Niue Case Study

Cost-Benefit Analysis training workshop - Nauru

November 1-4, 2011

Case study

- *Least-Cost Analysis of Water Supply Options in Niue* SOPAC Technical Report 447, http://dev.sopac.org.fj/VirLib/TR0447.pdf

Outline

PART A: Look at study

PART B: Excel exercises

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PART A: Look at study

1. Background
2. Scope and objective
3. Method: Least-cost analysis
4. Timing
5. With and Without Analysis
6. Data generation
7. Key assumptions
8. Results
9. Sensitivity Analysis
10. Study conclusions

Background

- Niue's water availability is characterised by groundwater, rainwater and no surface water. While rainwater tanks have sometimes been used in the past to supply water, Niueans have now come to rely almost exclusively on the groundwater lens. In order to access this groundwater, fossil fuel-based pumping is currently used; however, fuel is expensive.

- This reliance on costly fossil fuel has provided the impetus for the Government of Niue to begin exploring alternative options for water supply.

Scope and objective

- The ToR limits the study to an analysis of which supply option is least-cost.
  - Only looking at supply-side/production efficiency

- Supply options examined were:

i. Fossil fuel-based groundwater pumping (status quo).

ii. Solar energy-based groundwater pumping

iii. Rainwater tanks

Method: Least-cost analysis

- Least-cost analysis simply seeks to assess the cheapest way to achieve a stated goal.
  → Focus on efficiency of production

- Goal: to provide 57ML/year of water supply (16% of current supply)

- Presumes goal is a worthy use of resources.
  – Does not valuate water output (i.e. benefits of/demand for water)
  – Therefore does not allow for comparisons with other competing Government priorities/projects such as education.

Method: Least-cost analysis

- If a project is going to use least cost analysis, it must compare alternatives that provide the same benefit
- In this case, the amount of water being replaced should be the same across options
- The water quality should be the same

Method: Least-cost analysis

- Least-cost analysis often used for practical reasons – sometimes difficult and expensive(!) to valuate benefits of project.
  - In this case, there are data gaps on usage and no price information is available (water tariffs not charged).

Timing

- If one decommissions an existing pump prematurely, then one loses the remaining life of that pump. This can be modeled simply by assuming that there are no capital costs of the status quo.

- However, if the project is designed to replace pumps as they fail, then all options have a capital cost including the status quo option of pumping with current methods

With and Without analysis

Status quo- fossil fuel-based groundwater pumping	Solar energy-based groundwater pumping	Rainwater tanks
Costs		
1. Fuel costs of pumping 3. Repairs and maintenance 5. Carbon costs	1. Capital costs (solar panels) 2. Repairs and maintenance	1. Capital costs (rainwater tanks) 2. Repairs and maintenance

Data generation

- The dataset for the least-cost analysis was mostly derived from:
  - interviews with government and community stakeholders;
  - past SOPAC reports; and
  - Government of Niue documentation regarding water usage and supply.
- There are some important data gaps and issues
  - E.g. no technical/scientific information on water yield from rainwater tanks

Key assumptions

- The project goal is to provide 57 ML / year
- Analysis period is 10 years
- There are no capital costs of the status quo
- The useful life of solar panels is 10 years
- The useful life of rainwater tanks is 15 years
- Real (inflation adjusted) prices of fuel, electricity and other inputs remain constant over time
- Infrastructure repairs & maintenance cost are approximately the same for all technologies

Key assumptions cont.

