer

There is one cement mixer available on Funafuti for rental at a very high rental rate. The PACC project is therefore purchasing a cement mixer which will be handed over to PWD at the end of the project. A rental rate for the cement mixer was calculated using the following formula where R is the rental rate, P=Price, r = interest rate and T = lifetime of mixer

$$R = rP/[1-\exp(-rT)]$$

Water for construction

Water is needed for construction of the cistern. The PACC project have loaned two water tanks from PWD and are using the catchment from the church roof to fill these tanks to provide water for construction. These water tanks are due to be installed as part of ongoing water supply programmes but would currently be sitting at the PWD Headquarters unused. It is therefore assumed that their opportunity cost is zero and the value of water used for construction is therefore also zero.

Capital cost

The cost of the roofing, gutting, pump and tank for the cistern were all the actual costs incurred when pruchased from a company in Fiji. The cost in Fijian dollars ($1,91766.69) was converted to AUD (AUD$78,595.58) using the actual exchange rate (0.4098) on the date of the actual payment.

Total cost for rent of loader

A loader is needed to load materials at the site of the water cistern project. There is a loader available for rent on Funafuti. Total costs ($3,200) were calculated based on estimated number of days (10), working hours per day (8 working hours) and the rental rate per hour ($40).

Cost of hiring trucks

A truck will be rented from a private company to transport materials to the project site at the hiring rate of $70 per day for the duration of 10 days.

Rental of dump truck

A dump truck is required to transport waste material from the site to the main dump site. Total costs ($x) were calculated based on estimated number of days (x), working hours per day (8 working hours) and the rental rate per hour ($x).

Fuel cost for loader and dumb truck

The cost of fuel for both the loader and dump truck was calculated by multiplying the fuel price per drum (x) by the number of drums required for the loader (x) and dump truck (x).

Labour costs

The labour costs for the construction of the cistern are calculated based on four groups: (a) construction workers, (b) the foreman and the labour required for operating (c) the loader and (d) the dump truck.

The cost for construction workers (casual workers -x) and the foreman (x) are calculated by multiplying the number of workers (x) and foreman (x) by the hourly wage rate (x), and an estimate of total hours worked (based on x construction weeks).

The costs for the workers (x) for the loader and dump truck are calculated by multiplying the number of workers by the wage rate (x) and the total number of working hours (x)..

Total construction costs

The total cost for constructing the water cistern are calculated by adding the total costs for capital, labour, water for construction, and equipment hire.

Maintenance costs

Another important aspect of the project costs are the maintenance cost.

The estimated lifespan of the cistern is 30 years. The PWD estimated the total replacement materials needed to maintain the cistern at 3% of the overall capital costs (x) and the number of maintenance labour days as x. The total maintenance labour and material costs are then averaged out through a 30 year period as per the lifespan of the cistern.

Total Cost Discounted

Since the project has costs and benefits that accrue over extended years, the future costs and benefits are aggregated using the method of discounting. The present value of the total costs of the cistern is calculated by the formula:

Present Value = Future Value*1/[(1+r)^t]

Where r is the real interest rate and t is the time period for future value.

Benefits

<u>Additional supply of water for the Lofeagai Community</u>

The main benefit of the project is greater availability of water during the dry season at Lofeagai.

Valuing this water requires being explicit about the assumptions being made.

Currently households collect rainwater in rainwater tanks and during the dry season purchase desalinated water and a very limited amount of bottled water. They purchase desalinated water from PWD in 500, 1000 and 2000 gallon purchases. The price paid for this water is subsidised by the government.

The main benefit of the PACC project is additional water availability to households in Lofeagai during the dry season.

It is assumed that the water supply from the cistern will displace current purchases of desalinated water and bottled water.

Information on current purchases (from PWD) and bottled water (from trade statistics) was used to calculate the amount currently spent on purchased water. For these volumes of water the price of desalinated water and price of bottled water was used to value the water supplied by the cistern as these would represent cost savings or avoided costs to the community.

As water is subsidised reductions in the volume of water supplied to Lofeagai households also represents a cost saving or avoided costs to the government (as they now have to produce less desalinated water). The subsidy rate per litre of water was calculated using information supplied by PWD[3]. This was multiplied by the volume of current purchases to calculate benefits to the government.

