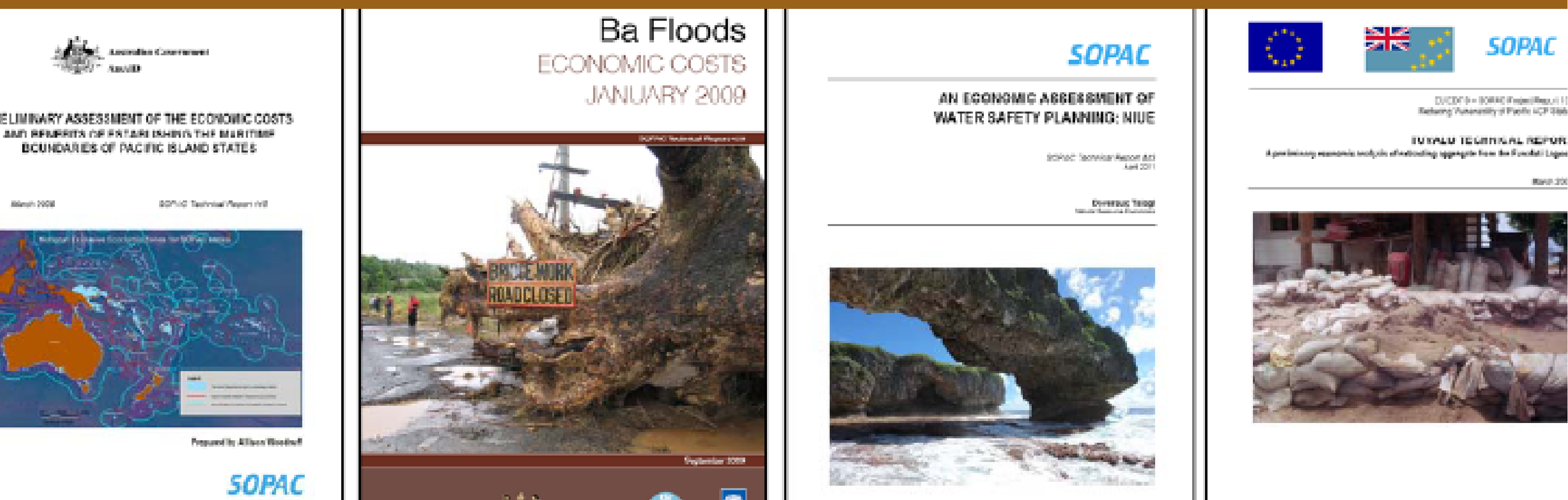
Applied Geoscience and Technology Division (SOPAC)

# Simple Introduction to Cost-Benefit Analysis

(Prepared for SPREP PACC Cost-Benefit Analysis Workshop: Food Security Pilot Demonstration Projects, Suva, 24-27 January 2012)

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## SOPAC TECHNICAL NOTE (PR84)

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**Annex**

# 1 INTRODUCTION

Cost-benefit analysis is a framework to assess the merits of an activity (project, policy) from the perspective of society (as opposed to a single individual). It involves:

- measuring the gains and losses (benefits and costs) from an activity to the community using money as the measuring rod; and
- aggregating those values of gains and losses and expressing them as net community gains or losses (see Pearce 1983).

## 1.1 What is cost-benefit analysis used for?

Cost-benefit analysis is used to help people make decisions. Depending on when the analysis is undertaken (before, during or after an activity), cost-benefit analysis can provide information to help assess:

- whether a project or activity will be or is worthwhile:
  - Should we invest in this project?
  - Which of these two projects should we support?
    - Which project will give us the best pay off per dollar invested?
    - Which project will generate the highest value to society once we have paid for it?
- whether a project or activity has been worthwhile.

In the process of conducting a cost-benefit analysis, the information generated may also inform:

- what it would take to make the potential benefits of an activity actually materialise (what the pre-conditions for success in the activity are); and
- the progress of an activity and how it should proceed/be revised, based on the benefits and costs identified.

## 1.2 Broad steps

Cost-benefit analysis involves comparing the values (costs and benefits) of an activity by assessing the benefits and costs faced by a community *with the activity* compared to *without the activity*. This allows decisions makers to see what difference the activity would make to well being. There are several basic steps involved in conducting a cost-benefit analysis (Figure 1).

