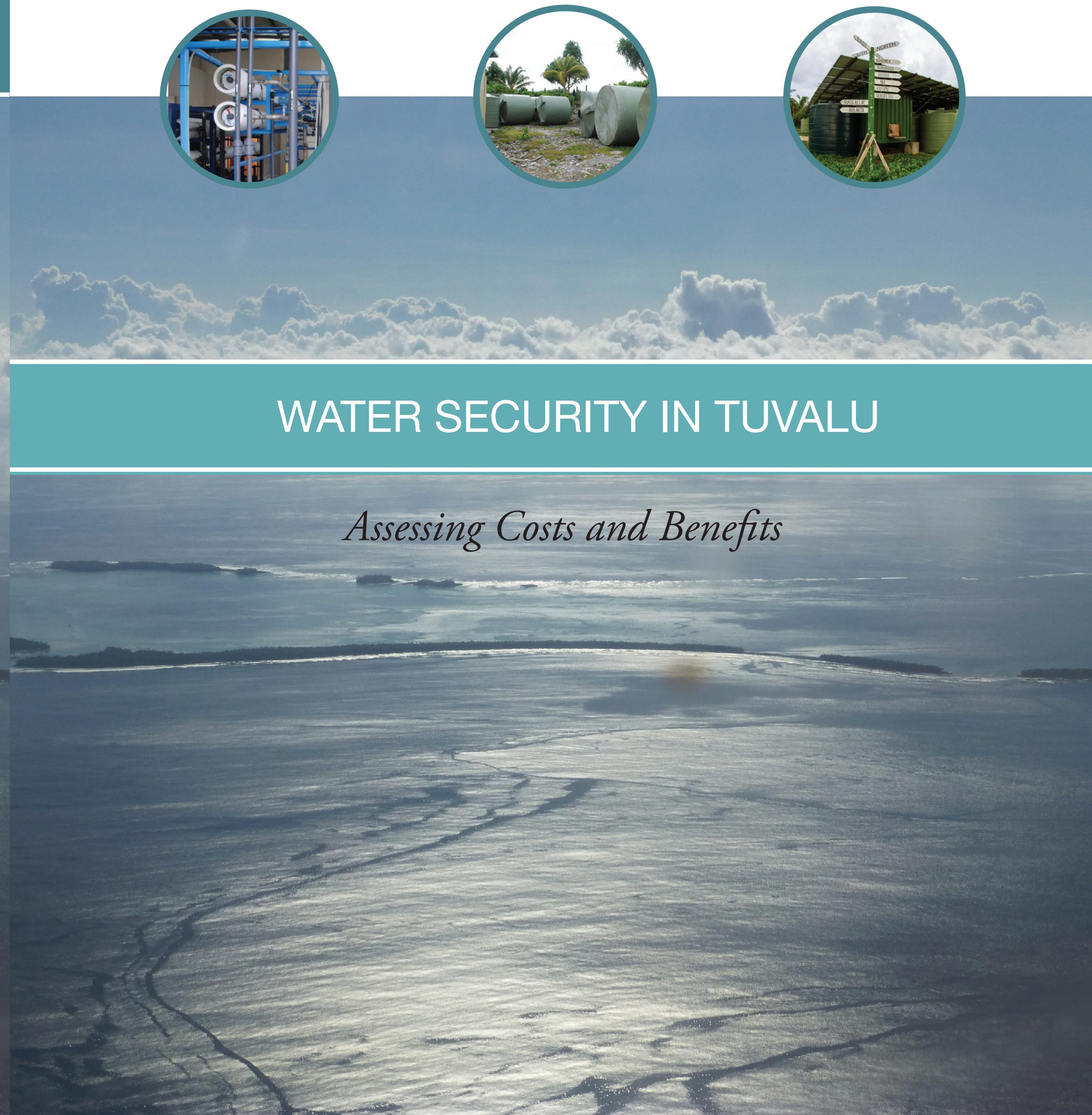

WATER SECURITY IN TUVALU

Assessing Costs and Benefits

Australian Aid

TUVALU MO TE ATUA

PACCSAP

The *Pacific-Australia Climate Change Science and Adaptation Planning (PACCSAP)* programme is building the capacity of Pacific Island Countries to manage future climate risks. While there is widespread concern about climate change across Pacific Island Countries, there are still significant gaps in understanding the likely timing, nature, and extent of impacts and the types of effective adaptation actions available. Economic analysis of climate change impacts and adaptation options is particularly limited. Such an analysis would assist central agencies and decision makers to make more informed development decisions given competing priorities and constrained resources.