In addition to the volume of water supplied that can displace purchased water the cistern will supply the community with additional water available for consumption that the community currently does not have access to. In order to value this additional water it was necessary to understand in more detail the current water supply situation during dry months and the community demand for water.

On a household level it is estimated that the amount of additional supply of water for each household will increase by 11,290.75 litres per year under this project.

Water demand in Funafuti

Currently during the dry season PWD restricts sales of water (e.g. to the minimum volume of 500 gallons) to ensure they have available emergency supplies should they require them. In the event of severe shortages it is not possible to buy desalinated water and the government supplies rationed water (two buckets per household) to households from designated supply points.

Available data showing purchases by the Lofeagai community and discussions with PWD staff and the PACC coordinator indicate that there is unmet demand for desalinated water from the community (i.e. the community would buy more desalinated water from PWD if it were available). This assumption is made based on the relatively high volumes of water purchased either side of months where no water is purchased due to restrictions (e.g. August, November and December). Also, in 2004 a private owner of a cistern was selling water to

[3] Supplied by Greg Wolff based on PWD data. This takes into account the fuel, labour, depreciation and maintenance costs of running the plant and also the delivery costs of water.

other members of the community at a rate six times the value of the purchased priced of water. The owner cannot recall how much he sold but it was more than a one-off sale.

Given the indication of unmet demand the price charged by PWD for desalinated water is used as a lower-bound for the value (or willingness to pay) for water in the Lofeagai community. For the purposes of sensitivity as this is likely to be a conservative value the results are tested using the following prices to value the additional water available as a result of the cistern.

- Purchase price of desalinated water (x)
- 200% of the purchase price of desalinated water (x)
- Rate charged by private seller in 2004 (x, for illustration as an upper bound)

<u>Avoided time and travel costs</u>

Another benefit from the cistern is the average avoided time and travel costs to purchase desalinated water. The avoided time costs was calculated by having the number of desalinated water deliveries to Lofeagai on an average rainfall scenario multiplied by the cost per return trip from Lofeagai to the PWD complex. It is then estimated that only 25% of the travel time is spent on purchasing desalinated water as the other will be spent on doing other things while in the main town area.

The avoided time costs from purchasing desalinated water is calculated by the numbers of deliveries of desalinated water to Lofeagai multiplied by the estimated amount of time spent on buying desalinated water and the wage rate. The wage rate is used to put a monetary cost of the amount of time spent on purchasing desalinated water.

Total Benefits (Discounted)

Just as the calculation of total costs discounted, the calculation for total benefits by discounting is:

Present Value = Future Value*1/[(1+r)^t]

Where r is the real interest rate and t is the time period for future value.

There are also additional benefits that the report has not attempted to quantify but are important have been proven in previous studies which state that in general, water supply projects do have significant health benefits[4]. Health benefits of increased water supply (decreases in illnesses caused by water shortages). In other studies the health benefits have been the largest element of the total benefits of water supply and water quality improvements but in Lofeagai's case as the cistern is only to be used as a supply during dry periods and it is

[4] Lal et al (2006) Lal, P., Saloa, K. and Uila, L. (2006) 'Economics of liquid waste management in Funafuti, Tuvalu,' Apia, Samoa: SPREP

difficult to disentangle the effects of this additional supply vs the supply impacts of rainwater tanks or other water improvement policies.

3.4 General assumptions, scope

There are some uncertainties that are factored into the cost benefit analysis. The method to test these uncertainties is to undertake a sensitivity analysis on proposed assumptions. This will enable the analysis to show the impacts of certain assumptions on the results (net present value or benefit/cost ratio) of the analysis. The major assumptions that the analysis takes into account are as follows:

- The possible increase in the real rate of cost of production of desalinated water based on rising real fuel prices;
- An average, low and high annual rainfall scenario;
- The lifespan of the water cistern which will be tested for the periods of 30, 40 and 50 years;
- The possible changes in the discount rate; and
- The possibility of extending contruction weeks due to unforeseen circumstances.

All of the above assumptions are tested to see their individual impacts on the overall results.