In some cases, step 1 of cost-benefit analysis (defining options) may require little effort. This would be where activities (options) are pre-determined, such as where a community or government has already decided that an activity is important or where it appears to be the only option available. However, all other steps are critical to the analysis. Steps 2 and 3 generally require the most time, effort and expertise.

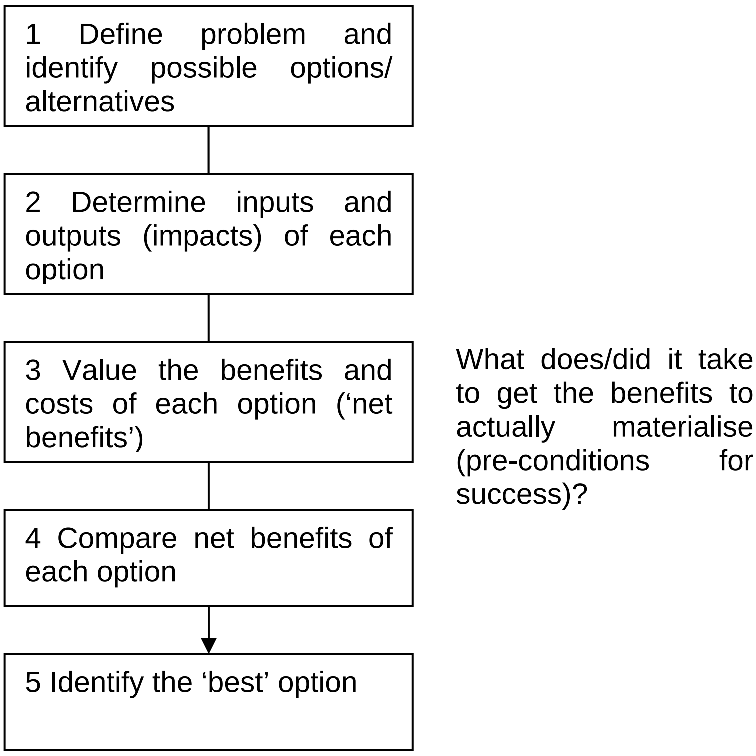



*Figure 1: Basic steps in a cost-benefit analysis.*

### 1.3 Why not use more conventional decision methods?

People can make decisions in several ways. In the Pacific, common ways to make decisions are:

- voting systems; and
- consensus.

Voting (democracy) draws on individuals' perceptions about the pros and cons of an activity. The activity with the highest votes 'wins' the right to proceed. Consensus based decision making focuses on different stakeholders reaching agreement on which activity to pursue (Lal and Holland 2010).

Compared to cost-benefit analysis, both voting and consensus based decision making systems have limitations:

- Votes may bear little relation to the effect of the activity on human wellbeing (as measured by benefits and costs). Such a system is subject to political and emotive arguments.
- Consensus based decision making can be a time consuming and costly way to make decisions when many people are involved in the process. There can be immense time and energy demands before people get to agree, especially where there are widely divergent opinions and/or numerous groups are involved. In other words, consensus decision making can have high 'transaction' costs (Lal and Holland 2010).

Consider an intensive farming project that makes producers better off but which is expected to lead to run off and downstream pollution. As a result, those using the river for drinking water and washing might find the water no longer useable and might have to go further to find water or have to buy it. Using a voting system, votes on whether to back the project might appear like that in Table 1.

*Table 1: Vote based decisions versus economic cost-benefit analysis.*

| Stakeholder | Benefits ($) | Costs ($) | Net benefit ($) | Vote |
|---|---|---|---|---|
| Farmers | 15 | 10 | 5 | 1 |
| Wholesalers | 20 | 10 | 10 | 1 |
| Retailers | 15 | 10 | 5 | 1 |
| Water consumers | 20 | 40 | -20 | -1 |
| Environmental group | 10 | 20 | -10 | -1 |
| Total social impacts | 80 | 90 | -10 | -1 |

Source: Lal and Holland 2010

Assuming these impacts, three groups might be expected to vote in favour of the project while two would reject it. Using a vote based or democratic system, the project would be supported regardless of its overall negative impacts. Under a consensus system, deciding whether or not to support the project would be expected to lead to considerable debate and would likely consume a large amount of time and – possibly – resources.