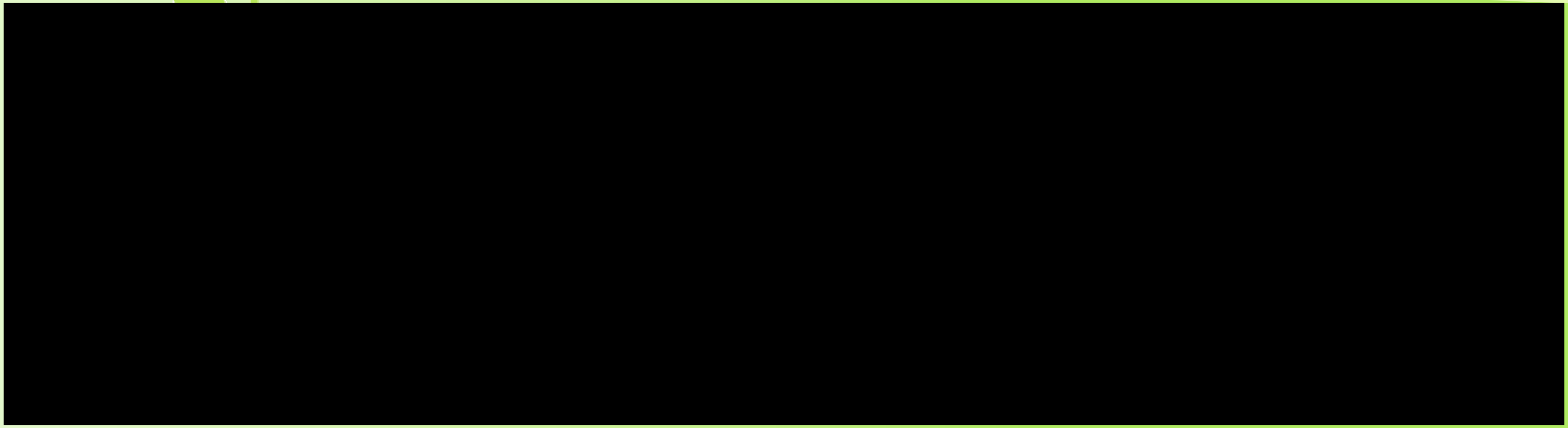
- Solar and rainwater technologies do not generate any carbon emissions
- The price of carbon is NZ$28.37 per tonne of CO2
- Water yield from each rainwater tank is 0.12ML/year
- Discount rate is 10% (real)

Results – Fossil-fuel (status quo)

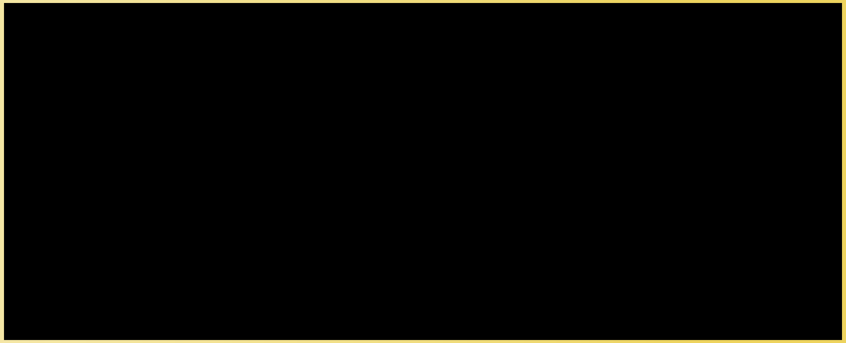
[redacted]

Results – Solar panels

Results - Rainwater tanks



Results - Economic cost of supplying 57 ML/year for 10 years (discounted), by technology



Sensitivity Analysis

1. Real (inflation adjusted) prices of fuel, electricity and other inputs remain constant over time
   - Fossil fuel price increase by 5% p.a.
     - → No change in ranking
     - → Total cost for groundwater over 10 years still cheaper than solar and rainwater tanks

2. The useful life of solar panels is 10 years
   - every five years, a 25 per cent reinvestment in solar panels must be made as a result of weather damage
     - → Solar becomes lowest ranking option

Sensitivity analysis

Does not test assumptions:

- **Analysis period is 10 years**
- **There are no capital costs of the status quo**
- The useful life of rainwater tanks is 15 years
- Infrastructure repairs & maintenance cost are approximately the same for all technologies
- The price of carbon is NZ$28.37 per tonne of CO2
- **Water yield from each rainwater tank is 0.12ML/year**

Study conclusions

- "Given the large infrastructure costs any new water supply system would incur, it was found in both the financial and economic analysis that it would be cheaper to maintain the status quo fossil fuel based system, as the infrastructure to support this is already in place."

Study conclusions

"..there remains considerable work [to assess whether the rainwater harvesting option is] both technically and socially feasible.

At a technical level, a detailed analysis of the rainfall to be captured, type and amount of usage, and the storage required for rainwater harvesting would still need to be conducted."

Questions or comments?