Authors

Peter Kinrade, Nadja Arold, Phil Pickering (Marsden Jacob Associates);
Eric Rooke (Gilbert & Sutherland); Joey Manfredo (DAI)

Contact: Peter Kinrade (peter.kinrade@marsdenjacob.com.au)

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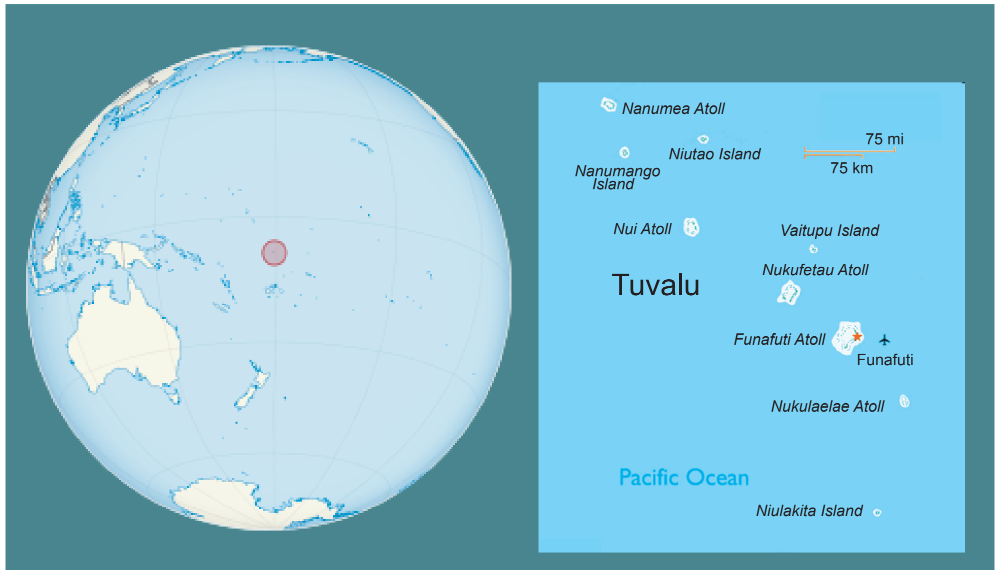
Making every dollar and drop of water count in Tuvalu

Tuvalu received 1,488 millimetres (mm) of precipitation over the 12 months between 2010 and 2011—only 42 percent of the long-term average. During this historic drought, Funafuti households were allocated 40 litres of water per day. To put that into perspective, the average Australian surpasses that quantity every morning after five minutes in the shower.

Three years later, Tuvalu is facing a host of new risks that range from an increasing population—driven by opportunity-seeking internal migrants from outer islands; a higher standard of living that is driving increased water demand; an uncertain future climate, but with the possibility of greater rainfall variability; and the threat of a drought-inducing La Nina on the horizon.

Funafuti is the most populous atoll in Tuvalu and the country's capital.

Figure 1: Location of Tuvalu, showing Funafuti, Vaitupu, and other atolls and islands



The Government of Tuvalu (GoT), however, aims to address water security challenges by mitigating these risks. Partnering with the *Pacific-Australia Climate Change Science and Adaptation Planning (PACCSAP)* programme, a core group of GoT stakeholders participated in the 2014 *Water Security in Tuvalu—Assessing Costs and Benefits* project.

In August 2014, the *PACCSAP Water Security in Tuvalu* project completed a comprehensive Cost Benefit Analysis (CBA) of potential water security interventions in Funafuti and Vaitupu, two of the major islands in Tuvalu (see Figure 1). This booklet presents the results of the CBA, and in doing so, aims to support smart, data-driven investment decisions that are essential for resource-challenged nations like Tuvalu.

The GoT, donor agencies, and other partners can use this booklet to inform decisions on prioritising and selecting major public infrastructure interventions. The booklet serves as:

- a guideline for implementers on project design and strategy development; and
- a catalogue of vetted water security interventions to be considered for GoT and partner government funding.