By comparison, a cost-benefit analysis would explicitly include consideration of the likely benefits and costs the project would involve. If the benefits and costs of the project to the different stakeholders were considered and summed, it could be seen that – overall – the total benefits of the project would likely be outweighed by its costs. That is, the community would be less well off if the project went ahead.

Consider now if the project still caused run off and downstream pollution but the food production benefits were considerably higher. In this case, impacts and resulting decisions might look like that provided in Table 2.

In this case, consideration of the likely benefits and costs would suggest that – overall – the total benefits of the project outweigh its costs. That is, the community as a whole might be better off if the project went ahead. On the other hand, the analysis would still highlight that the project would be expected to have negative impacts on water quality and the environment. If the project went ahead, expectation of these negative impacts might result in resistance to the project from community groups and obstruct project success. Identifying the distribution of benefits and costs should then form part of the dialogue for how best to design the project to minimise impacts and decide whether the project is indeed appropriate.

*Table 2: Vote based decisions versus economic cost-benefit analysis.*

| Stakeholder | Benefits ($) | Costs ($) | Net benefit ($) | Vote |
|---|---|---|---|---|
| Farmers | 25 | 10 | 15 | 1 |
| Wholesalers | 25 | 10 | 15 | 1 |
| Retailers | 20 | 10 | 10 | 1 |
| Water consumers | 20 | 40 | -20 | -1 |
| Environmental group | 10 | 20 | -10 | -1 |
| Total social impacts | 100 | 90 | 10 | 1 |

The advantage of using a cost-benefit framework is therefore that decision makers are forced to consider the *overall impact* of projects from the perspective of the group. It also allows for decision makers to view the *distribution* of benefits and costs across the community. Using this information, more informed decisions can be made.

Importantly, cost-benefit analysis is not the only way to make a decision. The findings of an analysis can then be used to *inform* voting and consensus processes so that people make more balanced decisions.

### 1.4 Financial feasibility versus economic feasibility

Note that the examples provided describe the *benefits* and *costs* of activities, as distinct from their *revenues* and *costs*. Cost-benefit analysis describes the merits of an activity from *society's* perspective – so it considers all impacts. By comparison, a financial feasibility assessment would consider only the financial impacts of an activity and would not include impacts that do not involve money, such as environmental impacts, the distribution of wealth impacts across the community or effects on social cohesion.

For example, Section 2.1 describes a cost-benefit analysis in Kiribati where it is found that dredging a lagoon for sand is commercially feasible. By comparison, the cost-benefit analysis also conducted indicates that the project would financially disadvantage certain groups in the local community. That is, even though the project would make a small profit, the benefits and costs experienced by different groups would be unevenly distributed across the community. This could ultimately lead to the failure of the project. As a result, the project would need to be redesigned to minimise these risks.

