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Building Resilience to Climate Change in Pacific Communities

PACC TECHNICAL REPORT 8

JULY 2014

Guidelines for the design of a conjunctive water supply system in Nauru

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Guidelines for the design of a conjunctive water supply system in Nauru

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This report is an output of the Nauru PACC Project. It was written by Louis Bouchet, with contributions from Nauru PACC Project Coordinator Mavis Depaune and PACC Project Assistant Natasha Detanamo. The report was reviewed by a team that included Netatua Pelesikoti and Peniamina Leavai (SPREP), Ilisapeci Masivesi (Australian Department of Foreign Affairs and Trade), Gabor Vereczi (UNDP), and Joseph Cain (Marshall Islands), Haden Talagi (Niue), Paula Taufa (Tonga), Taiane Apelu (Tuvalu) and Jewel Toloa (Tokelau) (PACC Project Coordinators).

EXECUTIVE SUMMARY

This report describes the process undertaken to identify, design and implement two demonstration projects under the Pacific Adaptation to Climate Change (PACC) project in Nauru. The aim of the Nauru PACC project is to improve resilience to drought, and the projects are contributing to this by helping to develop a conjunctive water supply system for the island.

Water resources are limited in Nauru and represent a major challenge for the nation. The vast majority of the potable water supply comes from domestic rainwater harvesting, and also desalinated seawater produced by reverse osmosis (RO). The non-potable water supply comes from groundwater and seawater. Groundwater in Nauru is not potable due to salination and pollution.

In Nauru, conjunctive use of water refers to the use of water from the various sources for different uses at different times. Because desalination is expensive, using rainwater, seawater and groundwater appropriately and depending on availability is a sensible way to sustainably improve Nauru's water supply. Desalination is considered to be more appropriate for major users (i.e. hotels and industry) and to serve as a back-up supply during drought periods.

The PACC project team and stakeholders identified two main criteria to select the demonstration project areas: (1) heavy reliance on desalinated water; and (2) high population density. Based on these criteria, the sites selected were Location area and Aiwo district.

The team then carried out a vulnerability and adaptation (V&A) assessment to identify the vulnerabilities of the two communities, and to identify and evaluate available adaptation measures. The V&A findings confirmed that the most threatening climate impact in Nauru is deficiency of rainfall and drought, and that in the selected districts adaptive capacity is generally low with socio-economic factors adding to the communities' vulnerability to drought.

Adaptation options were identified with the communities, and subjected to multi-criteria analysis to select the most feasible, relevant and sustainable options. This resulted in selection of the following as PACC demonstration projects:

1. Implementation of solar water purifiers in selected households in Aiwo district;
2. Rehabilitation of the seawater network in Location area.

PROJECT 1: SOLAR PURIFIERS FOR SELECTED HOUSEHOLDS IN AIWO DISTRICT

Solar water purifiers are solar panels connected to a distillation unit. The system receives impure water, and through a distillation process driven by solar energy, pure water is collected and diverted into a storage tank. Each panel can produce around 20 L of water per day which meets WHO standards for drinking water.

Nineteen households each had four solar panels fitted, providing 80 L of additional potable water per day per household. During a drought, this can be used for drinking, cooking and if in sufficient quantity, personal bathing. Even when not under drought conditions this is a useful and safe potable water supply. The system is operated by the household and does not require any major maintenance. The lifespan of the solar purifier is 15 years and no replacement of material is expected during this time.

The solar panels were installed during 2nd and 3rd quarters 2011, and at the time of writing (2012) the project was in the monitoring phase.

PROJECT 2: SEAWATER RETICULATION SYSTEM FOR TOILET FLUSHING IN LOCATION AREA

This project aims to provide an alternative source of water for non-potable uses in Location area, thus saving precious potable water. This is a rehabilitation project of the once operational and effective seawater reticulation system built to supply water for industrial, domestic and emergency uses. The intended use for its rehabilitation is toilet flushing only, however it could also provide for other uses if necessary. At the time of writing, Demo Project 2 was still in the design phase.

Lessons learned from experiences during the project include: (1) projects need to be community specific; (2) it is important to consider ongoing costs and capacity needs; (3) it is also necessary to identify operating and maintenance needs during project design; and (4) health and environment issues should also inform the project design.

ABBREVIATIONS

AOSIS	Alliance of Small Island States
BoS	Bureau of Statistics
CIE	Commerce, Industry and Environment [Department]
DRM	Disaster Risk Management Unit
ENSO	El Niño Southern Oscillation
IWRM	Integrated Water Resource Management
JICA	Japan International Cooperation Agency
M&E	Monitoring and evaluation
MCA	Multi-criteria analysis
MED	Multi-effect distillation
NAPA	National Adaptation Plan of Action
NBSAP	National Biodiversity Strategy and Action Plan
NFMRA	Nauru Fisheries and Marine Reserves Authority
NGO	Non-governmental organisation
NHWP	Nauru Housing Water Project
NIANGO	Nauru Island Association of Non-Governmental Organisations
NISIP	Nauru Infrastructure Strategy and Investment Plan
NPC	Nauru Phosphate Corporation
NRC	Nauru Rehabilitation Corporation
NUA	Nauru Utilities Authority
NUC	Nauru Utilities Corporation
PACC	Pacific Adaptation to Climate Change [programme]
PAD	Planning and Aid Division
RO	Reverse osmosis
RoN	Republic of Nauru
SNC	Second National Communication
SPREP	Secretariat of the Pacific Regional Environment Programme
SST	Sea surface temperatures
UNFCCC	United Nation Framework Convention on Climate Change

1. INTRODUCTION

The Pacific Adaptation to Climate Change (PACC) programme is the largest climate change adaptation initiative in the Pacific region, with projects in 14 countries and territories. PACC has three main areas of activity: practical demonstrations of adaptation measures; driving the mainstreaming of climate risks into national development planning and activities; and sharing knowledge in order to build adaptive capacity. The goal of the programme is to reduce vulnerability and to increase adaptive capacity to the adverse effects of climate change in three key climate-sensitive development sectors: coastal zone management, food security and food production, and water resources management. The programme began in 2009 and is scheduled to end in December 2014.

In Nauru, drought has been identified has one of the most threatening impacts of climate change. In order to improve the country's resilience to drought, the PACC project addressed water resources management.

These guidelines for the design of a conjunctive water supply system to improve resilience to drought in Nauru have been developed as part of the Nauru PACC demonstration project. These guidelines are mainly directed at government agencies, local NGOs, regional organisations and donor agencies interested in developing conjunctive water supply systems in the Pacific Island countries, in order to improve the availability of drinking water, especially during drought periods. It details the process undertaken by the PACC team to design two demonstration projects:

- Implementation of solar water purifiers in selected households in Aiwo district;
- Rehabilitation of the seawater network in Location area.

This document aims to provide the reader with the following information:

- An understanding of the challenges that come with drought events in Nauru, and the added stress due to climate change;
- How a conjunctive water supply system is a sensible and sustainable way to improve resilience to drought events in Nauru;
- The steps to design and implement a water supply project in the Nauru context;
- From the PACC team experience, the critical factors that need to be addressed in order for Nauru to implement effective adaptation measures.

CONJUNCTIVE USE OF WATER

In most countries, conjunctive use of water refers to the coordinated use of surface water and groundwater. According to the New Oxford American Dictionary (2011) conjunctive means 'combined' or 'joined together'.

In Nauru, there is no surface water and conjunctive use of water refers to the use of water from different sources for different uses at different times. For example, conjunctive use of water in a household with access to groundwater and rainwater could be as detailed in Table 1.

Table 1. Conjunctive water uses for an average household having access to groundwater in Nauru.

Water source	Above average rainfall	Low rainfall	Extended drought
Rainwater	▪ All uses	▪ Drinking only	▪ Not used (storage empty)
Seawater (desalinated)	▪ Not used (no need)	▪ Drinking only	▪ Drinking only
Groundwater	▪ Outdoor ▪ Laundry	▪ Outdoor ▪ Laundry ▪ Personal bathing	▪ Outdoor ▪ Laundry ▪ Personal bathing ▪ Cooking

Note: This table is derived from the findings in Bouchet and Sinclair (2010).The use of groundwater is not in fact recommended for personal bathing, laundry and cooking due to the high contamination from faecal bacteria.

1.1. Climate change in the Nauru context

1.1.1. Climate change policy in Nauru

The potential disastrous effects of climate change on atoll islands have been recognised for more than 30 years. In 1985, Nauru was the first signatory to the climate change convention in Vienna. In 1994, Nauru was with the first set of country to join the United Nation Framework Convention on Climate Change (UNFCCC). In the same year, Nauru participated with the Alliance of Small Island States (AOSIS) in putting forward the first draft text in the Kyoto protocol (UNFCCC, 1999).

Various projects have since been implemented in Nauru. The first National Communication, prepared under the UNFCCC in 1999, was one the first documents to review Nauru's vulnerability to climate change and identify gaps and critical sectors affected. The Second National Communication (SNC) project under the UNFCCC started in 2008, leading to the development of the National Adaptation Plan of Action (NAPA) for Nauru, currently under review by the Cabinet (at time of writing, i.e. February 2012). Along with the NAPA, a Climate Change Unit was established with a primary mission of drafting the first national climate change policy for Nauru.

1.1.2. Identified impacts of climate change

According to the NAPA, the following have been identified as the most likely impacts of climate change in Nauru:

1. Coastal erosion – loss of land;
2. Flooding – kitchen gardens, food crops and infrastructure affected;
3. Low productivity/yield of crops;
4. Frequent intense rainfall and storms;
5. Drought affecting water supply and increasing risk of fires;
6. Sea-level rise – inundation of land and saltwater intrusion;
7. Loss of natural ecosystem resources – mangroves and littoral vegetation, coral reefs.

In Nauru, the water sector is likely to be one of the first sectors to be affected by climate change. Although cyclones and other natural disasters are not expected because of Nauru's proximity to the equator, extreme rain events – both drought and heavy rain – are predicted. Drought is already a significant threat and drought periods could worsen in the future. Sea-level rise could also contribute to the water supply issue, by increasing saltwater intrusion and raising the groundwater level, which increases the risk of contamination from surface activities.

1.2. PACC and the national climate change adaptation strategy

1.2.1. Current climate change projects and initiatives

With the termination of the SNC project in 2011, PACC is currently the only international development project directly targeting climate change in Nauru.

Under the Environment Division of the Commerce, Industry and Environment (CIE) Department, the Climate Change Unit aims at reducing the impacts of climate change in Nauru through the implementation of a climate change policy framework (currently under development). The Unit is also addressing coastal erosion, an activity previously under the SNC project (Figure 1).