Water security in Tuvalu is achievable

Improving water security in Tuvalu is an area where the GoT must exercise caution with major public investments. There is little margin for error in this thin atoll nation, the third smallest country in the world. Both resources and capital are scarce. As people crowd into Funafuti from one side of the island (Tuvalu boasts the second highest population density in the region), sea level rise threatens to inundate coastal land on the other side, crowding out viable locations for housing, agriculture, and infrastructure.

As water security interventions are considered, the analysis presented here should increase decision-makers' confidence that the GoT is making sound investments that will achieve net benefits for the people of Tuvalu. All interventions require a significant investment[1], but surprisingly, one of the most effective options considered would cost significantly less than the GoT currently pays for emergency water supply. Immediate creation of a **gutter cleaning and maintenance programme** in Funafuti would annually cost the equivalent of $44[2]/household while increasing total water supply by up to 47,000 kilolitres (kL) in a drought year. On its own, the gutter cleaning and maintenance programme would meet the people of Funafuti's emergency water supply during droughts for the next 20 years.

The cost of desalinated water during drought emergencies is approximately 20 times more expensive than an equally effective gutter cleaning and maintenance programme.

Other core findings include:

- a slightly larger annual investment in new or upgraded community or government cisterns, equivalent to approximately $101 per household when combined with the gutter maintenance and cleaning programme, could meet Funafuti's critical water supply needs (90 litres/day per household), increasing total water supply by up to 58,000 kL in a drought year (additional to the 47,000 kL delivered by the gutter cleaning and maintenance programme).

[1] All costs are estimates based on the PACCSAP Cost Benefit Analysis of water security interventions in Tuvalu. For details on assumptions, please refer to the *PACCSAP Water Security in Tuvalu: Assessing Costs and Benefits Technical Report.*

[2] All $ figures are in Australian dollars.



- installation of centralised rainwater cisterns will generally be more cost effective and practical than providing households with additional rainwater tanks—while some households will benefit from an additional rainwater tank, land resources are too limited to enable households to achieve water security with multiple tanks.

- most interventions would be similarly cost effective in Funafuti and Vaitupu; while development of groundwater resources may be feasible in Vaitupu, Funafuti's groundwater supply is too contaminated to warrant an investment. The project recommends that the GoT and partner countries explore the technical and long-term feasibility of installing groundwater pumps and header tanks in Vaitupu.

Although the project assessed water security interventions for both Funafuti and Vaitupu, examples in this booklet are only for Funafuti. More detailed information on both sites can be found in other PACCSAP Water Security in Tuvalu *materials.*

- desalination is only viable if it is implemented in tandem with a plant maintenance and repair programme and emergency fund. If combined with a gutter cleaning and maintenance programme and additional cisterns, a desalination plant could ensure 300 litres/day for every household in drought years. This would annually cost the equivalent of $307/household, quite modest when compared with current expenditure on desalination water of about $420/household per year.

Proactive interventions can achieve water security for the people of Tuvalu. The GoT, partner countries, multilateral organisations and other stakeholders can use this guide and other products of the *PACCSAP Water Security in Tuvalu: Assessing Costs and Benefits* project to help make a water secure Tuvalu a reality.

Water Security Decision-Making Framework

The Water Security Decision Making Framework (Figure 2) developed for this project will help the GoT to define island-scale solutions that deliver the greatest benefit at the lowest cost. The Framework walks decision makers through five stages [3].