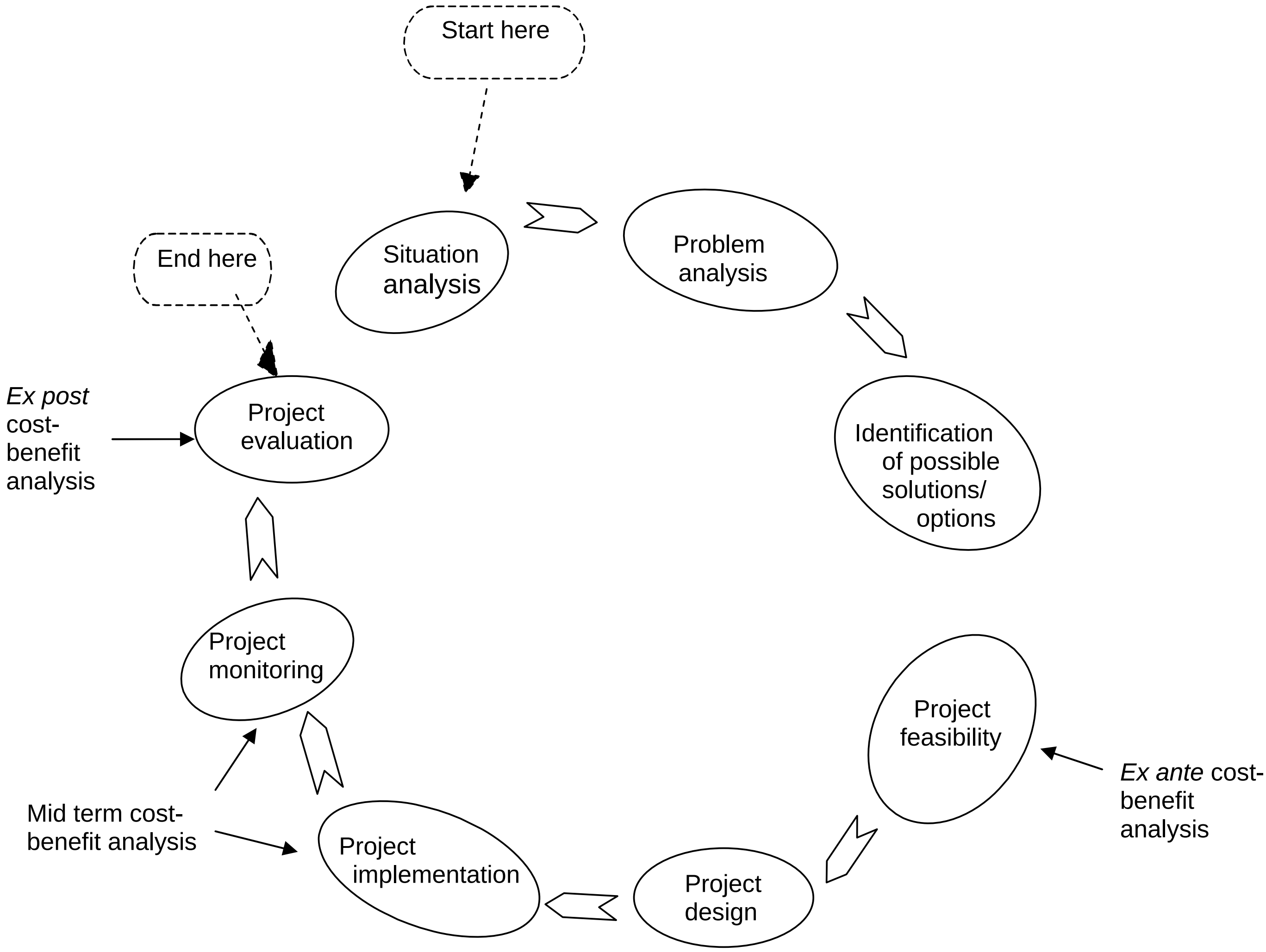
A major activity that would affect both incomes as well as changes in how resources are used might thus require both a financial feasibility assessment as well as a cost-benefit analysis.

## 2 COST-BENEFIT ANALYSIS AND THE PROJECT CYCLE

Cost-benefit analysis can be undertaken at any stage in the life of a project. They may occur:

- Before an activity (*ex ante*) — to decide whether or not to undertake an activity and or to identify key topics (variables) to monitor to check that the activity is on track;
- During an activity — to inform the progress of an activity and enable its refinement as needed to maximise benefits;
- Following an activity (*ex post*) — to assess whether or by how much an activity improved the quality of life (Figure 2).

Critically, *ex ante* and in-project assessments can help inform what is needed to ensure that the potential benefits of an activity actually materialise (to identify the pre-conditions for project success).



Source: Lal and Holland (2010).

*Figure 2: Cost-benefit analysis in the project cycle.*

In the Pacific, the use of cost-benefit analysis to support the design and assessment of projects is still relatively new. Ten years ago, examples of cost-benefit analysis were hard to find. A good example of a project that did draw on the lessons of cost-benefit analysis to inform which activities to fund is the SPREP-executed South Pacific Biodiversity Conservation Project (SPBCP). Otherwise, however, cost-benefit analyses were generally limited in application (or at least, limited in documentation and accessibility).