PART B: Excel Exercises

1. Replicate results
2. Lengthening the time frame and including capital costs for status quo
3. Perform sensitivity analysis
4. Insights and next steps

Replicate analysis

- Excel document includes a worksheet for each option
- Replicate results on slides 15, 16, 17 using information in parameter tables
  - Individually, or in pairs if not enough computers
  - Do one at a time
  - 15 min each

Lengthening the time frame and including capital costs for stat quo

- Recall assumptions:
  - Analysis period is 10 years - even though useful life for rainwater tanks is 15 years
  - There are no capital costs of the status quo - even though we expect to replace 20% of pumps every 2 years
- As discussed, these assumptions bias the analysis.

→ Lets adjust them

Lengthening the time frame and including capital costs for stat quo

- How then do we compare projects with different useful lives?

→Best way is to make it a long time frame where all project infrastructure must be replaced over time.

One can then compare alternatives that have short and long lifetimes.

Tip: ‘roll-over’ fossil fuel and solar projects 3 times (3 * 10 = 30) and ‘roll-over’ rainwater tanks 2 times (2 * 15 = 30).

Lengthening the time frame and including capital costs for stat quo

- For the purpose of this exercise, assume:
  - Analysis period is 30 years
  - Useful life of fossil fuel pumps are 10 years
  - Capital cost of fossil fuel pump with 57ML/year capacity is NZ$870,000
  - First replacement is required in year 2
  - 4% real discount rate (10% is closer to a nominal rate – that is, including inflation)

- Calculate PV of costs for all 3 options.

Sensitivity Analysis

- We are going to perform 4 sensitivity tests, 1 at a time.
- For each test, report PV costs of each option and rank options.
- <u>For this exercise</u>, change parameter values back to what they were originally after each test.

Sensitivity Analysis

1. Assumption: Real (inflation adjusted) prices of fuel, electricity and other inputs remain constant over time

→ Sensitivity test: fossil fuel price increases by 5% p.a.

2. Assumption: The useful life of solar panels is 10 years

→ Sensitivity test: Useful life is 5 years

Sensitivity Analysis

3. Assumption: The price of carbon is NZ$28.37 per tonne of CO_2
   → Sensitivity test: carbon price increases by 5% p.a.

4. Assumption: Water yield from each rainwater tank is 0.12ML/year
   → Sensitivity test: Water yield is ±25% (i.e. 0.9ML/year/tank, 0.15ML/year/tank)

Tip: need to also vary the number of tanks installed. This is required because analysis is least-cost and goal needs to be same for each project (i.e. yield is 57ML/year). So for lower water yield 0.9 the number of tanks is 633 (57ML/0.9) and for high water yield 0.15 the number of tanks is 380 (57/0.15).

Alternatively use cost-effectiveness ratio

Insights and next steps

- Results sensitive to some assumptions
  - Ranking of options change

  → Findings not robust

- Need to collect better data on some elements of analysis. Particularly:
  1. rainfall
  2. yields from rainwater tanks (as a function of rainfall, catchment area, and storage capacity)
  3. capital costs of status quo

Questions or comments?

PART C: Approach to developing workplans

1. Approach to developing CBA workplans for PACC demonstration projects
2. Incorporating climate change
3. Additional comments

Approach to developing CBA workplans for PACC demonstration projects

a. Define problem, set objective
b. Specify options, identify costs and benefits/yields
c. Generate data, valuate costs
d. Compute present values
e. Sensitivity Analysis

a. Define problem, set objective

<u>Problem</u>

- inadequate annual supply of potable water
  - Existing technology (fossil fuel-based groundwater pumping) is expensive
  - Reliance on one source

<u>Objective</u>

- Goal is x ML/year

b. Specify options, identify costs

b. Specify options, identify costs

- Assess costs only
- Benefits (xML/year) are only a small % of total Niue water supply, and difficult to valuate
- Presume goal is worthwhile
- Estimate demand function when design system for entire country

c. Valuate costs – status quo

Cost	Data	Source
1. Capital costs of pump (capacity commensurate with goal)	•Purchase price of pump (less any taxes/subsidies) •Installation cost •Expected useful life	•PWD •WWD Annual Report
2. Fuel costs of pumping (cost/ML)	•Quantity of fuel used to pump 1ML of water •Price of fuel (less any taxes)	•SOPAC Technical Report 447 •WWD Annual Report
3. Repairs and maintenance (cost/ML)	•Total R&M cost •Total quantity of water supplied → pro-rata share	•SOPAC Technical Report 447 •WWD Annual Report
4. Other operating costs (cost/ML)	•Total other operating costs •Total quantity of water supplied → pro-rata share	•SOPAC Technical Report 447 •WWD Annual Report
5. Carbon costs	•CO_2 emissions per litre of fuel •Price of CO_2	•SOPAC Technical Report 447
Yield	•Groundwater reserves •Rainfall •Annual re-charge	•Department of Meteorology •Pacific Climate Change Science Program (PCCSP), www.pacificclimatechangescience.org •PWD, Department of Water → Need to check groundwater extraction is within sustainable yields