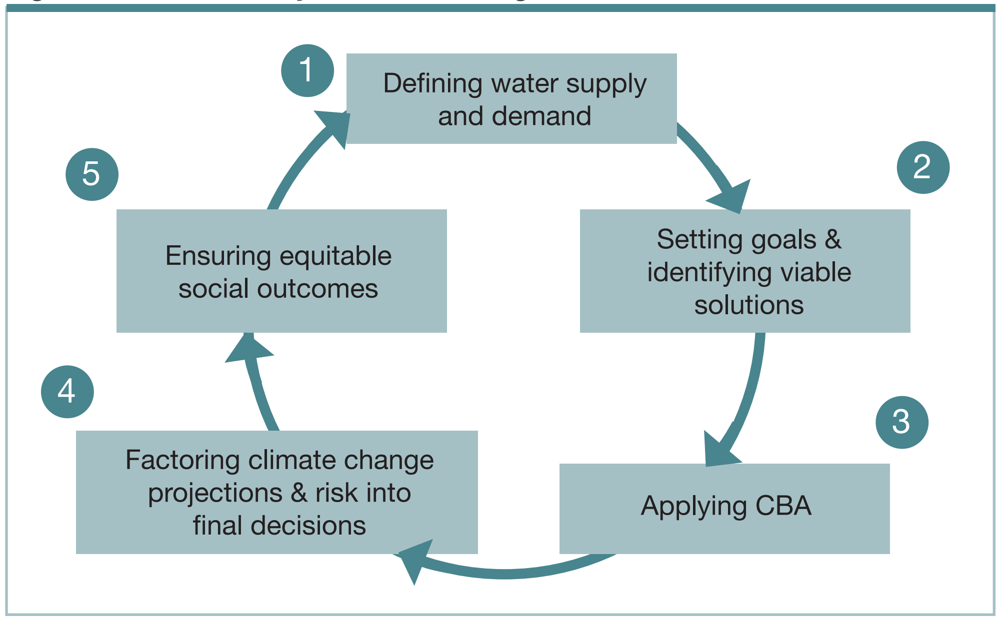
1. Defining water supply and demand

Security of water supply is based on:

(i) Total water storage capacity and consumption patterns

- small households, which make up 70 percent of all Funafuti households, have an average of 1,800 litres of storage capacity in rainwater tanks, and consume an average of 350 litres per day;

Figure 2: Water Security Decision Making Framework



[3] A more comprehensive water security decision-making framework is presented in the *Water Security in Tuvalu: Assessing Costs and Benefits Technical Report.*

Rainwater tanks in storage at the Public Works Department depot, Vaiaku Funafuti

- large households, 30 percent of all Funafuti households, have an average of 3,850 litres of storage capacity in rainwater tanks, and consume an average of 550 litres per day; and
- government and community cistern storage capacity of 10,200 kL, which is rationed at 45 litres/day per household during drought emergencies when household rain-water tanks have run dry.

(ii) Rainfall patterns

- a standard drought scenario (see p.13) was set to the lowest 12 months of precipitation in the his-toric record, 1,488 mm (42 percent of the long-term average), which occurred between 2010 and 2011.

Using the information on established water supply capacity, consumption patterns and rainfall, an Excel spread-sheet water supply-demand model was developed to assess water supply shortfalls under different scenarios and the feasibility of various options to address those shortfalls (see Box 1).

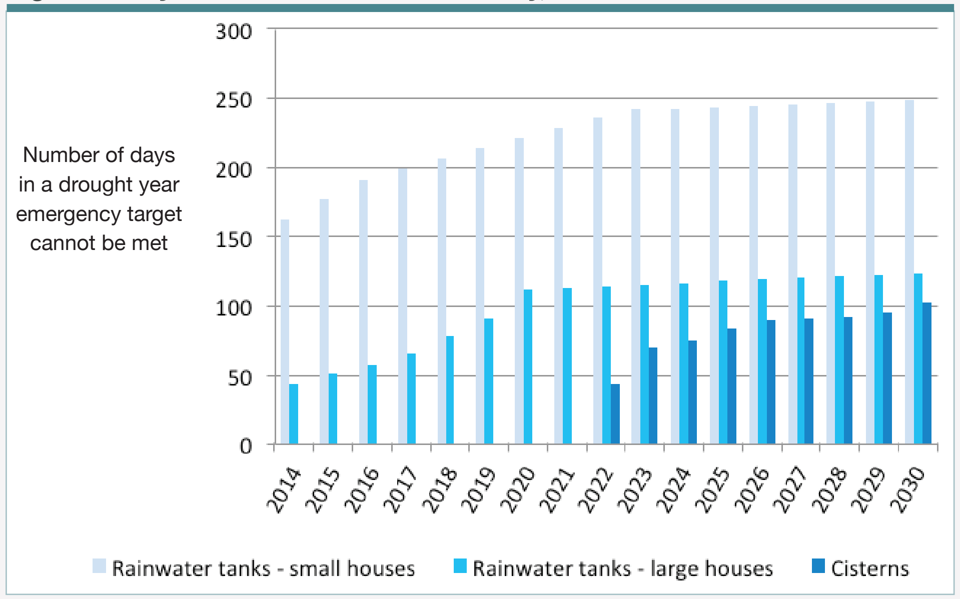
Box 1. Water supply-demand modelling

The water supply-demand model was first programmed to assess water sup-ply shortfalls relative to 'emergency', 'critical' and 'longer term' water security targets (see p.8) under different drought scenarios (see p.13).