By comparison, there has been a relative explosion in the number of cost-benefit analysis used in recent years (see Annex for some examples).

### 2.1 *Ex ante* cost-benefit analysis

The following case study summary is taken from Greer (2007). In Kiribati, a combination of growing populations, inward migration from rural areas/islands and development investment has resulted in the rapid growth of its capital, located on the small atoll of Tarawa. Growth has been typified by an increase in small scale domestic developments (such as houses) as well as sporadic large scale investments (such as public facilities such as hospitals, schools and/or government buildings). The construction to underpin these developments demands access to 'aggregates' – sand, gravel, rip rap or rocks used for construction.

Conventionally demand for aggregates for construction around Tarawa has been met by digging up aggregate from the beaches and coastal flats. Although this mining is a cheap and effective way to supply aggregates on Tarawa, the supply is often insufficient to meet local demand. Moreover, the removal of too much aggregate on Pacific atolls has been demonstrated to increase coastal erosion (see Webb 2005a, 2005b, 2006). On Tarawa, increased flooding of key amenities such as the hospital, and saltwater intrusion into groundwater has thus been linked to the coastal mining. Flooding is becoming an increasing concern in the face of rising sea levels from climate change. At a time when Tarawa residents most need aggregates to build seawalls to protect them from the sea, removing aggregates from their coastlines to build those walls ironically puts them at greater risk of flooding.

An alternative to coastal mining is to import aggregate from overseas (with Fiji being a common source for the Pacific); however, importation of aggregate is usually extremely expensive, out of the reach of most commercial or domestic users and therefore only practical for donor led developments. Further, importation risks the introduction of plant, insect or other pests. Previous imports to Pacific atoll countries had seen the discovery of a (dead) frog in cargo to Kiribati (see Greer 2007) and the introduction of some 19 invasive weed species to Tuvalu (see Ambroz 2009).

Given the risks to the environment of importing aggregate and the threats to wellbeing from coastal mining, the Government of Kiribati sought to replace aggregates sourced from the beaches with aggregates located on the sea bed of Tarawa Lagoon. Work conducted under a previous development project had confirmed the existence of large reserves of aggregate there and assessed their suitability for low scale construction or infilling (Smith and Biribo 1995). Theoretically, these aggregates could be extracted from the lagoon bed by using a suction dredge (effectively sucking aggregates from the sea bed using a pipe) or clamshell dredge (scraping them up from the sea floor) attached to a barge. The aggregates could then be transferred to shore for sorting and use. If dredging aggregates could continually replace coastal mining, coastal protection could be increased and livelihoods improved. The Government of Kiribati, however, was keen that any activity to access aggregates in an ongoing manner would be financial and socially sustainable. An economic analysis of dredging was therefore conducted to assess this.

Based on a provisional design for a suction dredge in Tarawa Lagoon, preliminary analysis indicated that lagoon dredging could be commercially feasible in a 'quiet' year when no major developments were underway and only demand as usual applied. In these cases, a small profit (around A$60 000) might be expected. In years when large scale developments were also underway, it was estimated that profitability might be expected to improve. From an economic perspective, lagoon dredging was estimated to generate potential economic returns of 16 per cent. This high rate of return does not include the positive benefits of protecting infrastructure and property, public utilities (water and sewerage, electricity and phone lines), agriculture and public health. These benefits were not quantified because of lack of data on the impact of coastal mining (as distinct from natural processes) on coastal process. Nevertheless, they could be significant. The economic return from diverting aggregate mining from the coasts to the lagoon is therefore likely to be higher than 16 per cent in real terms.

Although the financial and economic benefits of lagoon dredging looked promising, there were a number of issues that threaten its sustainability. Critically, a recent household survey had indicated that around 1200 local families conducted coastal mining and at least 150 relied on the sale of those aggregates as their primary source of income (Pelesikoti 2007). Commercial dredging would compete for business against these households as well as against commercial miners to sell its sand and gravel. The risk is that – especially where families rely on the sale of coastal aggregates for income – businesses and households could undercut the sale price of lagoon sourced aggregates. The results would be continuing coastal mining, continued coastal erosion and the waste of resources involved in establishing a dredge operation that would not survive.