Under the Project Division, the National Biodiversity Strategy and Action Plan (NBSAP) project is currently reviewing the challenges related to stress on natural ecosystems. The Integrated Water Resource Management (IWRM) project is working closely with PACC on water related issues, particularly sanitation and water use efficiency. As a joint initiative of the PACC and IWRM projects, the Water Unit has been formed to oversee the water sector and implement water policy (this was endorsed in January 2012).

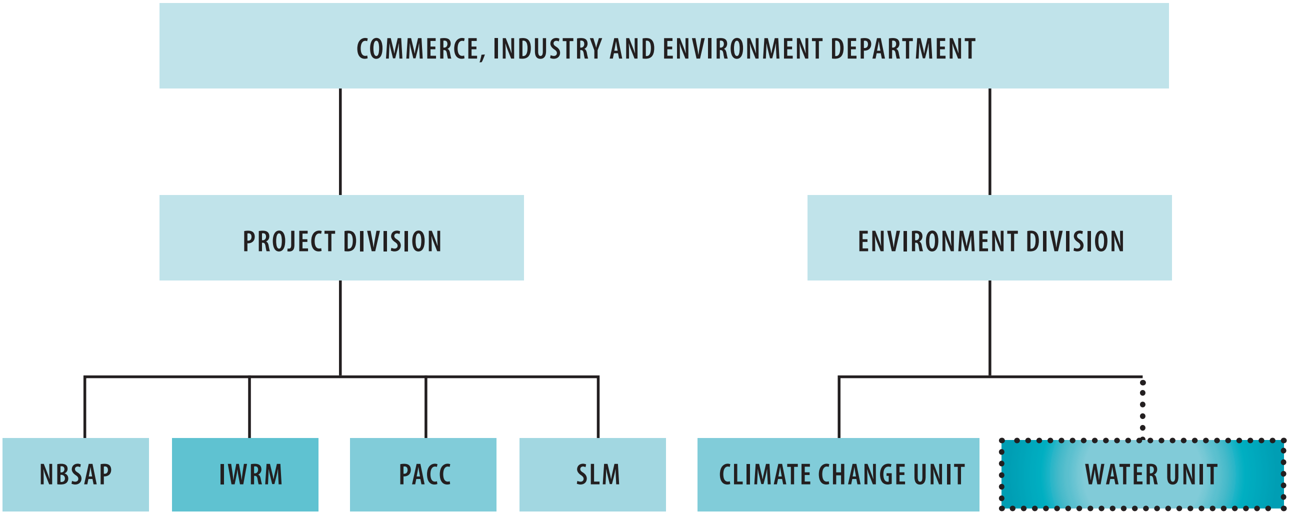

Figure 1. Organisational structure of the climate change sector in Nauru.

A solar groundwater pump and storage tanks, and a solar reverse osmosis (desalination) plant, are being installed at a district level by a separate project, funded by the Japan International Cooperation Agency (JICA) in collaboration with CIE.

1.2.2. PACC objectives

In collaboration with the Government of the Republic of Nauru (RoN), the PACC project identified the water sector as the sector most vulnerable to climate change, and proposed to focus on adaptation measures to mitigate the impact of climate change on water resources and supply. The Project objective is *demonstrating the benefits of taking current climate variability and projected climate change into consideration in the water sector to better prepare for climate risks.*

In Nauru, and especially for the water sector, the approach to climate change is a 'no regrets' approach, considering that climate change is likely to exacerbate current threats (e.g. drought, saltwater intrusion and groundwater contamination). Three main outcomes are expected from the project:

Outcome 1: Policy changes to deliver immediate vulnerability-reduction benefits in the context of emerging climate risks defined in Nauru;

Outcome 2: Demonstration measures to reduce vulnerability of the water sector implemented;

Outcome 3: Capacity to plan for and respond to changes in climate-related risks improved.

This report describes the design process for the implementation of the demonstration measures (Outcome 2).

2. COUNTRY INFORMATION AND CONTEXT

2.1. Description

Nauru is a small isolated raised coral limestone island located 1,243 km northeast of the Solomon Islands and 60 km south of the equator. The island area is 22 km^2 (2,200 hectares) (NPC, 1988). Most of the population live on the 150–300 m wide coastal plain, and in the Buada lagoon area. The central area or 'Topside' rises to 61 m and is composed of a dolomitic limestone which was covered by large deposits of high grade tricalcium diphosphate, now largely mined out (Figure 2). This area is now characterised by karst pinnacles (Jacobson and Hill, 1997).

Figure 2. Aerial view of Nauru showing the coastal plain and mined out interior (photo Torsten Blackwood, AFP; reproduced with permission).

2.2. Socio-economic situation

Nauru is a small island nation with a population of 10,185 (SPC, 2011). The official language is Nauruan, but English is widely spoken and understood. The average household has six people and a yearly income of $9,555 (SPC, 2011).

Economic development is very limited, with phosphate extraction and export the main source of income. Having been extensively mined for the past 50 years, remaining phosphate resources are scarce and mining activity has significantly reduced. Serious issues such as rehabilitation of mined land and replacement of income from mining activities threaten Nauru's future. In the late 1990s, the government faced bankruptcy from mismanagement of the trust funds which had been set up to sustain Nauru's future in anticipation of the exhaustion of phosphate resources. The state is now heavily indebted and Nauru's economy relies on foreign development grants (ADB, 2010).

With no major industries or services, employment opportunities are rare and usually through the public services and state-owned enterprises (ADB, 2010). The closure of the Australian Offshore Processing Center for asylum seekers left hundreds of locals without employment. The current unemployment rate is 22.7% (PRISM, 2010).

Deterioration of housing, the hospital and other public plants and infrastructure is a significant concern (CIA, 2009), including access to water and adequate sanitation.

Public services such as education, transport and health care are free to Nauruan citizens and there is a strong perception among Nauruans that the government should be responsible for running costs and maintenance of facilities, including water supply and sanitation. This derives from the time of economic prosperity, when a broad range of public services was provided to the community. Belief that past governments should be accountable for mismanagement of phosphate income that led to the bankruptcy also contributes to this perception (Audoa and Tilling, 2010).

2.3. Climate

2.3.1. Current climate

Nauru's climate is equatorial, hot and humid. The temperature does not vary greatly throughout the year, with the minimum and maximum daily temperatures (1951–1980) ranging from 24°C to 31°C. Mean annual rainfall is 2,117 mm. The 'wet' season is usually from December to April with more than 200 mm of rain per month (Figure 3), and is influenced by the movement of the South Pacific Convergence Zone (SPCZ) and the Inter-tropical Convergence Zone (ITCZ).

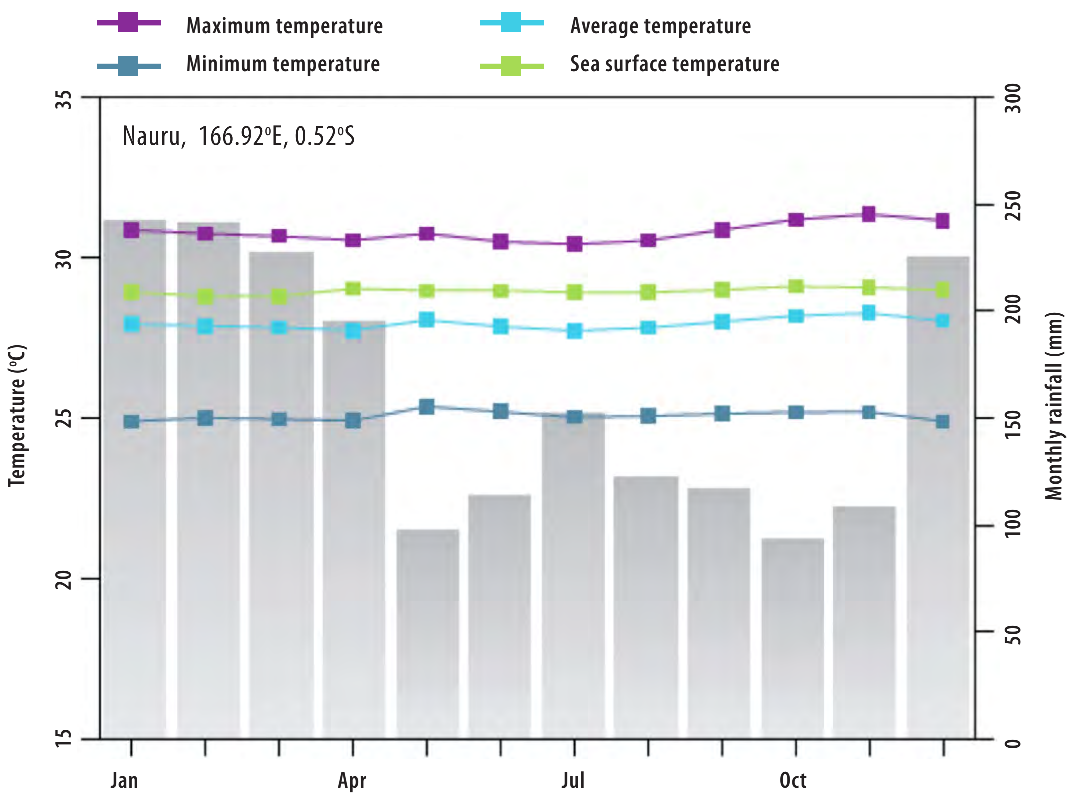

Figure 3. Monthly rainfall and temperatures in Nauru (from PCCSP, 2011).

According to the records available from 1884 (with some gaps), Nauru's rainfall is characterised by a high degree of variability, with a minimum annual rainfall of 278 mm recorded in 1950 and a maximum of 4,588 mm in 1930.

Nauru's high rainfall variability is mainly attributed to the El Niño Southern Oscillation (ENSO). Rainfall patterns are strongly related to ENSO events (Figure 4): an irregular warming in sea surface temperatures (SST). An El Niño event – warming SST in the central and eastern Pacific – usually results in higher rainfall in Nauru whilst a La Niña event – cooling SST in the central Pacific – generally results in reduced rainfall and the likelihood of an extended drought period (White, 2011).