4 DATA

Data Sources

The Water production costs and charges both for the Government of Tuvalu and for the community of Lofeagai. The second sub-group data is Price the Lofeagai community information which includes the population, population growth rate of Lofeagai, the number of households and the average number of persons within a household in Lofeagai. The third sub-group data comprises the amount of deliveries of desalinated water to the Lofeagai community as well as the cost of utilizing other alternatives to desalinated water such as imported bottled water. The cost of time spent on purchasing desalinated water was also included in the third sub-group of data. The fourth group of data is the amount of water the water cistern project is expected to supply both in a average and low rainfall scenario together with the expected lifetime of the cistern. The last set of data for the analysis is the aggregate costs of constructing and maintaining the water cistern which were provided by PWD. The discount rate for this analysis is 8% which was provided by the Ministry of Finance and Economic Development. Data collection was carried out within a period of two months.

(Refer to Data Table – Annex 2)

5 ECONOMIC PAYOFFS

5.1 Net Present Value

Benefits during dry season- Average rainfall scenario

The results of the analysis showed that during an average rainfall scenario the water cistern is expected to supply an additional amount of 1,460,000 litres of water per year to the Lofeagai community. Using current purchases of desalinated water to estimate future consumption (363,680 litres), the Lofeagai community's consumption of desalinated water will be replaced by the water supply available from the cistern. This amounts to community savings of $1,724.73 per year for the period of thirty years.

To show the total savings in the base 'with project' scenario the analysis also included the avoided costs of bottled water purchases. Based on a nationally estimated consumption annual per capita of bottled water (1.72 litres), which assumes that 25% of bottled water is consumed by visitors and functions the savings to the Lofeagai community will be 1,117 litres or $781.94 based on current bottled water prices.

The estimate value of the additional water the community will be receiving above the current consumption levels, the analysis looked at the total amount of additional water supply from the cistern once the savings in alternative sources of water (desalinated and bottled water) had been taking into account. In an average rainfall scenario the cistern is expected to supply an additional 1,095,203 litres over and above current consumption levels. As indicated above it is probable that there is unmet demand for desalinated water in the community so the price paid for desalinated water by the community is used to estimate this additional supply ($5,194 per annum).In addition to the community benefits, another major benefit of the project is the avoided government costs of the production of desalinated water to supply the Lofeagai community as it has now been replaced by the additional supply of water from the cistern. The total value of the avoided government costs is $6,352 per annum at the subsidy rate of 0.0170 per litre.

The analysis also looked at the benefits from avoiding travel and time costs. Residents of Lofeagai will not be required to travel to the PWD complex to purchase desalinated water. The total value of avoided time and travel costs for the Lofeagai community is estimated at $187.69 per year.

The discounted total benefits of the cistern are estimated at $199,579.03 using a discount rate of 8% over a 30 year timeframe. Should the discount rate be at 5% or 4% over the same year timeframe the total discounted benefits will be $283,183.80 and $322,861.47 respectively.

Total Costs

The total discounted capital and maintenance cost are estimated at $148,977.63 using an 8% discount rate over a thirty year period. In the scenarios where the discount rates are at 5% or 4% the total discounted costs over the thirty year period will be $153,579.66 and $155,217.79 correspondingly.

The results show an outcome that favours the benefits more to the costs with a benefit to cost difference of $50,601.39 or a 1.340 benefit/cost ratio. In other words that for every $1 spent on costs an amount of $3 will be accumulated in benefits.

In the case of a 5% discount rate the benefit to cost ratio will be 1.844 and 2.080 in the case of a 4% discount rate over the same time period of thirty years.

Low-Rainfall scenario

With a low-rainfall scenario the estimated benefits also change. The major change is the decrease in the additional water supply from the cistern which is 730,000 litres with 365,203 litres of additional water available on top of the current consumption. Also during this scenario, the community's current purchases of desalinated water increase to 422,778 litres which is the amount that will be offset by the additional water supply from the cistern. However, during a low rainfall scenario it is likely that the willingness to pay for water would be higher than the price assumed (the price of desalinated water).

Table 1: Annual additional water available to community from water cistern (2013)

	Litres of additional dry season water supply (annual)	Current desal water purchases (annual)[5]	Current bottled water purchases (annual)[6]	Additional water available for consumption[7] (annual)
Average rainfall	1,460,000	363,680	1117	1,095,203
Low rainfall	730,000	422, 778	1117	365, 203

This additional water supply equates to between 3-16 litres per person per day depending on the rainfall scenario and monthly extraction rate.