In light of these drivers, economic analysis indicates a number of policy implications to prevent coastal erosion that include the following:

- A total ban on coastal mining would be impractical. If current restrictions are not observed, it is unlikely that the government could enforce a wider ban. It would be more sensible to rework the current designated/non designated area scheme and police that more effectively, accompanied by an awareness campaign.
- A strategic communications campaign would be needed before embarking upon operations to ensure that the community understands the benefits of controlling costal mining and the benefits of using lagoon sourced aggregates instead.
- A sensitive and sensible scheme would be required to assist disenfranchised families to cope with the loss of income generation from coastal mining. The government will need to embark on community consultations to identify options.

Other critical issues affecting the feasibility were the need to consider dual pricing policies (to encourage purchases from the company rather than from local coastal miners) and the need for an appropriate environmental impact assessment and ongoing environmental monitoring.

The findings of the analysis were ultimately incorporated by the Government of Kiribati to a proposal to fund the establishment of commercial dredge operations to divert aggregates sourcing to Tarawa Lagoon. The proposal was successful and the EU provided €2.2 million to establish a dredge company over two years and ultimately transfer its operation to the Government. The project is presently involved in intensive consultations with the community on a plan for community involvement in the scheme and the dredge was being built at the time of writing.

## 2.2 Mid project cost-benefit analysis

The following case study summary is taken from Woodruff (2008). River floods, especially severe flash floods caused by heavy rainfall, are a frequent occurrence in Apia, Samoa, during the rainy season due to its geography and high rainfall. Apia, the capital, is built on the low-lying floodplains of five rivers: the Fagali'i to the east, and the Fulouasou, Gasegase, Mulivai and Vaisigano to the west (Taule'alo 2002). Severe floods have occurred in Apia in 1939, 1974, 1990, 2001 and 2006. The Government of Samoa recently worked with international agencies in the mid 2000s to develop management guidelines and a plan of action to reduce flood risks in the lower Vaisigano catchment area. The initial action plan included a number of structural options and non-structural management options that could potentially reduce flood risk:

- Structural flood management options:
    - Construction of floodwalls
    - Construction of a by-pass channel
    - Construction of a reservoir
    - Increasing channel conveyance
    - Pumping
    - River maintenance
- Non-structural flood management options:
    - Development control – raised floor heights
    - Improved flood forecasting system

The activities considered in the plan included investment in surveillance and forecasting. This was important given that Apia is a well established city and that people and businesses are unlikely to relocate, despite the ongoing risk of flooding. Consequently, upfront investment may be appropriate to enable forecasting so that people can plan for and mitigate disaster impacts.

The options contained in the plan were numerous. A preliminary cost-benefit analysis was conducted of a selection of measures to assist the Government of Samoa compare options and select which measures to target.

The results (Woodruff 2008) indicated that while investing in structural flood management options was unlikely to be economically viable due to high construction and maintenance costs, the economic pay-off from investing in non-structural measures including raised floor heights might be very high. For example, for every Tala invested in constructing homes with elevated floor heights, it was estimated that 2 to 44 Tala would be saved in terms of avoided flood damages. Similarly, the benefits from investing in an improved flood forecasting system were found to be positive, with every Tala invested in the improved system estimated to yield between 1.72 to 1.92 Tala in avoided future flood damages.

The findings of the study were intended to be used to implement the Samoa Flood Management Action Plan and, importantly, to lobby the government to invest in disaster mitigation measures such as more training in flood forecasting and building controls to raise floor levels. Some donors expressed interest at the time the report was released in supporting some of the interventions that were assessed as most economically feasible. For example, the European Union expressed early interest in using the information generated to determine whether to invest in further flood modelling work (Nadia Meredith, European Union Water Sector Support Programme, personal communication, 11 September, 2007). It is unclear at this point whether investment was finally secured.

### 2.3 *Ex post* cost-benefit analysis

The following case study summary is taken from Woodruff (2007). The coconut tree is a vital component of island ecosystems and economies, and traditionally copra has been an important source of rural income on many of Pacific islands. Although the technology has been around for many years, it has only been in the last ten years, that there has been renewed interest in using coconut oil as a biofuel in the Pacific (Cloin 2005). The development of coconut oil as a renewable energy in the region not only provides the opportunity to reduce reliance on imported fossil fuels but also to provide rural communities with a cost effective source of energy.