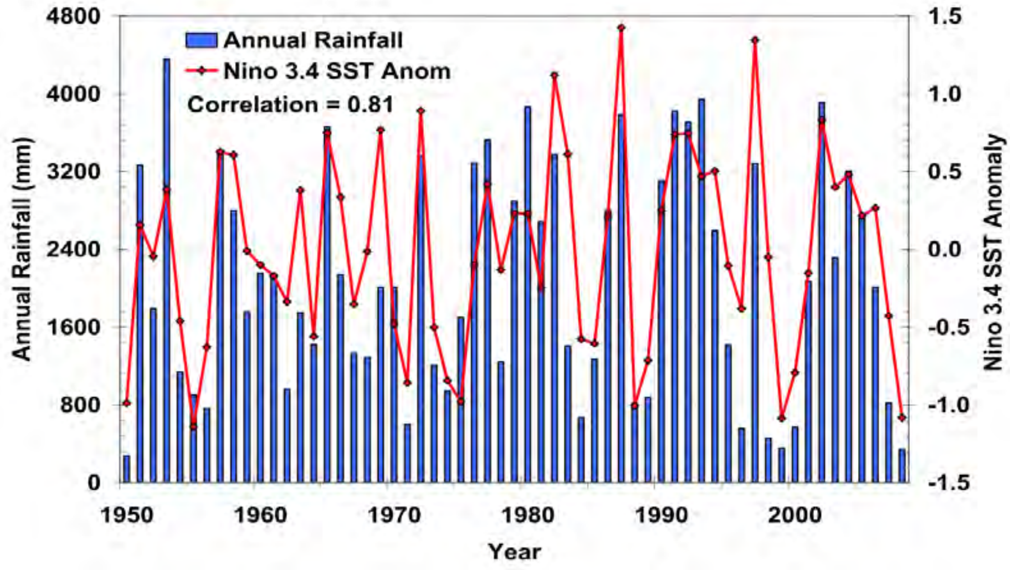

Figure 4. The strong correlation between annual rainfall in Nauru and the sea surface temperature anomaly in the Niño 3.4 region (from White, 2011).

Drought periods are a frequent threat for the country and are largely associated with La Niña events. Occurring on average every 5 years, they can last up to 3 years (Table 2). The country is particularly vulnerable to extended drought periods as it relies primarily on rainwater for its water supply.

Table 2. Characteristic of major 6 months drought (from White (2011), updated).

No.	Start Date	End Date	Duration (months)	Lowest ranking (%)	Drought interval (years)	6 months rainfall (mm)
1	Sep-49	Apr-51	19	1.8	–	65
2	Jul-54	Feb-57	31	8.2	4.8	171
3	Jul-64	Jan-65	6	5	10.0	130
4	Sep-70	Feb-72	17	0.9	6.2	49
5	Jul-73	Jan-75	18	0.1	2.9	31
6	Aug-75	Mar-76	7	7.8	2.0	158
7	Aug-78	Feb-79	6	7.4	3.0	155
8	Dec-83	Mar-86	27	5.8	5.3	136
9	Jun-88	Jan-90	19	0.0	4.5	23
10	Aug-95	Mar-97	19	2.5	7.2	89
11	May-98	Aug-01	39	0.3	2.7	36
12	Jun-07	Aug-09	26	0.2	9.1	34.8
13	Sept-10	Jul-11	10	2	2.2	70.5
		Mean	**18.8**		**4.6**	**89.8**

2.3.2. Future climate

There is no clear evidence yet that global warming is affecting ENSO events, however it has been suggested that it could be a major factor affecting current climate regimes and the changes that come with ENSO events (PACC, 2009).

According to the last climate change projections for Nauru (PCCSP, 2011):

- Rainfall is expected to increase during the course of the century (high confidence);
- Expected increase in rainfall is 5% by 2030 and 15% by 2090 (low confidence);
- Incidences of drought periods are expected to decrease over the course of the century (moderate confidence);
- Sea level rise is expected to increase (high confidence);
- Sea level rise of 15–20 cm by 2030 (moderate confidence).

Incorporating climate change science into sector planning and policy-making is challenging because of the uncertainty involved. Climate change scenarios for Nauru have seen some evolution since the beginning of the PACC project. During the design phase of the project in 2009, climate change projections indicated an increase in extreme events (long lasting drought and high rainfall events). However, the latest projections suggest that drought could become less frequent.

Because drought will inevitably remain a threat for Nauru, regardless of their exact frequency, the approach taken by Nauru is a 'no regrets' approach. Improvements in the water sector are needed and will be beneficial for Nauru, regardless of climate change.

2.4. The water sector

2.4.1. Water resources

Water resources are limited in Nauru and represent a major challenge for water management. There are three natural sources of water on the island:

- Rainwater;
- Groundwater;
- Seawater.

Rainwater is the only source of freshwater, with the exception of a small area around Ewa district where groundwater seems to remain fresh. Everywhere else on the island, groundwater is greatly affected by rainfall with huge variation in salinity levels, from less than 1,000 µS/L (WHO drinking standards) during average and above rainfall years, to more than 12,000 µS/L (very brackish water) during drought periods. High salinity is not the only factor that limits the use of groundwater. A high rate of contamination with faecal bacteria in domestic wells around the island was recorded in 2010 in a survey undertaken by SOPAC, which poses a serious health concern if groundwater is used for drinking, but also for cooking, personal bathing and laundry.

Reliance on desalinated seawater is therefore relatively high, especially during drought periods when rainfall is insufficient to meet people's needs. Untreated seawater is also an important source of water for Nauruans, especially for bathing during drought periods (Bouchet and Sinclair, 2010; CIE, 2011).

2.4.2. Water supply

Water supply is often divided in two components: potable water and non-potable water.

POTABLE WATER SUPPLY

The potable water supply is limited to domestic rainwater harvesting and desalinated seawater produced by reverse osmosis (RO) at Nauru Utilities Corporation (NUC) (i.e. excludes bottled water and the few freshwater wells).

Rainwater

The total capacity of domestic rainwater tanks was about 25,000 kL[1], supplying 90% of the population, which corresponds to approximately 25 days of storage. There is no clear figure on average rainwater capture per household, as roofs, gutters and tanks vary in size and condition. According to CIE (2011), 50% of the domestic infrastructure is not properly maintained. The average rainwater tank size was stated to be 6,000 L (BoS, 2011), which is small for an average household of six people. The SOPAC 2008 survey findings are similar, but detail the actual average tank capacity per person per house at 3,000 L, which is more reasonable, offering a month's supply with an estimated consumption of 100 L per day (CIE, 2011).

Desalinated seawater

Reverse osmosis at the NUC can produce freshwater at a rate of up to 360 kL/day. The production rate will increase to up to 460 kL/day by 2013, when an additional solar RO plant is provided by JICA.

Current storage capacity at Nauru Utilities Authority (NUA) is estimated around 6,000 kL. This figure could go up to 28,000 kL if all the storage tanks were in good condition; however, significant losses of up to 40% are estimated. According to the Nauru Infrastructure Strategy and Investment Plan (NISIP), repairing leaks in NUA tanks would bring the storage capacity of the island up to 35 days of supply.

Two other RO plants are in use, at Menen hotel and the hospital. The Taiwan agriculture farm also has its own small RO unit.

There is no operational water network in Nauru (except a small network from the desalination plant to the hospital), and the RO water is delivered by truck. The delivery capacity is currently less than 300 kL/day, however, trucks are hired from other government entities when the demand is high.

NON-POTABLE WATER SUPPLY

Groundwater

The non-potable water supply consists of private wells around the island, and is more difficult to assess as there is no monitoring programme in place. According to Bouchet and Sinclair (2010), there are approximately 350 domestic wells around the island coastal strip, with the average total (i.e. entire island) abstraction in April 2010 estimated at 300,000 L/day. However, considering that April 2010 was a relatively good rainfall period, it is assumed that during drought periods abstraction would be significantly higher than that (because of a lack of rainwater and therefore heavier reliance on groundwater).

Seawater

Seawater has always been used has a non-potable water source for Nauruans. A seawater reticulation system was once in use in Location district, supplying the area with water for toilet flushing and swimming pools. The system was not maintained and is no longer operational. The PACC project is considering rehabilitating the network as part of a conjunctive water resource management initiative.

2.4.3. Water uses, consumption and demand

WATER USES AND CONSUMPTION

Water uses are mainly domestic. Except for mining activities, there are no major industries on the island. As mentioned above, rainwater and desalinated water are mainly used for potable needs, which include drinking, cooking and to some extent personal bathing and laundry. Groundwater is mainly used for non-potable needs, which include outdoor uses, personal bathing, laundry, and to some extent cooking (NBS, 2009; Bouchet and Sinclair, 2010).

1 Geographical Information System (GIS), Republic of Nauru, Environment Department

There is currently no monitoring of water consumption. Some data are however available from NUC (i.e. from 2007 with gaps) on the monthly production and delivery of desalinated water.

Water use and consumption depend first on the availability of rainwater (i.e. rainfall), and second on access to the resources. During periods of heavy rainfall, when tanks are full, rainwater is used for both potable and non-potable needs (including toilet flushing) (Falkland, 2009). During average to low rainfall periods, households are likely to rely on desalinated water. In this case, households will ration their potable water for potable use only. This does however depend on the household having access to another source of water for non-potable uses (i.e. mainly groundwater). Generally, households with a direct and convenient access to groundwater (i.e. pump and reticulated network) tend to use groundwater for most of their needs (83% of water use) except drinking and cooking (Bouchet and Sinclair, 2010).

During extended drought periods, with no rainwater available, the only source of potable water is desalinated water. With current supply providing less than a third of demand, households become very careful with their water use, consumption decreases, and in most cases desalinated water is strictly used for drinking purposes. Households with no direct access to groundwater fill buckets and reservoirs from community or neighbours' tanks to provide for non-potable uses.

WATER DEMAND

There is often confusion between water demand and water consumption. In this report, we will refer to water demand as the amount of water that dwellings would like to access.

In this case, water demand refers to the perception of the community on how much water they would need to sustain their lifestyle, health and livelihood. There is yet to be a water demand monitoring programme in Nauru. This has recently been recognised by the Water, Sanitation and Hygiene Policy and could be implemented in the coming years. In the absence of local data, the Nauru government estimates water demand (Table 3) based on a water plan drafted by Wallis (WHO, 2001).

Table 3. Water demand for potable and non-potable uses.

Water demand	Potable	Non-potable
Per person/day	100 L	70 L
Commercial and others/day	270–350 kL	150 kL
Total/day (2011)	1,290 kL	875 kL
Total/day (2020)	1,467 kL	1000 kL

It is acknowledged that theses figures are likely to be an overestimate for Nauru demand. Also, considering that the current capacity of the desalination plant (360 kL/day) against the actual estimated demand for 2011 (1,290 kL) is nearly four times lower, it may seem unrealistic. However, it is important to bear in mind that the domestic rainwater harvesting system plays an important role in meeting the water demand for potable water. Therefore, stating that Nauru's current water supply capacity is nearly four times lower than the demand is not correct. A more accurate statement is that during drought periods, the island capacity to meet demand for potable water is very low.