As illustrated in Figure 3, under the standard drought scenario, in 2014, small households run out of water for more than 150 days over the course of the year, while large households run out of water for almost 50 days. Given pop-ulation growth and increased consumption rates, by 2022, Funafuti's entire storage of water would be exhausted for nearly 50 days of the year.

After establishing water supply shortfalls, the water supply-demand model was then programmed to assess additional capacity required to meet the wa-ter security targets. It was used to assess portfolios containing different types of options (cisterns, rainwater tanks, desalination, groundwater, etc.) in an integrated manner (see p. 9).

Figure 3: Days of extreme water insecurity, 2014–2030



2. Setting goals and identifying viable solutions

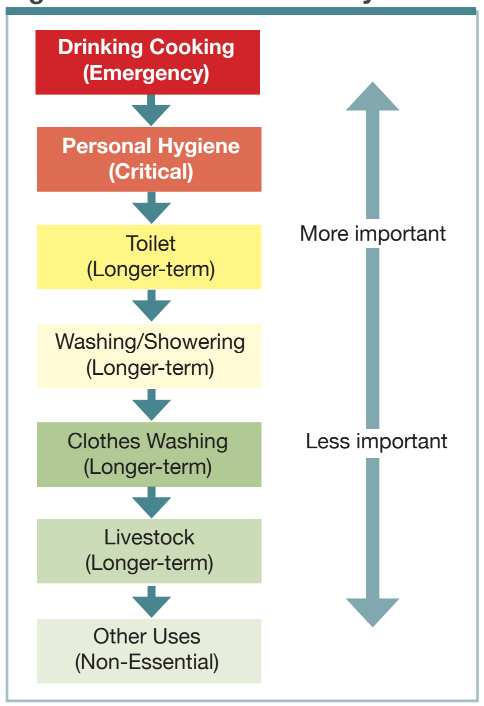
Goals should reflect everyday water uses and demand. They are best set by defining a hierarchy of water uses (see Figure 4) and the supply required for each. Water security goals in Tuvalu can be grouped into three target levels[4]:

(i) **Emergency**—45 litres/day per household for household drinking and cooking;

(ii) **Critical**—90 litres/day per household to meet 'Emergency' supply *and* personal hygiene needs; and

(iii) **Longer-term**—300 litres/day per household, which factors essential toilet, washing/showering, and clothes washing into water supply needs.

Figure 4: Water use hierarchy



Solutions must address the gap between our goals and the supply shortage calculated through water supply-demand modelling. *Water Security in Tuvalu* partners from across the GoT identified a wide range of water security interventions that are either currently being implemented, or could be considered for Funafuti and other parts of Tuvalu in the future.

Conducting a **filtering exercise**, a number of these options were excluded from further assessment on effectiveness, feasibility, environmental, social or cost grounds. A shortlist of options remaining after the filtering exercise was then assessed in more detail. The shortlist of options that was assessed for Funafuti[5] includes:

- additional household rainwater tanks;
- additional community cisterns situated on reclaimed borrow pit land;
- additional community cisterns situated on other available land;
- upgrade of existing cisterns;
- composting toilets;
- desalination water including a training and maintenance program;
- a gutter cleaning and maintenance program;
- implementing the Tuvalu Water Act and associated measures including community education and awareness programs and monitoring of community and government cisterns.

Community cistern, Lofeagai

A portfolio of options to collectively meet targets

Even the most promising and viable shortlisted option cannot on its own bridge the gap between water supply and demand. Nor would this be the wisest approach. Spreading risk across multiple smaller interventions is often wiser than attempting to meet water demand through one large investment. For example, relying wholly on one high-capacity desalination plant could result in major water insecurity in the event of mechanical problems or fuel shortages.

[4] The targets were developed drawing on discussions with stakeholders at a workshop held in March 2014 in Funafuti. The targets represent 'drought targets' and as such are the minimum water requirements of a typical household for defined uses when water supplies are restricted, such as during a drought.