A comparison is made with the purchase of rainwater tanks that would supply the same volume of additional water supply. Both scenarios are compared to the 'without PACC' scenario.

The net present value and benefit/cost ratio for both cases are given in table 2. In both cases the net present value is positive (i.e. total benefits are higher than the total costs). The benefit cost ratio for the cistern is 1.2 indicating that for everyone $1 invested in the cistern it is estimated to generate $2 worth of benefits.

The net present value of installing additional rainwater tanks is slightly higher than the water cistern construction. This is mainly due to the lower cost of installing and maintaining rainwater tanks in each household. However, a disadvantage to installing rainwater tanks in each household is the large amount of space needed whereas the community cistern will be used as a foundation for a proposed community hall. The analysis does not attempt to estimate the value of the land used for rainwater tanks which would lower the overall net present value. Supplying additional individual rainwater tanks does also not meet the need of having a community reserve that is available for all community members.

[5] Assumed to grow in line with population growth
[6] Assumed to grow in line with population growth
[7] Taking into account current water purchases

Table 2: Results (base case)

Results for average rainfall scenario	Community Cistern	Rainwater tanks
Net Present Value	$50,601.39	$76,650.37
Benefit cost ratio	1.34	1.62

It is important to note that these results do not include any benefits associated with improved health outcomes. As the cistern will be providing a relatively small proportion of overall households' consumption of water (though a very important part of available water supply during dry periods) it would be difficult to attribute possible health improvements to this additional water supply. However, in previous studies[8], health impacts have formed a significant proportion of the benefit of water projects and their inclusion would therefore likely lead to higher overall benefits of the project.

5.2 Sensitivity Analysis

There were assumptions made during the analysis that were tested using the method of sensitivity analysis. Results from each test showed some slight and some significant changes in the results according to the different assumptions.

The first assumption was included in section 5.1 with a comparison of results of average and low rainfall scenarios.

An assumption was also tested on the value of water or willingness to pay for water of the Lofeagai community members. At the current price charged for desalinated water there is unmet demand for water. This indicates that the real willingness to pay for water in the community is likely to be higher than the price charged for desalinated water. A sensitivity analysis was conducted using 200% of the desalination price. This increased the benefits, net present value (x) and benefit cost ratio(1.3) of the project as shown in Table x. Residents may also be willing to pay higher rates for water as was the case when private seller was selling water at a much higher price in 2004. Using this price as the upper bound for illustrative purposes increases the NPV to (x) and the benefit cost ratio to (y).

A sensitivity analysis was also made on the impacts of the lifespan of the project on the estimated benefits. In this test, the result showed that the total net benefits (or net present value) will increase according to the number of years for the lifespan of the project, though not significantly. Increasing the lifespan from 30 years to 50 years increases estimated net benefits by ($x) and the benefit cost ratio to (x).

Table: Results from Sensitivity Analysis

Cases	**Benefits - Costs**	**Benefits/cost ratio**
1. (Base Case)	$7,291.89	1.042
2.	$67,878.96	1.387

[88] E.g. Lal et al (2006). Economics of solid and liquid waste management.

3.	$ 329,969.83	2.883
4.	$23, 806.10	1.136
5.	$32,743.19	1.187
6.	$4,186.83	1.024
7.	$90,218.86	1.515
8.	$28,988.31	1.165
9.	$35,937.68	1.205

(A more detailed description of the results from the sensitivity analysis is attached in Annex 1)

6 POLICY IMPLICATIONS

6.1 General findings

In general the results confirm the value of investing in water supply and conservation projects both from the perspective of the community and also the government, given the amount of revenue spent on subsidies for the desalination plant. Around 45% of the overall benefits of installing the cistern accrue to the government in costs savings for subsidised water. This confirms the importance of the Tuvalu government prioritising policies and programmes to promote water conservation measures and increase community and household storage.

It is also important to note that key benefit (e.g. health benefits) are not included which would likely increase the overall net present value.