DRIVERS OF CURRENT WATER CONSUMPTION

Current water consumption is closely linked to the accessibility and availability of water. A dwelling's consumption will mainly depend on the following:

1. Current rainfall: As the majority of the population relies on rainwater as a primary source of potable water, the availability of rain is the main factor that influences water consumption in Nauru. The lower the rainfall the more dwellings will need to be supplied with desalinated water. Because the supply of desalinated water is limited, water consumption will likely decrease when rainfall is low.
2. Rainwater harvesting capacity: The roof surface, guttering and the tank storage of the dwelling will also have a significant impact on the consumption. The daily consumption per capita for a household of three people with sufficient roof and guttering and a 10,000 L tank, will most likely be higher than another household with the same water harvesting capacity but with 10 residents.
3. Access to a secondary water source for non-potable uses: At similar rainwater harvesting capacity, a dwelling with access to a secondary source of water (i.e. a non-potable source such as groundwater or seawater) will logically consume more water than a dwelling without access to such a source.
4. Income: Often seen as a less important factor, income can impact on water consumption. Households who can afford a regular supply of desalinated water are likely to use more water than others. However, because the current desalinated water supply is limited this factor does not have a great influence at the moment. Income can also play a role in households' ability to improve their rainwater harvesting capacity or groundwater access.

Therefore, considering that: (1) drought periods are frequent in Nauru; (2) rainwater harvesting capacity is low in 50% of households; (3) less than half of the population has direct access to groundwater (Bouchet and Sinclair, 2010); and (4) the average income is $9,555 per household, the current water consumption is likely to be lower than the actual demand, especially during drought periods.

2.4.4. Water management and institutional capacity

GOVERNMENT AGENCIES INVOLVED IN THE SECTOR

Various government agencies are involved in the water sector in Nauru:

- The Department of Commerce, Industry and Environment (CIE) is responsible for water policy and also hosts the two water-oriented projects PACC and IWRM.
- The Nauru Utility Corporation (NUC) is in charge of desalinated water production and supply.
- The Nauru Rehabilitation Corporation (NRC) is in charge of waste management, including sewerage. NRC is also involved in a groundwater monitoring programme, assessing salinity and pollution of various boreholes on the island every 3 months.
- The Planning and Aid Division (PAD) of the Finance Department is in charge of coordinating projects and managing donor funds.
- The Health Department is responsible for water quality standards and monitoring of water quality in schools and government buildings.

Other agencies are also involved in water planning, such as the Bureau of Statistics (BoS), the Disaster Risk Management Unit (DRM), Nauru Fisheries and Marine Reserves Authority (NFMRA) and the Education Department.

NON-GOVERNMENT AGENCIES AND AID AGENCIES

External donor agencies provide important financial and technical support to the government. The following list summarises the major NGOs and aid agencies in Nauru:

- The Community Based Organisation (CBO);
- Nauru Island Association of Non-Government Organisations (NIANGO);
- AusAid (now under the Australian Department of Foreign Affairs and Trade) and the New Zealand Aid Programme;
- JICA;
- SPREP;
- SOPAC;
- Republic of China (Taiwan).

INSTITUTIONAL CAPACITY

Institutional capacity is relatively low in Nauru. There is a lack of trained people in many sectors such as environment and water resources management. In order to meet this need, overseas consultants are employed in some key jobs on a short-term basis (i.e. contracted mainly for two years). In CIE, the environment team is mostly 'project based' and most of the work carried out in the water sector is through project coordinators.

Since the implementation of the PACC and IWRM projects, great improvement has been made in water management and planning. Two coordination committees have been created to facilitate decision making and a Water Unit is being created at time of writing (2012) (Figure 5). Education and training of local staff still remains an issue.

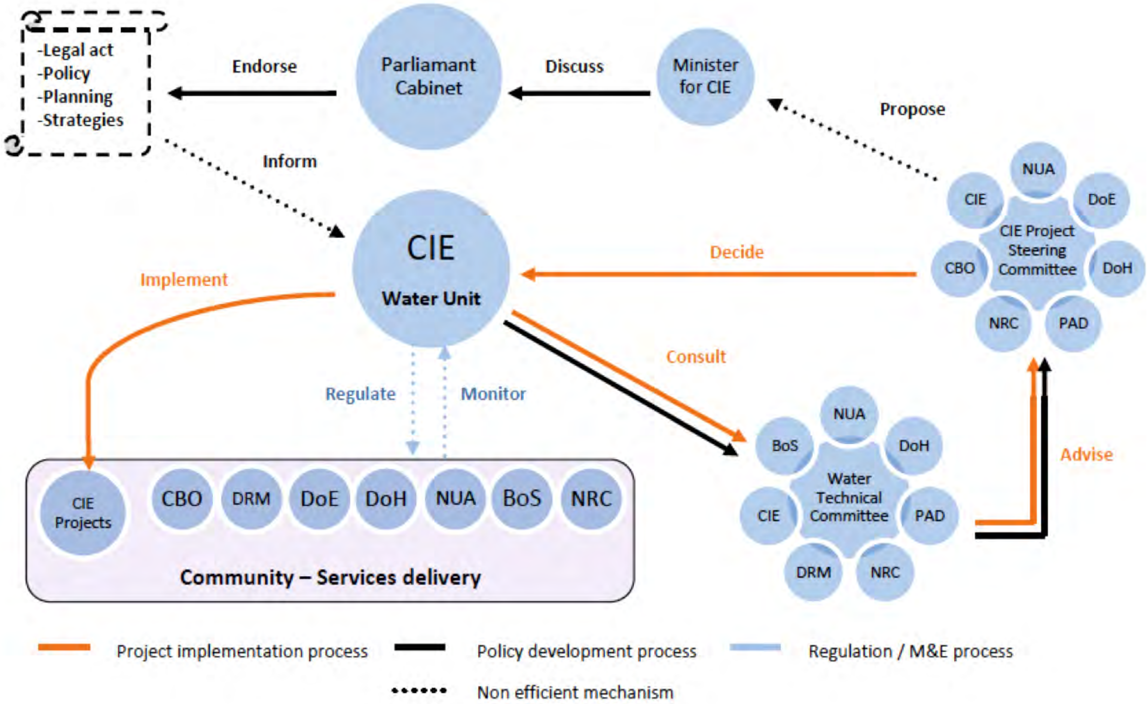

Figure 5. The decision making process for the water sector in Nauru.

LEGAL FRAMEWORK

There is a lack of legal structure to regulate, monitor and protect water supply sources. There is no legislation, strategy or guidelines covering rainwater harvesting in Nauru. Groundwater resources are also not under any legislation although it is acknowledged that groundwater belongs to the landowner. There is no restriction or permit necessary for digging or extraction of water.

The Cabinet has endorsed the Water, Sanitation and Hygiene Policy, an important milestone for both the IWRM and PACC projects. Although it is likely to take time for the policy to be fully implemented (i.e. for related laws and programmes to be created), this is a good indication that the water sector is moving forward.

2.4.5. Summary of key issues faced by the sector

Key issues and emerging threats faced by the water sector have been summarised in the National Outlook for Water, Sanitation and Hygiene, developed by CIE (2011). Similar issues have been detailed in the Water, Sanitation and Hygiene Policy developed by White (2011). They are summarised as follows.

Operation and maintenance has been identified as a major issue in past reports (e.g. ADB, 2011; Falkland, 2009) at both national level (NUA RO plant and storage) and household level (rainwater collection and groundwater infrastructures). One of the main factors leading to deterioration of infrastructure is the country's financial crisis and low GDP. At the household level, low income is contributing to poor maintenance, however a lack of community participation is also thought to play a role. Since the civil works agency, which used to provide free maintenance services to households, shut down after the financial crisis, household maintenance has been neglected. There is a general belief that government should be responsible for household maintenance.

Water quality is a major issue in Nauru, with some of the higher rates of diarrhoea in the Pacific (WHO, 2008). Contamination occurs principally in the groundwater but also in rainwater harvesting systems that are poorly maintained. The desalinated water delivered by NUA is now free of contamination, with chlorine disinfection at delivery.

Climate variability and climate change are identified as a major threat. Drought is a recurring threat that creates serious stress on the sector, the main one being the availability of potable water. Climate change will bring additional issues, such as sea level rise and more uncertainty.

Water infrastructure and supply is currently insufficient to guarantee water security. Domestic rainwater infrastructure is not in an optimum state to meet the population needs but is currently sufficient (in most dwellings) to provide enough water during average or above rainfall, especially if the households have access to a secondary source of water. However, during extended drought, the national desalination plant is barely sufficient to provide the population with minimum water requirements.

Institutional capacity is low and there is a lack of skilled workers for the sector. There is currently no legal framework to regulate the sector.

3. CONJUNCTIVE USE OF WATER IN NAURU

Nauruans have used a combination of rainwater and groundwater for hundreds of years. Rainwater was originally harvested using palm trees to capture water and wooden storage (Figure 6). Elders recall times when during drought, people use to fetch water from natural galleries accessing groundwater.

Figure 6. Rainwater harvesting in the old days (from http://www.janeresture.com/nauru_picture_gallery/index.htm).

It is evident that Nauruan needs for water are far greater nowadays to sustain lifestyle and public health and to support the island's economic development.

During the past century, Nauru has been using a creative combination of water sources in order to support its economic development: bulk water shipped by boat during the era of the Nauru Phosphate Corporation (NPC), the seawater reticulation system for toilet flushing (ex-NPC housing area), a multi-effect distillation (MED) plant (seawater desalination technology), extensive rainwater harvesting (ex-NPC housing area), and extensive groundwater abstraction (domestic wells). The MED is no longer functioning and has been replaced by three small self-contained RO units, producing a third of the MED's total production.

New technologies such as reverse osmosis (i.e. desalination) are able to produce large amounts of potable water, however the current high cost of production and maintenance limit its role as a water source for Nauru. Similarly, relying exclusively on rainwater is prohibitively expensive because of the large volume of storage needed to sustain supply during drought periods. Groundwater is not a reliable source of potable water due to the high variability of quality. However, it is an indispensable source of non-potable water, and a potential source of potable water in some areas.

Using rainwater, seawater and groundwater as conjunctive sources is a sensible way to sustainably improve Nauru's water supply, leaving desalination technology for major users (i.e. hotels and industry) and to serve as a back-up supply during drought periods.

4. PACC DEMONSTRATION PROJECTS

Climate change is likely to increase the stress on availability of freshwater in Nauru. The PACC demonstration project aims to enhance community resilience to drought, through suitable adaptation measures. The PACC team has worked closely with the targeted communities and established that developing a conjunctive water supply system would be the most appropriate adaptation measure for the pilot areas. A vulnerability and adaptation (V&A) assessment was also undertaken for the selected sites to evaluate the current and future threat to the communities in relation to drought events, and to review the available technical solutions.