c. Valuate costs – solar panels

Cost	Data	Source
1. Capital costs of solar panel (capacity commensurate with goal)	•Purchase price of solar panel (less any taxes/subsidies) •Installation cost •Expected useful life	•SOPAC Technical Report 447, p.29 → Need to verify useful life.
2. Repairs and maintenance (cost/ML)	•Annual maintenance cost for system.	•Secondary sources (e.g. reports on solar power tariffs for PIGAREP) → Need to check validity of assumption as per SOPAC Technical Report 447
3. Other operating costs (cost/ML)	?	?
Yield	•Groundwater reserves •Rainfall •Re-charge	•Department of Meteorology •Pacific Climate Change Science Program (PCCSP), www.pacificclimatechangescience.org → Need to check groundwater extraction is within sustainable yields

c. Valuate costs – rainwater tanks

Cost	Data	Source
1. Capital cost of a rainwater tank	•Purchase price of rainwater tank (less any taxes/subsidies) •Installation cost •Expected useful life	SOPAC Technical Report 447, p.29 → Need to verify useful life
2. Repairs and maintenance cost	•Annual maintenance cost for system.	•Secondary sources (e.g. . IWRM projects, EU B-envelope projects, AusAid projects) → Need to check validity of assumption as per SOPAC Technical Report 447
3. Other operating costs	?	?
Yield	• rainfall •Catchment area •Storage capacity	•Department of Meteorology •Pacific Climate Change Science Program (PCCSP), www.pacificclimatechangescience.org •WWD •Results from pilot undertaken by WWD, p.30 SOPAC Technical Report 447 •Technical reports from other water projects in region (e.g. IWRM projects, EU B -envelope projects, AusAid projects) •→ Engage GIZ to do a technical assessment if req

d. Compute present value (of costs)

- Use long time frame, allowing for replacement of capital infrastructure for each option
- Use 4% real discount rate

e. Sensitivity Analysis

- Useful life of solar panels
  - 5 years
- Maintenance of rainwater tank
  - If not maintained properly, yield is reduced by x% in second half of useful life
- Risk of groundwater contamination
  - Get expert opinion of likelihood and extent of contamination from poor sanitation and/or saltwater inundation (if relevant)

e. Sensitivity Analysis

- Fuel prices
  - Real prices increase by 5% per annum
- Price of carbon
  - Price of carbon is?% higher
- Tropical cyclone impacts (other than damages to solar panels)
  - Refer PCCSP country report for starting point

e. Sensitivity Analysis

- Maintenance of rainwater tank
  - If not maintained properly, yield is reduced by x% in second half of useful life
- Fuel prices
  - Real prices increase by 5% per annum
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  - Price of carbon is?% higher
- Tropical cyclone impacts (other than damages to solar panels)
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Incorporating climate change

- Climate change risks in this example mostly pertain to rainfall
- Projections about changes in rainfall patterns resulting from climate change are highly uncertain (probability distribution is not known). Moreover, rate of change is slow (i.e. not large changes over next 15 years).
- For these reasons, and because project proposals have short expected lifespans (<15 years), suggest climate change is factored into the CBA using sensitivity analysis (rather than probablistic analysis).
  - E.g. lower and upper bound rainfall, which flows through to low and high estimates for water yields from rainwater tanks
- Refer to PCCSP country reports for guidance on lower and upper bound rainfall scenarios over useful life of project options
  - pacificclimatechangescience.org or contact Philip Wiles at SPREP for help, philipw@sprep.org.

Additional comments

- The effects of climate change on rainfall is highly uncertain. This uncertainty increases the further into the future we look.
- It therefore makes sense to invest in projects that meet more immediate needs that are less uncertain
  - ‘no regrets’
- Where projects have relatively short life spans (~20 years), this allows Niue to wait and react to the climate change that actually happens
  - avoid ‘maladaption’

Questions or comments?