[5] Groundwater was also included in the shortlist of options for Vaitupu but was excluded from the Funafuti shortlist on environmental and health grounds.

The *Water Security in Tuvalu* project took a 'portfolio approach' to meet Funafuti's water demand. Like a suitcase, multiple water security interventions were packed into portfolios calibrated to address the gap between water demand and available supply (see Figure 5). Numerous portfolios were considered to meet the GoT's Emergency, Critical, and Longer-term water security targets. The most promising portfolios—listed horizontally along the top line of Table 1, below— were then assessed in detail.

Figure 5: Critical target—Portfolio A

Table 1: A portfolio of solutions to meet Funafuti's water security targets

	EMERGENCY TARGET PORTFOLIOS			CRITICAL TARGET PORTFOLIOS		LONGER-TERM TARGET PORTFOLIOS	
	A	B	C	A	B	A	B
Gutter Cleaning and Maintenance Programme	X			X	X	X	X
Tuvalu Water Act enforcement	X	X	X	X	X	X	X
Cistern installation —2,250 kL capacity		X		X			X
Cistern installation —6,000 kL capacity						X	
Composting toilets —80% of households			X				
Composting toilets —40% of households						X	
Rainwater tank installation—2.6 kL added capacity					X	X	
Desalination plant with lifetime operations & maintenance							X

Most cost-effective portfolios

3. Applying cost-benefit analysis

CBA can be a powerful tool for informing public infrastructure investment decisions. The PACCSAP CBA Model for Water Security in Tuvalu was custom built by:

(i) comprehensively identifying the costs and benefits of each proposed intervention;

(ii) assigning values to both market and non-market costs and benefits; and

(iii) aggregating the costs and benefits of each portfolio.

Based on the Model's calculations:

- at the **Emergency** Target level, **Portfolio A** (see Table 1) is the most cost effective, with a total cost of $44/household per year, only 60 percent of the cost of Portfolio B and 28 percent of the cost of Portfolio C. Forty four dollars per household per year is arguably a small price to pay for water security, particularly when considered alongside the current cost of desalination, which is up to 10 times more expensive.

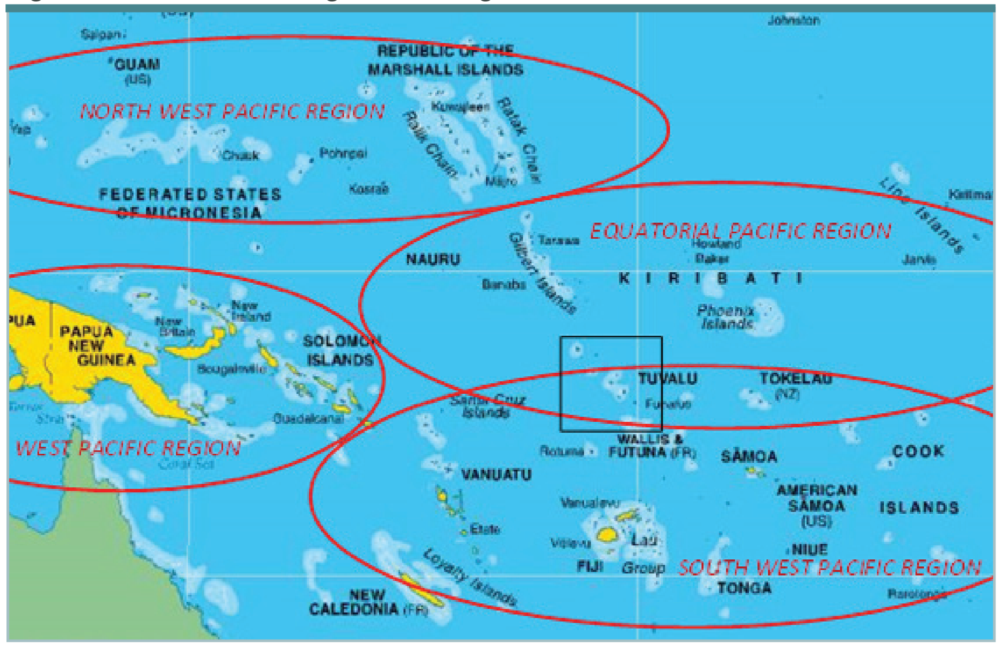
Desalination plant at the Public Works Department depot.