Two demonstrations projects have been proposed by the PACC project, as follows:

- Demonstration Project 1: Solar water purifiers in selected households, Aiwo district.
- Demonstration Project 2: Seawater reticulation system in Location area.

This section presents both projects and details background research, selection process, expected benefits and M&E.

4.1. Site selection

Two main criteria were used to select the demonstration project areas:

1. Heavy reliance on desalinated water. Considering that most households in Nauru rely primarily on rainwater for potable water needs, areas with heavy reliance on desalinated water have a poor coping capacity against drought events (e.g. not sufficient storage per capita, no access to a secondary source of water). Location and Aiwo are the two biggest consumers of desalinated seawater[2]. Reducing the reliance of these two areas on desalinated water will increase availability of water for the entire island (by reducing stress on the desalination plant).
2. High population density. Highly populated areas use more water than less populated areas and, in Nauru, are generally more vulnerable to drought. Location area has the highest population density, and Aiwo is one the highest populated districts.

The location of the two selected sites, Aiwo and Location, is shown in Figure 7.

Figure 7. Aerial view of Nauru showing Location area and Aiwo district (source: Google Earth).

2 Data available from 2007 (with gaps) at the Nauru Utilities Corporation (NUC), Republic of Nauru.

4.2. Vulnerability and adaptation (V&A) assessment

4.2.1. Objectives and methodology

During the early stages of the project in August 2010, a V&A assessment was undertaken to assess the vulnerability of the selected sites to environmental changes and to evaluate available adaptation measures.

The V&A used various methods and tools to appraise the pilot sites, including a literature review, community workshops, technical group working sessions and independent assessments (Table 4). A door-to-door survey in the selected districts, known as the Nauru Housing Water Project (NHWP), was also undertaken to inform the V&A.

Table 4. Data used for the V&A.

Existing data	Collected data
• PSCCP climate change report for Nauru • NAPA • PACC reports • Water, sanitation and climate outlook • Water policy • IWRM diagnostic report • GW vulnerability report • ARMS rainfall data • Census 2006 data	• Nauru Housing Water Project • Community workshops • Meetings with community leaders • Technical working group sessions

The V&A assessment followed a 5-step process:

- Identification of current and future natural hazards and environmental changes affecting the water sector;
- Identification of risks to the water sector associated with environmental changes;
- Identification of current and future capacity to cope with environmental change;
- Prioritisation of risks at community level;
- Recommendations and review of adaptation measures for the two pilot sites.

Seven indicators were used to facilitate the V&A process. Each indicator is linked to one or more parameters used to identify particular risks associated with environmental change and adaptation capacity (Table 5).

Table 5. Vulnerability indicators (adapted from CSIR, 2003).

Sphere		Parameter	Vulnerability indicator
Environment	Climate	• Rainfall • Sea level	**VI-1. Water availability and quality**
	Ecosystems	• Water dependency • Land uses	
	Hydrology	• Storage • Quality	
	Hydrogeology	• Yield • Recharge	
Socio-economic	Demography	• Population size and distribution • Water demand	**VI-2. Water demand and population density** **VI-3. Access to water** **VI-4. Water use and usages** **VI-5. Storage and supply infrastructure** **VI-6. Income and GDP**
	Infrastructure	• Water production and supply capacity • Water storage • Water asset	
	Economy and livelihood	• Water pricing • Cost of production • GDP • Household income	
Governance	Legislation	• Policies • Acts • Regulation • Guidelines	**VI-7. Sector reform and adaptive capacity**
	Institutional	• Adherence to IWRM principles • Human resource capacity	
	Knowledge	• Literature/data	

Community consultations were central to the V&A, held in both the Location area and Aiwo district. The first set of workshops took place in early 2010 to inform the community of the PACC project and prioritise issues related to environmental change in the community. Once the vulnerability assessment was completed, communities were again consulted to present and discuss the various adaptation measures. Finally, adaptation measures recommended in the V&A were presented to the Aiwo and Location communities. The findings and decisions were forwarded to SPREP and submitted to the Cabinet of the Republic of Nauru.

4.2.2. Key findings

The most threatening climate impact in Nauru is rainfall variability and drought. In the selected districts for the demonstration projects, adaptive capacity is generally low and socio-economic factors add to the communities' vulnerability to drought (Table 6).

The average number of people per dwelling is high in both districts (11). The majority of the population is young, and the population in both districts is expected to double by 2034. With no indication that the economy will develop on the island and offer more or better employment opportunities, this presents a serious risk to the communities' capacity to develop and/or maintain household infrastructure.

In Aiwo, stored rainwater is often less than a month's supply per capita, and reliance on desalinated water is high. Some households in lower Aiwo are also facing pollution of groundwater from industrial activities and contamination of roofs and water tanks with phosphate dust. Sea level rise could add to this, by further increasing groundwater contamination from surface activities.

In Location, the current coping capacity is very low. Stored rainwater per capita is just a couple of weeks' supply, and reliance on desalinated water is the highest on the island, because of lack of access to any other source of water. With the lowest average income on the island, Location is also the only place where a significant proportion of the inhabitants are not landowners, again limiting their household coping capacity.

Table 6. Key findings from the V&A. Level of vulnerability according to indicator shown in red cells (HH = household).

Vulnerability indicator	Parameter	Location	Aiwo
VI-1. Availability and quality of water resources		MODERATE	MODERATE TO HIGH
	Water availability	• Rainwater (frequent drought) • Groundwater (no access) • Seawater (coastal access)	• Rainwater (frequent drought) • Groundwater • Seawater (coastal access)
	Water quality	• No data on groundwater quality in Location. Likely to be brackish • Sea level rise is likely to increase the risk of groundwater contamination	• Rainwater in lower Aiwo often contains dust from roofs • Pollution from oil (petroleum) can be find in several wells in lower Aiwo • High rate of contamination with faecal bacteria • Sea level rise is likely to increase the risk of groundwater contamination
VI-2. Density of population and water demand		HIGH	MODERATE TO HIGH
	Population density	5,710/km^2	• 1,196/km^2 (100% of land area) • 3,988/km^2 (30% of land area)
	Growth rate (2006–2011)	3.85%	2.09%
	Average population	• Per HH: 6 • Per dwelling: 11	• Per HH: 6 • Per dwelling: 11
	Average water demand	• Per capita: 170 L • Per HH: 1,000 L	• Per capita: 170 L • Per HH: 1,000 L
	Total daily water demand	214,000 L	218,000 L
VI-3. Access to water		HIGH	HIGH
	Primary source of freshwater	Desalinated water (70%)	Rainwater (50%) and desalinated water (50%)
	Secondary source of freshwater	Rainwater (30%)	Rainwater (50%) and desalinated water (50%)
	Access to a secondary source of water (non-potable)	0% of the population access to groundwater	25% of the population access to groundwater
	Water scarcity	30.5% of HH report to often lack water	37.6% of HH report to often lack water
VI-4. Water uses and usages		HIGH	MODERATE TO HIGH
	Water use	100% urban (100% domestic)	100% urban (breakdown)
	HH using flush toilet	90%	90%
	Daily freshwater use per capita	• Average: 169 L • During drought: 156 L	• Average: 130 L • During drought: 91 L
	Daily groundwater use per capita	• Average: negligible • During drought: negligible	• Average: 65 L • During drought: 104 L
VI-5. Storage and supply infrastructure		HIGH	MODERATE
	Public asset	3 freshwater tanks (6,000 L), only 2 in use	• 3 freshwater tank (6,000 L), 1 leaking • 1 groundwater tank with solar powered pump
	Private asset	• Storage tanks, avg. 5,000 L (95% of HH) • Rainwater harvesting facilities (98% of HH)	• Storage tanks, avg. 5,000 to 9,000 L (90% of HH) • Rainwater harvesting facilities (80% of HH) • Groundwater wells (25% of HH)
VI-6. Income		MODERATE TO HIGH	MODERATE
	Ave. income per HH $3,200<	27%	5%
	Ave. income per HH >$7,800	32%	52%
VI-7. Sector reform and adaptive capacity		MODERATE TO HIGH	
	Sector reform	In progress	
	Current adaptive capacity	Low	

4.2.3. Selection of adaptation measures

Aiwo and Location are facing a similar threat from climate variability and climate change. However, differences in the physical and socio-economic environments and coping capacities indicated the need for different adaptation measures, and therefore different demonstration projects.

LOCATION

Location area is the most populated area on the island and also has one of the lowest incomes per dwelling. Access to rainwater is scarce as people live in flats that are often in bad condition, with little rainwater catchment area per capita and ageing concrete tanks. Because there is no access to any secondary source of water, freshwater, mostly from the desalination plant, accounts for all water uses. Therefore, there is a clear need to develop a conjunctive water supply system in Location.

After discussion with the technical working group and the Location community, possible options identified were:

- Reticulated groundwater wells: drill wells around Location area and (if possible) develop a reticulation system to all dwellings in Location;
- Community groundwater tanks with solar pump: drill one or two wells around Location area linked to 6,000 L storage tanks with solar-powered pumps;
- Rehabilitate the seawater reticulation system: rehabilitate the old seawater reticulation system to provide water for flushing toilets in all dwellings;
- Restore existing storage tanks: rehabilitate underground bulk storage in Location in order to significantly increase the storage capacity of freshwater.

To assess the feasibility, relevance and sustainability of each option, a multi-criteria analysis (MCA) was undertaken by the PACC team, using the recommendations from the vulnerability assessment (Table 7). For more detail on the attribution of scores, please refer to the original V&A report.

Table 7. Multi-criteria analysis of identified adaptation options for Location.

	Parameter	Reticulated groundwater wells	Community groundwater tank (solar pump)	Seawater reticulation system	Restoration of existing storage tanks
Environmental					
VI-1	Water source available during drought	3	3	3	2
	Potential environmental impact	1	1	2	3
Socio-economic					
VI-2	Amount of water provided per capita	3	3	3	2
VI-3	Improved access to freshwater during drought	0	0	0	2
	Improved access to a secondary source of water	3	2	3	0
VI-4	Contribution to daily water usage (%)	2	2	1	3
	Health risk related to use	1	1	3	2
VI-5	Maintenance required	1	2	0	3
	Expected lifespan	2	1	2	3
VI-6	Reasonable running cost	2	3	1	0
	Implementation cost	1	3	1	2
	Economic benefit to the water sector	3	2	3	0
Landowners acceptance		0	0	2	0
TOTAL		**22**	**23**	**24**	**22**

The issues ‘water available during drought’, ‘health risks’, ‘maintenance required’ and ‘landowners acceptance’ were considered critical. After a review of the MCA, the technical working group and the community selected rehabilitation of the seawater reticulation system as the most suitable option.