Given the benefits to the government of reducing dependency on desalinated water over the longer term there would be merit in examining in more detail water demand and the water pricing structure in Tuvalu to maximise the incentives for water conservation whilst ensuring that basic needs are met. This could involve for example a progressive pricing structure that keeps the current pricing structure for purchases up to a certain quantity of desalinated water but gradually increases them for water purchases above a certain quantity. This would help to introduce stronger incentives for water conservation measures.

6.2 Constraints to realising benefits and recommendations to overcome them

The ability of the Lofeagai community to realise the benefits predicted in the cost-benefit analysis rely on the following factors;

<u>Effective management and monitoring of the cistern supplies</u>

The cistern has been designed to provide emergency supply during the dry season and drought periods. As such there will need to be a management plan in place with responsibility for monitoring assigned to a community body. The technical assistance of a water specialist and the met office should be sought to help develop this plan. It will need to include suggested extraction schedules based on different rainfall scenarios and simple, user-friendly triggers for community members to manage this appropriately. This could include, for example, a flow-chart of what action should be taken in different scenarios and emphasise maximum extraction rates in these different scenarios. The PACC project should examine whether a rain-gauge installation will be necessary to assist with this at the site. If required this could generate some additional awareness around water management (e.g. by getting the school involved in monitoring activities).

The PACC project should assist the community in developing this management and monitoring plan and conduct training and awareness with community members on the plan. Community members will need to understand that they cannot access the community cistern freely and the reasons that the cistern is not accessible during the wet season.

Effective monitoring of the extraction rates by community members will be necessary to enable the community to determine how much water has been extracted each month and the remaining balance each month.

A memorandum of understanding will be signed with the community and this should reference the management and monitoring plan and responsibilities assigned within it.

The risk of not having this is in place is that the cistern is over-used and when it is needed most (i.e. at the end of the dry season or during drought periods) the cistern may be empty.

Support to expand catchment area

The community are proposing to build a community hall on the cistern and to use the roof catchment as additional catchment to supply the cistern. The additional water catchment area will increase the net present value of the project from $50,601.39 to $74,943.72 or cost benefit ratio from 1.3 to 1.5.

The PACC project could assist in ensuring this happens by providing technical assistance on the appropriate design for the catchment management system.

The catchment area (even when the additional catchment of the proposed community hall is taken into account) will still not enable the community to extract freely but the management plan will need to be adapted to take this additional catchment area into account, if and when it is in place.

7 REFERENCES

1. Lal et al (2006) Lal, P., Saloa, K. and Uila, L. (2006) 'Economics of liquid waste management in Funafuti, Tuvalu,' Apia, Samoa: SPREP

2. Pacific Climate Change Science Programme Report

Comment [C1]: Get year of report from Marita or Loia

Annex 1 – Sensitivity Analysis

Case 1 (base case)

Assumptions

- Average rainfall
- 30 year lifetime of plant
- Production costs of desal increase at 2% a year
- Value of water = desal rate

Benefits - costs	$7,291.89
Benefits / cost ratio	1.042

Case 2 (higher value of water)

Assumptions

- Average rainfall
- 30 year lifetime of plant
- Production costs of desal increase at 2% a year
- Value of water = 200% of desal rate

Benefits - costs	$67,878.96
Benefits / cost ratio	1.387

Case 3 (higher value of water)

Assumptions

- Average rainfall
- 30 year lifetime of plant
- Production costs of desal increase at 2% a year
- Value of water = rate charged by private seller in 2004

Benefits - costs	$329,969.83
Benefits / cost ratio	2.883

Case 4 (40 year lifespan)

Assumptions

- Average rainfall

- 40 year lifetime of plant
- Production costs of desal increase at 2% a year
- Value of water = desal rate

Benefits - costs	$23,806.10
Benefits / cost ratio	1.136

Case 5 (50 year lifespan)

Assumptions

- Average rainfall
- 50 year lifetime of plant
- Production costs of desal increase at 2% a year
- Value of water = desal rate

Benefits - costs	$32,743.19
Benefits / cost ratio	1.187

Case 6 (Low rainfall, high price)

- Low rainfall
- 30 year lifetime of plant
- Production costs of desal increase at 2% a year
- Value of water = 200% desal rate

Benefits - costs	$4,186.83
Benefits / cost ratio	1.024

Case 7 (Low rainfall, higher price)