- at the **Critical** Target level, **Portfolio A** is the most cost effective, with a total cost of $101/household per year, only 42 percent of the cost of Portfolio B.
- at the **Longer-Term** Target level, **Portfolio B** is the most cost effective, with a total cost of $267/household per year, only 57 percent of the cost of Portfolio A.

4. Factoring climate change projections and risk into final decisions

Rural-urban migration and global warming are changing Tuvalu. Although there is high confidence in demographic trends, climate change projections are less certain. Tuvalu is located between the Equatorial Pacific region, where average rainfall is projected to increase, and the South West Pacific region, where average rainfall is projected to decrease (see Figure 6).

Figure 6: South Pacific region showing main climate zones and Tuvalu



Selecting the wrong rainfall projections could invalidate the CBA findings and lead to poor investment decisions. Scenario analysis helps to address this uncertainty by running the CBA model against multiple future scenarios:

- **Standard drought scenario**—for severe drought conditions based on the lowest 12-month rainfall in the historic record.
- **Worst case drought scenario**—set at -10 percent of the Standard Drought Scenario, with drought occurring in two consecutive years.
- **Best case drought scenario**—set at +10 percent of the Standard Drought Scenario.

Although there are significant differences in rainfall between scenarios, the results of the CBA did not change when the standard drought scenario replaced the worst case and best case drought scenarios. **Emergency A, Critical A, and Longer-term B were the most cost-effective portfolios under each rainfall scenario.**

Scenario analysis does, however, highlight the significant risk that climate change poses to water security in Tuvalu. Under the worst case drought scenario for 2014, the water supply-demand model projects that small households in Funafuti would rely on government rationing for 194 days and large households would rely on the government for 120 days. That would increase to 264 days for small households and 186 days for large households by 2035, if none of the options are adopted.

Under the worst case drought scenario the Emergency Target could not be met from 2019 if a business as usual approach is adopted. **The GoT and partner countries must act now to address Tuvalu's current and future water security needs.**

Pictured here, a Tuvaluan collects his household water ration during a draught.
Photo source: Google Images

5. Ensuring equitable social outcomes

Whilst important, cost is not the only consideration for a water security strategy. Public investments must also address equity objectives. **Distributional impact mapping** can be used to highlight the distribution of costs and benefits between stakeholders; and to weigh those costs and benefits according to social priorities. Distributional impact mapping involves identifying all groups who will either benefit or pay for the costs of each intervention, and analysing whether certain groups bear an unfair cost burden, or whether benefits are sufficiently distributed across groups.

Based on a distributional impact mapping exercise completed by GoT partners (see Table 2), there are potentially significant distributional impacts, from a policy implementation standpoint, associated with the installation of cisterns on reclaimed borrow pit land in Funafuti.

For instance, tenant families who currently reside next to the borrow pits would have to relocate if the borrow pits are reclaimed. There would also be costs to livestock owners who keep their stock next to the borrow pits. These distributional impacts would be highly concentrated due to the overlap between livestock owners and tenant families.

Table 2: Distributional incidence matrix, cisterns constructed on reclaimed borrow pit land

Benefits and costs of option	Funafuti community	Landowners (borrow pit land)	Families living in area (not on pits)	Tenant families living in area (on pits)	Livestock owners	Kaupule	GoT	Donor partners
Benefits								
Water security benefits	✓✓		✓					
Health benefits	✓		✓✓			✓	✓	
Groundwater quality	✓	✓	✓✓					
Water accessibility			✓✓					
Reclaimed land	✓	✓✓	✓			✓		
Environment	✓	✓	✓✓			✓		
Costs								
Capital costs							X	XX
Operating costs						X	XX	
Water collection costs			X		XX			
Relocation costs				XX	XX			

Key: ✓✓ = significant benefits, ✓ = minor benefits; XX = significant costs, X = minor costs

These impacts would need to be addressed in the implementation phase—possibly through:

- government, Kaupule[6] and/or donor partner compensation and assistance to tenant families for relocation;
- government, Kaupule and/or donor partner compensation and assistance to livestock owners;
- land swap, with some of the reclaimed land made available for relocation of the tenants and/or livestock; and/or
- landowners waiving or deferring land-lease charges to tenants.