As the rehabilitation process could be significantly expensive, a feasibility study and cost–benefit analysis were recommended. Without more details on the implementation, running and maintenance costs for the seawater reticulation system no final decision could be made. If further investigations reveal that the project is not feasible or that the government does not have the capacity to run or maintain it, other solutions mentioned above will need to be reconsidered.

AIWO

Aiwo has similar characteristics in housing and water supply as the rest of the island. However, some dwellings in Aiwo were facing additional issues with their water supply, namely contamination of the groundwater from industrial activities (oil), and phosphate dust on roofs and in water tanks. Although the dust deposit seems to be only a taste issue (no effects on health have been identified so far), it has led some households to completely abandon rainwater harvesting, so they now rely entirely on desalinated water. Regarding the oil contamination, efforts are yet to be made to stop the source of pollution. In Aiwo, the community expressed the desire to address these issues so that they can use rainwater or groundwater.

After discussion with the technical working group and the Aiwo community, possible options identified were:

- Reticulated groundwater wells for upper Aiwo: drill wells in upper Aiwo with (if possible) a reticulation system to selected households;
- Reticulated groundwater wells for lower Aiwo: drill wells in lower Aiwo with (if possible) a reticulation system to selected households;
- Improve rainwater harvesting system (roofing and gutters): renovate roofs (e.g. remove asbestos) and repair/ install guttering systems for selected households;
- Improve rainwater harvesting system (filters): install filters on rainwater tanks in selected households to prevent phosphate dust from entering the tanks;
- Solar purifiers for selected households: connect solar purifiers to groundwater supply to convert small volumes of brackish or contaminated water into drinking water.

To assess the feasibility, relevance and sustainability of each option, an MCA was undertaken by the PACC team, using the recommendations from the vulnerability assessment (Table 8). For more detail on the attribution of scores, please refer to the original V&A report.

Table 8. Multi-criteria analysis of identified adaptation options for Aiwo.

	Parameter	Reticulated groundwater wells for upper Aiwo	Reticulated groundwater wells for lower Aiwo	Improvement in rainwater harvesting system (roofing and gutters)	Improvement in rainwater harvesting system (filters)	Solar purifiers
Environmental						
VI-1	Water source available during drought	3	3	0	0	3
	Potential environmental impact	1	1	3	3	2
Socio-economic						
VI-2	Amount of water provided per capita	3	3	2	2	1
VI-3	Improved access to freshwater during drought	0	0	0	0	3
	Improved access to a secondary source of water	3	3	0	0	2
VI-4	Contribution to daily water usage (%)	2	2	3	3	3
	Health risk related to use	1	0	2	2	3
VI-5	Maintenance required	1	1	3	2	3
	Expected lifespan	2	2	2	1	1
VI-6	Reasonable running cost	3	3	3	3	3
	Economic benefit to the water sector	3	3	2	2	1
Landowners acceptance		2	2	3	3	3
TOTAL		**24**	**23**	**23**	**22**	**28**

The issues 'water available during drought', 'health risks', 'maintenance required' and 'landowners acceptance' were considered critical. After review of the MCA, the technical working group and the community selected the solar purifiers option as the most suitable option. The main advantages identified for the solar purifiers option were:

- It enables both groundwater and rainwater to be purified to international drinking quality standards;
- It enables groundwater to be used all year to supplement rainwater harvesting and as an emergency potable water source during drought;
- It is an affordable solution for households in Nauru.

4.3. Overview of the projects

4.3.1. Project 1: Solar purifiers for selected households in Aiwo district

PROJECT SUMMARY

The main purpose of the project is to make potable water available to selected households using the purifiers. The selected households each have 80 L of additional potable water per day. During a drought, this can be used for drinking, cooking and if in sufficient quantity, personal bathing. Even when not under drought conditions this is a useful and safe potable water supply. Stored rainwater cannot be guaranteed to be free of contamination, while water from the purifier is completely safe and free of contamination. Table 9 summarises the project at time of writing (2012).

Table 9. Summary of Demonstration Project 1: Solar purifiers in Aiwo.

Project status
The solar panels were installed during 2nd and 3rd quarters 2011. Currently in monitoring phase
Beneficiaries
Number of household benefiting from the project: 19
Number of community tanks benefiting from the project: 1
Number of panels installed per HH[3] or community tank: 4
System features
Water quality: potable (WHO drinking standards)
Water uses: drinking/all uses
Effective water production rate per HH: 30–50 L per day (4 panels)
Total water supplied per year by Demo Project 1: 584,000 L
Estimated costs
Implementation costs: Aus$78,934.00
Estimated annual cost of production per HH: less than $5 per year[3]

3 This is based on a residential electricity price of max $0.3 per kW (cost was $0.2 per kW in 2011), a water head of max. 6 meters and a volume of 50 L per day.

SYSTEM COMPONENTS AND DESIGN

Solar water purifiers are solar panels covering a water circulation circuit creating a distillation unit. A single panel produces around 20 L of water per day. Panels can be installed on a roof, a platform or concrete top (Figure 8). The purified water can be diverted to a rainwater tank or other storage.

Figure 8. Installing solar panels on a platform designed for householders in Aiwo district (photo: PACC Nauru).

The technology used for this project was the Carocell™ Solar Desalination Unit designed by FCubed. Similar technology is available from other global providers such as Sunsure Water.

The system receives impure water (in this case groundwater) using a pump, and it is dispersed evenly. Solar energy then heats the water, which vaporises and then condenses on the inside of the composite plastic panel enclosure. Droplets of distilled water run down into a water outlet at the bottom of the unit. The distilled water is free of dissolved materials such as salts and heavy metals, suspended sediment, or bacteria and viruses that remain in the unvaporised liquid (Figure 9).

The water produced after the distillation process is potable and meets WHO drinking water standards.

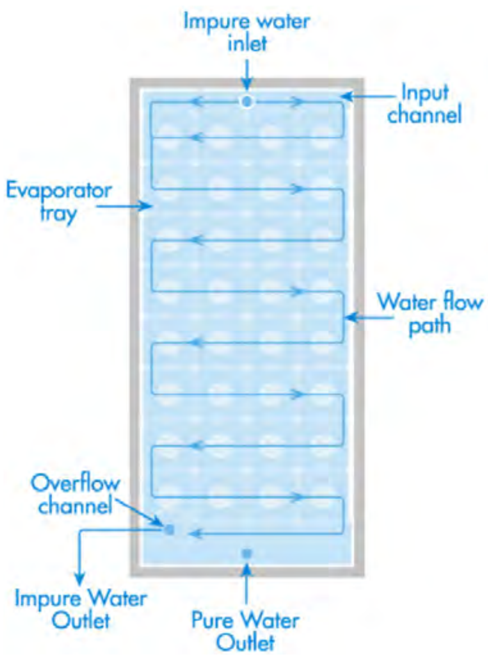

Figure 9. Solar water purifier process (Sunsure Water 2012).

OPERATION AND MAINTENANCE

Solar purifiers installed at selected households currently have four panels per household. The system is operated by the household and does not require any major maintenance. The lifespan of the solar purifier is 15 years and no replacement of material is expected during this time.

The maintenance is minimal because there is no complex filter system or chemicals involved (that would need to be replaced), and no electronic or moving parts (which could fail or break). According to the manufacturer, the only maintenance required is a regular cleaning of the panels to ensure their highest efficiency.

AFFORDABILITY AND ACCEPTABILITY OF THE SYSTEM

Solar purifiers are affordable for the average household in Aiwo, and for the majority of households in Nauru. Some householders were initially reluctant to divert the water produced by the purifier into their main drinking water tank because they did not trust the technology. But with the monitoring programme in place, the PACC team is demonstrating that the water produced with the solar purifiers is even safer than the harvested rainwater.

The panels could be marketed through local businesses and promoted to households as an affordable solution to improve coping capacity during droughts.

4.3.2. Project 2: Seawater reticulation system for toilet flushing in Location area

The information provided below is based on the draft feasibility study developed by Aremwa (2012). There are still some knowledge gaps, especially regarding maintenance costs and extent of the project. Opportunities for co-financing, extending the project to Denig district, are currently being discussed (at time of writing). Please contact the PACC project coordinator for up to date information on the project.

PROJECT SUMMARY

This project aims to provide an alternative source of water for non-potable uses in Location area, thus saving precious potable water. This is a rehabilitation project of the once operational and effective seawater reticulation system built by the BPC to supply water for the following uses:

- Industrial – cooling of power station generators and refrigeration condenser cooling;
- Domestic – toilet flushing, swimming pools;
- Emergency – fire fighting.

The intended use for its rehabilitation is toilet flushing only, however it could also provide for other uses if necessary. Table 10 summarises the project at time of writing (2012).

Table10. Summary of Demonstration Project 2: Seawater reticulation system in Location.

Project status
Demo Project 2 is in design phase. The draft feasibility report has been released in early 2012
Beneficiaries
Number of people benefiting from the project (estimate): up to 2,600
Number of households benefiting from the project: 506
Number of government buildings and commercial businesses benefiting from the project: up to 14
System features
Water quality: untreated seawater
Water uses: flushing toilets (potentially also industrial, fire fighting)
Water supply capacity: up to 200,000 L per hour
Total water supplied per year by Demo Project 2: 18,250,000 L (low estimate)
Water distributed per day per household: unlimited
Estimated costs (Aus$)
Implementation costs (range): $300,000–500,000
Annual running cost with subsidies: $1,000
Annual running cost without subsidies: $3,000[4]

4 This does not include implementation and maintenance costs.

SYSTEM COMPONENTS AND DESIGN

The seawater reticulation system is a network system that will supply seawater directly into connected households.

Seawater is pumped from the intake pump house (B) to a set of underground concrete tanks (D) also known as the cooling ponds (Figure 10). These tanks are located at the power station. Seawater is then pumped from the cooling ponds up to the Command Ridge concrete storage tanks (H). Situated on the highest point of Nauru (70 m), the seawater is then gravity-fed through a pipeline distribution network.