- Low rainfall
- 30 year lifetime of plant
- Production costs of desal increase at 2% a year
- Value of water = rate sold by private seller

Benefits - costs	$90,218.86
Benefits / cost ratio	1.515

Case 8

- Average rainfall
- 30 year lifetime of plant

- Production costs of desal increase at 2% a year
- Value of water = desal rate
- Catchment area includes church and community hall

Benefits - costs	$28,988.31
Benefits / cost ratio	1.165

Case 9

- Low rainfall
- 30 year lifetime of plant
- Production costs of desal increase at 2% a year
- Value of water = 200% desal rate
- Catchment area includes church and community hall

Benefits - costs	$35,937.68
Benefits / cost ratio	1.205

Annex 2 – DATA Sources

Costs of purchasing bottled water	Quantity of bottles purchased Price per bottle	DCCEE/IUCN water CBA study
Cost of purchasing desalinated water	Want to consider replacement of infrastructure and therefore need to calculate cost of production.	
- **Capital costs of constructing and setting up desalination plant**	Materials (quantity + market price) Equipment Delivery Labour installation Wage rate Useful life of plant/key equipment	PWD (unit at PWD – plumbing division) DCCEE/IUCN water CBA study
- **Repairs and maintenance**	Quantity of materials Price of materials Labour days Wage rate	
- **Fuel costs**	Quantity of fuel used to produce 1 litre of water Price of diesel	
- **Delivery costs**	Market price and any other relevant variable costs.	
- **Other operating costs**		
Time spent sourcing water during drought	Time spent ordering desalinated water. Wage rate as opportunity cost of time.	Lal et al (2006) Lal, P., Saloa, K. and Uila, L. (2006) 'Economics of liquid waste management in Funafuti, Tuvalu,' Apia, Samoa: SPREP ➔ I would think this is a relatively minor cost. If not available in the above-listed secondary sources, I suggest just describing/listing this cost – don't valuate it.
Travel costs associated with purchasing desalinated water	Fuel costs x Distance Is desal water delivered by the utility to the household? If so, this cost should be included as a variable cost as listed above	Fuel retailers GIS maps (Loia)

	(i.e. delivery cost)	
During states of emergency costs of accessing rationed water	Time spent Type of transport Costs associated with transport	V&A and SE Assessments HIES Report ➔ If data cannot be sourced from secondary, I suggest just describing/listing this cost – don't valuate it.
To be noted but may not be possible to quantify **Anxiety / stress** **Social unrest** **Physical effort of carrying water**		
Yield	Current usage (option 1) Increased yield to level of option 3 (option 2)	

Option 3 – community cistern

	Data	Source
Capital costs - **Materials** - **Cement** - **Aggregates** - **Rods** - **Transport costs (to deliver materials to site)** - **Installation costs** - **Consultation costs**	- Market prices adjusted for any significant taxes/subsidies/import tariffs - Lifetime of a concrete cistern 20-25 - Number of labour days - Wage rate - Funds spent on consultation	PWD costing report PACC costs
Maintenance costs - **Materials** - **Labour**	Labour days Wage rage Quantity of materials Market price of materials	PWD costing report Otherwise, get estimate from SOPAC (e.g. 5% of capital costs every year)
Land	Rental value of land since this land cannot be used for something else.	Community (church) signed a lease agreement with landowners
Yield	Rainfall Catchment area Storage	SOPAC Technical assessments already undertaken

Option 4 – additional rainwater tanks for all families (96 families)

	Data	Source
Capital costs - **Water tanks ($1,900)** - **Pipes** - **Fittings** - **Base (concrete)** - **Guttering** - **Taps** - **Roofing (in some cases)** - **Screens** - **Delivery costs** - **Consultation costs** - **Installation costs**	$ per unit of equipment - $1,900 approx per tank Capacity of rainwater tank (10,000 litres) Finances spent on community consultations Labour days Wage rate Height costs (fixed payment for risk of injury)	Supplier quotes PWD Finance PACC costs
Maintenance costs - **Materials** - **Labour**	Quantity of materials Market price of materials Labour days Wage rate	PWD
Land	Rental value of land since this land cannot be used for something else.	Community (church) signed a lease agreement with landowners
Yield	Rainfall Catchment area Storage capacity	SOPAC Technical assessments already undertaken