Distributional impacts of all major options were examined for this study, but only the borrow pit cisterns appear to have significant distributional impacts. Nevertheless, distributional impact mapping is an essential component of any public sector investment; some costs are simply worth bearing if they can reinforce important social objectives.

Workshop participants review group work on distributional impact mapping during the second of three workshops for the *Water Security in Tuvalu* programme. Distributional Analysis is designed to highlight issues with unequal distribution of costs and/or benefits between those impacted by the project under consideration.

[6] The Kaupule are local government administrators for land tenure and public service delivery.

Next steps

Drawing on results of the *Water Security in Tuvalu* project, the GoT and partners may consider the following action items to improve water security planning and management across Tuvalu[7].

1. A water security or drought management strategy should be completed for each island in Tuvalu.

2. Linkages between all GoT departments and agencies and non-government organisations involved in the management of water in Tuvalu should be strengthened so as to achieve more effective co-ordination of water management. This will require:
   - setting agreed priorities for water infrastructure, programmes and services;
   - clearly defining the roles and responsibilities of departments, agencies, Kaupule, communities and households in delivering on priorities and in managing water;
   - removing duplication in management roles;
   - co-ordination of funding and programme provision by donors or partner countries to ensure that assistance is targeted at priority infrastructure, programmes and services and at priority locations; and
   - improved management of water resources at the community level.

3. Conduct additional survey-based research on the levels and patterns of household, government and business water consumption in each of the islands in Tuvalu.

4. Analysis for the *Water Security in Tuvalu* project suggests that some 'winning options and portfolios' (see Figure 7) are likely to warrant implementation as soon as is practically feasible in Funafuti or Vaitupu.
   - the **gutter cleaning and maintenance programme** should be pursued as a priority in Funafuti and Vaitupu; and
   - **Borrow pit cisterns** are likely to be an important component of portfolios for delivering the critical and longer-term targets in Funafuti. Preliminary analysis suggests that filling in Funafuti's borrow pits has the potential to provide a relatively low cost means of providing the land required for the cisterns, as well as producing other community benefits (e.g., health benefits). Further research into the extent of the benefits created by the borrow pits may be useful. The significant potential distributional impacts of this option will also need to be addressed.

[7] Further details of these steps are contained in the *Water Security in Tuvalu: Assessing Costs and Benefits Technical Report*.



Figure 7. Winning portfolios, Funafuti

WINNING PORTFOLIOS
EMERGENCY TARGET PORTFOLIO A
Gutter cleaning and maintenance programme
Tuvalu Water Act enforced
CRITICAL TARGET PORTFOLIO A
Gutter cleaning and maintenance programme
Tuvalu Water Act enforcement
Cistern installation (2,250 kL capacity)
LONG-TERM TARGET PORTFOLIO B
Gutter cleaning and maintenance programme
Tuvalu Water Act enforcement
Cistern installation (2,250 kL capacity)
Desalination plant and maintenance programme (130 kL/day capacity)

Lessons for decision makers

Analysis for the *Water Security in Tuvalu* project also provides important lessons for decision making in Tuvalu.

1. The GoT should seek to integrate CBA into its decision making on all major investments, policies and programmes. This will help to increase confidence within government, the community and partner countries that decisions are being made in the best, long-term interests of the community. The following measures are proposed as ways to help achieve that integration:
   - existing decision-making processes of the GoT should include specific reference to whether a CBA has been or should be completed as part of the decision making process;
   - a hard copy of the SPREP and SPC CBA booklet[8] should be kept in all GoT departments;
   - new staff joining the GoT should be provided with introductory training on CBA and decision making processes; and
   - comprehensive CBA training should be completed in Tuvalu by selected departmental and agency staff.

2. Where possible, CBAs should be undertaken at the strategy/planning level. This will help to ensure that investment decision making considers short-, medium- and long-term outcomes. It will also help to ensure that CBAs are integrated into the strategy development process and not undertaken merely as an afterthought.

[8] Buncle, A., Daigneault, A., Holland, P., Fink, A., Hook, S., and Manley, M., 2013. Cost-Benefit Analysis for Natural Resource Management in the Pacific: A Guide, SPREP and SPC, Suva.

If you would like further information about this or other PACCSAP projects please contact the International Adaptation Strategies team at the **Australian Government Department of the Environment**, email: internationaladaptation@environment.gov.au.