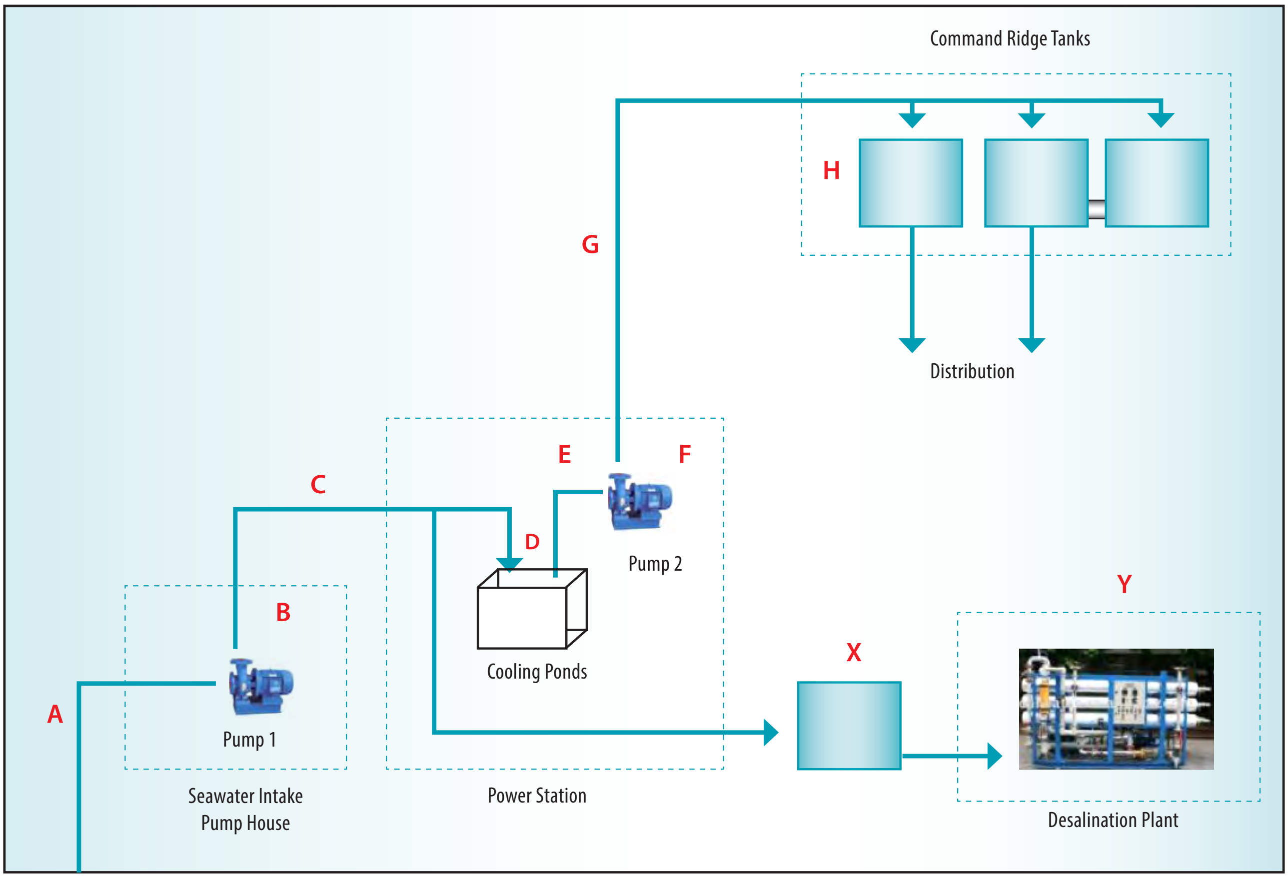

Figure 10. Seawater reticulation network (from Aremwa, 2012).

This seawater source currently supplies water to three RO units also located at the power station.

The first intention was to focus the adaptation measure on Location district only. However, there is an opportunity to extend the network to cover a wider area (Figure 11). The red dashed line on the figure is Location area, while the black line shows the possible extent of the network.

Figure 11. Possible extent of the seawater reticulation system network (from Aremwa, 2012).

If the system is extended to Denig and part of Aiwo district (as shown by the black line in Figure 11), the total population served by the network will be up to 2,600.

Table 11. Breakdown of population served by the network (from Aremwa, 2012).

Category	Sub-category	Heads (live-in or worker)
Domestic	Married quarters	300
	Single quarters	100
	Location	1,496
	Private	–
Industry	Loading bridge	48
	Drying plant	58
	Ship loading	57
	Power station	50[1]
	Water production	20[1]
	Fuel tank farm	15[1]
Offices	Ronphos head office	124
	Ronphos engineering	10
	Ronphos hardware store	8
School	Nauru College	150[1]
Hospitals	RON	55[1]
	NGH	20[1]
Workshops	Ronphos	85
	Marine	30[1]
Total		**2,626**

1 *Estimates.*

According to Aremwa (2012), and based on an estimated use of 25 L per person per day for flushing toilets, the seawater reticulation system could supply up to 70,000 L of water per day. It is not clear how many additional households and buildings (excluding Location) are currently using freshwater for toilet flushing. If an estimated 2,000 people are using freshwater for toilet flushing, the freshwater (desalinated water) savings per day will be around 50,000 L (Figure 12).

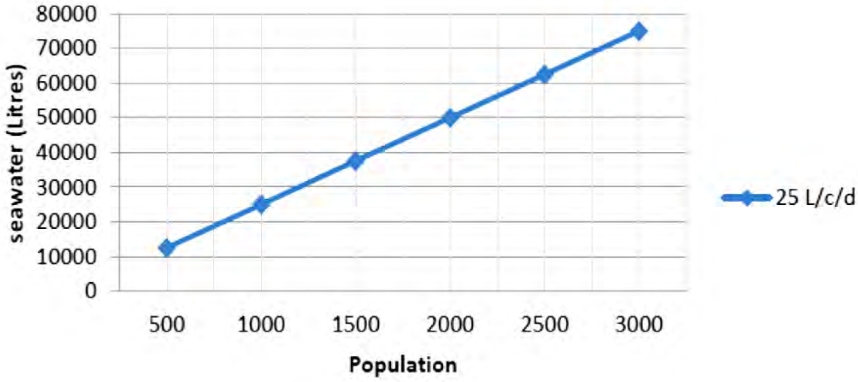

Figure 12. Seawater consumption as a function of population.

OPERATION AND MAINTENANCE

The reiculation system will be added to the national water infrastructure and operated under the NUC budget. Running costs have been estimated at $1000 to $3000 per year (depending on whether the current subsidies on petrol provided by the Australian Government are taken into account). Regular maintenance will be needed for the main components of the system, i.e. pumps, pipes, tanks and the home connection network. There are currently no estimates of the annual maintenance cost, but it is reasonable to suppose that the NUC will have the capacity to maintain it, as the system does not require expensive parts or for hardware to be changed regularly, and maintenance skills and hardware parts can be found locally.

EXPECTED IMPACTS OF THE PROJECT

According to Aremwa (2012), the government could save an estimated $70,000 per year if households used seawater instead of desalinated water for toilet flushing. This estimate is based on the implementation of a new RO plant, considering a water production cost estimated at $4 per kL. However, according to the NISIP (2011), the current total cost of production for desalinated water is up to $20 per kL (mainly due to major losses in the system). Therefore, in the current situation, the seawater reticulation system could save the NUC an estimated $400,000 per year.

It is important to note that both estimates are based on an assumed steady production of desalinated water. In reality, these figures are likely to be realistic during an average or above rainfall year. However, during a drought period, because the water demand is higher than the supply capacity, the production of water will not decrease. In this case, the implementation of the seawater reticulation network, by replacing (and making available) an estimated 50,000 L of desalinated water per day, will help to provide more freshwater to the entire island, which is its primary objective.

4.4. Expected outcomes

The main objective of the demonstration projects is to implement successful adaptation measures in order to reduce the water sector's vulnerability (PACC Project Outcome 2). Expected outcomes are detailed in the flowchart in Figure 13.

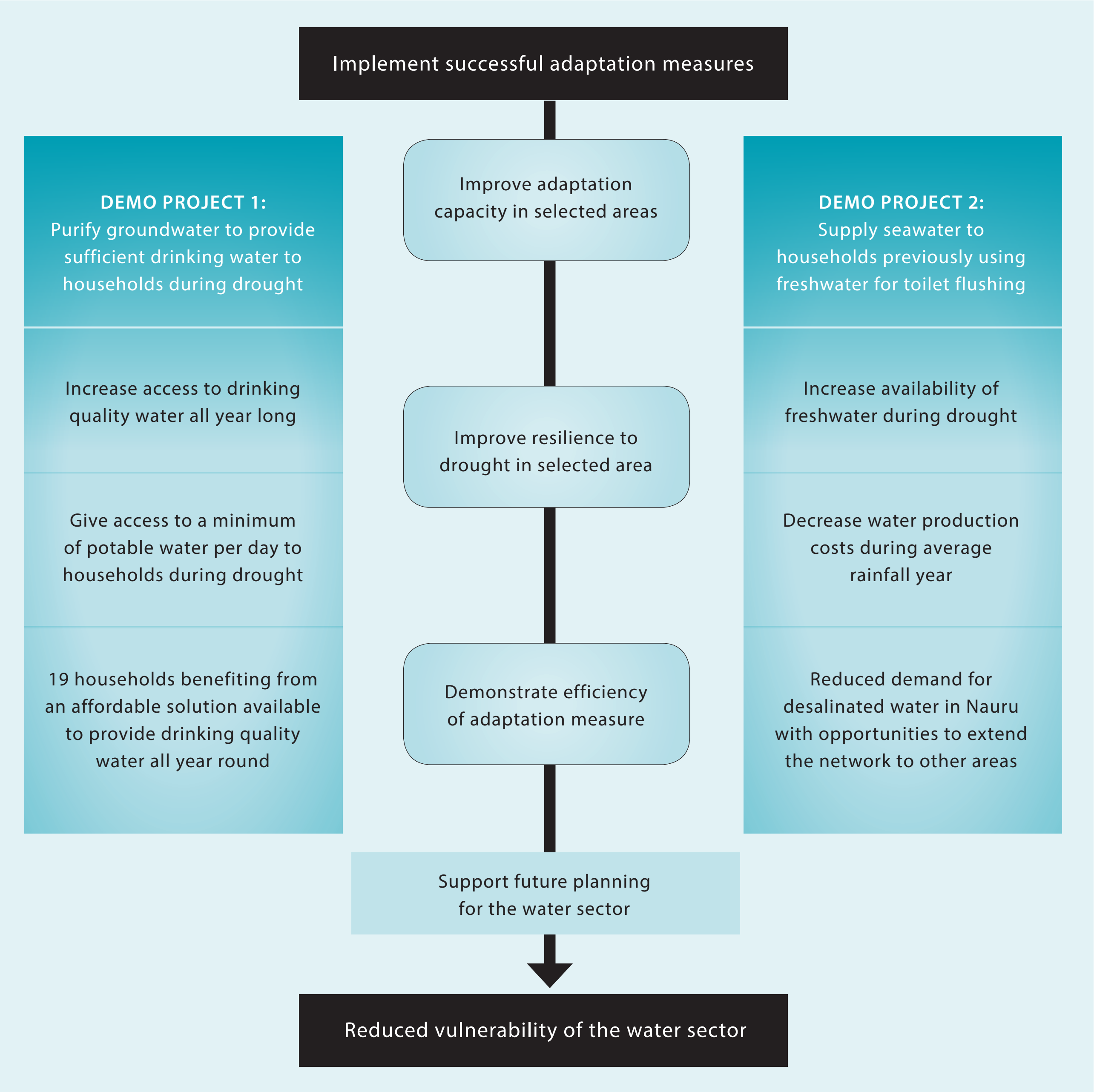

Figure 13. Project outcomes flowchart.

Overall, the demonstration projects are expected to deliver the following outcomes.

1. Support future planning for the water sector:
   - Demonstrate the effectiveness of conjunctive use of water at the household level;
   - Demonstrate the effectiveness of conjunctive use of water at the community level.
2. Reduce pressure on the demand for desalinated water:
   - Release up to 5% of the total demand for potable water during drought periods (thus reducing the likelihood of water-borne disease from contaminated water);
   - Decrease the production of desalinated water during average and above rainfall (saving up to $400,000 per year).
3. Provide 19+ households with drinking water all year round.

4.5. Monitoring and evaluation

The monitoring and evaluation (M&E) process is an ongoing activity from day one of project implementation, and has been a vital part of the demonstration project. The M&E process is used to assess whether or not the project is reaching its intended objectives and if not, what can be modified or improved in order to deliver expected outcomes.

4.5.1. Indicators and monitoring process

The M&E process commonly uses two different types of indicators: quantitative and qualitative. Quantitative indicators are often seen as objective and verifiable. They take into account hard facts, number or logical deduction, and are very useful for assessing outputs of projects. Qualitative indicators are more subjective and harder to verify, as they are based on people's perceptions. Qualitative indicators are however important, especially for projects that aim at delivery of services to the community, as they can assess whether the community is satisfied with the project and likely to take ownership of it.

The following table describes quantitative and qualitative indicators that have been set so far for the PACC demonstration project. Other indicators could be added and some removed if they are judged to be insufficient or irrelevant (Table 12).

Table 12. Monitoring indicators (Qt = quantitative; Ql = qualitative).

Indicator	Type	Output	Agency in charge of monitoring	Status (03/12)
Demo Project 1				
1. E. coli level in water <0 (MPN/l)	Qt	• Water quality meets WHO standards	Water Unit	Testing kit ordered
2. Amount of water produced per household per day (L)	Qt	• Availability to provide sufficient drinking water all year long • Domestic consumption impact	Water Unit	Monitored
3. Interest of the community in using the system	Ql	• Ownership • Sustainability	Water Unit	• Community initiative • Continual monitoring for feedback
4. General state of the system	Qt	• Quality of the product and strength against natural environment	Water Unit	Monitoring
Demo Project 2 (proposed indicators)				
1. Monthly power consumption (MWh)	Qt	• Energy efficiency of the system	NUC	–
2. Monthly water distributed (kL)	Qt	• Yearly input in national water supply • Domestic consumption impact	NUC	–
3. Number of people connected to the system	Qt	• Sustainability • Ownership	NUC	–
4. Percentage of running costs paid through user fee	Qt	• Cost recovery	NUC	–
5. Yearly maintenance cost	Qt	• Cost recovery • Sustainability	NUC	–
6. Impact on monthly availability of potable water for consumers	Ql	• Sustainability • Effectiveness of the project	Water Unit	–

4.5.2. Evaluation process

The evaluation process reviews results from the monitoring indicators and assesses if they are meeting expected targets. Evaluation and review of each demo project is an ongoing process. Every 6 months an evaluation report will document effectiveness of the project, using the current indicators.

If the indicators reveal that the project is not meeting the expected outcomes, the PACC team will take any necessary action to identify and address the issues to ensure validity of the M&E process. This will be then taken up with the Water Unit established under the Department of CIE.

5. LESSONS LEARNED

These lessons are drawn from experiences during project management in Nauru. They might be useful to decision makers and project coordinators during design and implementation of water supply projects.

1. Projects need to be community specific. Nauru is a small island and the different communities on the island have a lot of similarities. However, for a household or community project it is important to understand the specifics of the area, for example average income, current status of water and sanitation, geography and geology, household locations and population density, as well as previous initiatives that have been undertaken in the area.
2. Projects need to be cost effective. It is vital for project sustainability to ensure that the recipient (government agency, household, etc.) has sufficient capacity and resources to run and maintain the infrastructure. For national and community projects that involve significant running and maintenance costs, cost recovery mechanisms should be developed (such as introducing a user fee).
3. Identify operating and maintenance needs during project design. Maintenance of water infrastructure is a major issue in Nauru. The overall state of the water network and storage is poor. At a household level, 50% of rainwater harvesting infrastructure is not properly maintained. It is important to fully consider these issues during project design, including running costs, funding and operator capacity, and interest in maintaining the related infrastructure.
4. Consider health and environmental issues. Health needs to be considered with care when designing a conjunctive supply project, especially if the water supplied is of non-drinking quality. For example, if untreated groundwater is to be supplied to households for flushing toilets, it is vital to ensure that occupants will not use the water for other purposes, such as washing, cooking or even drinking. Environmental issues are also vital to avoid further contamination of scarce water resources. For example, a community RO plant should be monitored to ensure that no saltwater or brine from the desalination plant is spilled inland. Salt intrusion into the island's porous soil could heavily pollute the groundwater. Other environmental issues such as sewage disposal or other waste attached to the use of the supplied water will also need to be fully integrated and managed as part of the project.

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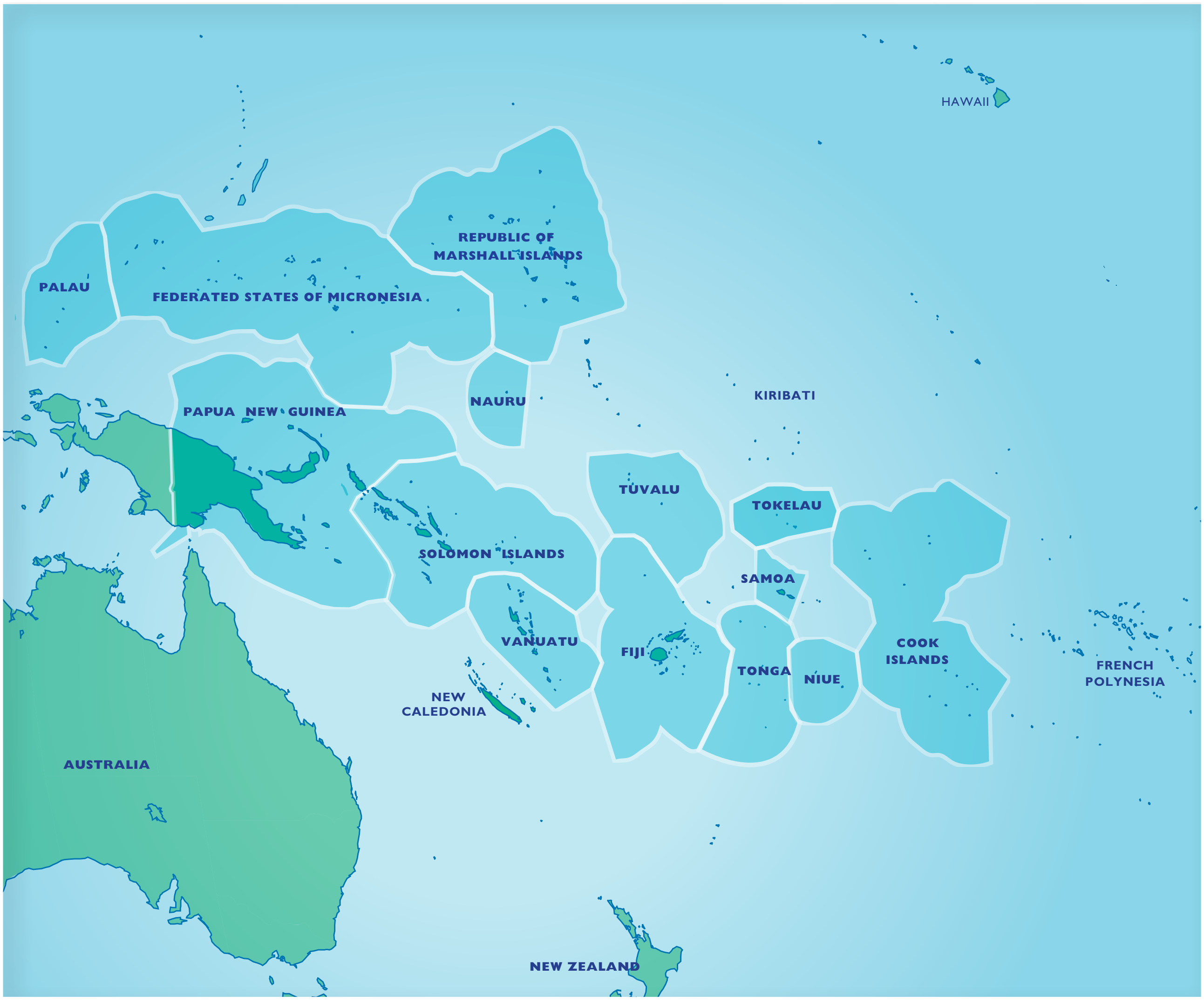

PACC – building adaptation capacity in 14 Pacific island countries and territories

PACIFIC ADAPTATION TO CLIMATE CHANGE (PACC) PROGRAMME

The PACC programme is the largest climate change adaptation initiative in the Pacific region, with activities in 14 countries and territories. PACC is building a coordinated and integrated approach to the climate change challenge through three main areas of activity: practical demonstrations of adaptation measures, driving the mainstreaming of climate risks into national development planning and activities, and sharing knowledge in order to build adaptive capacity. The goal of the programme is to reduce vulnerability and to increase adaptive capacity to the adverse effects of climate change in three key climate-sensitive development sectors: coastal zone management, food security and food production, and water resources management. PACC began in 2009 and is scheduled to end in December 2014.

The PACC programme is funded by the Global Environment Facility and the Australian Government with support from the United Nations Institute for Training and Research (UNITAR) Climate Change Capacity Development (C3D+). The Secretariat of the Pacific Regional Environment Programme (SPREP) is the implementing agency, with technical and implementing support from the United Nations Development Programme (UNDP).

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The PACC Technical Report series is a collection of the technical knowledge generated by the various PACC activities at both national and regional level. The reports are aimed at climate change adaptation practitioners in the Pacific region and beyond, with the intention of sharing experiences and lessons learned from the diverse components of the PACC programme. The technical knowledge is also feeding into and informing policy processes within the region.

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