In order to promote rural electrification and sustainable livelihoods, and demonstrate the use of biofuel as a substitute for diesel, the Fiji Department of Energy, with support from the Secretariat of the Pacific Community and the French Government, installed specially adapted generators, designed to operate on pure coconut oil, in Welagi Village located on Taveuni Island in 2001, and in Sawana Village, located on the island of Vanua Balavu, in the Northern Lau Group, in 2000 (Courty 2000). Village committees are responsible for overseeing the operation and maintenance of the generators, as well as setting and collecting user fees in order to ensure that the projects were financially sustainable (Fiji Department of Energy 2001).

A preliminary economic assessment of the projects indicated that, in Vanua Balavu, given high transport costs, locally produced coconut oil enjoyed a clear price advantage compared with imported diesel fuel. The coconut oil mill on the island, which was intended to supply the project with biofuel had however ceased operations, and a local source of coconut oil was no longer available. For a brief period, coconut oil was shipped to the project site from another mill, but added transport costs meant that using coconut oil in the generator was more costly than diesel fuel (Khan 2005).

In Welagi, the price advantage of biofuel compared with diesel fuel turned out to be less clear-cut since diesel fuel transport costs from the main port of Suva were lower. Also, the Welagi generator was operating on diesel fuel since there was a limited local supply of coconut oil. Ideally, the community could have switched between fuels, depending on which fuel was least cost. Therefore, the results from the analysis indicated that, for coconut biofuel to provide the least-cost option for rural electrification, compared with diesel fuel, there needed to have been sufficient low-cost coconut oil resources available locally, and households located in a location remote enough that added diesel fuel shipping costs were sufficiently high to make locally produced coconut oil cost competitive.

## 3 SOME CHALLENGES WITH COST-BENEFIT ANALYSES

### 3.1 Data

Information is needed in a cost-benefit analysis to assess benefits and costs. In general, the financial costs of a proposed activity are relatively easy to determine. More difficult is the estimation of benefits or intangible costs. This is because the benefits of many activities – especially before a project takes place – are still only hypothetical so their true extent may not be clear.

Predicting the impacts of a project cannot be achieved unless the situation without project is understood. Take the recent assessment of water projects in Tuvalu, for example (Gerber et al 2011). In this assessment, three projects were executed to improve the quality of water on Funafuti. In so doing, the projects were expected to reduce the level of water borne disease arising from consuming presently contaminated water. Unfortunately, while the Department of Health was able to provide data on the incidence of illnesses that *might* be caused by poor water (such as diarrhoea or boils), officials were unable to establish what percentage of those cases were actually caused by poor water consumption compared to – say – poor sanitary practices (such as leaving food out of the fridge for too long, not washing hands after using the bathroom etc.) (See Gerber et al. 2011.) In the absence of basic information on how many people suffer from water borne disease, assessing the impact of a project to address it is difficult.

Even if such data exists and the physical impacts of projects can be determined, it can be difficult to assign a monetary value to the non financial impacts of some projects. Numerous techniques exist to do this (see Pearce 1983) and they are evolving continually. Nevertheless, challenges exist for each.

### 3.2 Inputs

Conducting a cost-benefit analysis will take time and expertise. Data may need to be bought. Travel may need to be conducted. All of these items cost. In particular, there are only a limited number of agencies in the Pacific that routinely conduct economic analysis of development projects that link with the natural environment. As a result, it may be difficult to find the necessary expertise to conduct the work. Alternatively, it may be expensive to do so if consultants are used. There is a need to build the expertise of national agencies to conduct economic analysis for the development of Pacific island countries.

### 3.3 Selling the outputs

Cost-benefit analysis is a compelling input to the decision making process. By highlighting the economic impacts of projects, decision makers have a valuable insight to the contribution that different activities can make to social wellbeing. Nevertheless, economic issues are not the only consideration in a decision. For example:

- projects must be socially acceptable. A project which offers substantial net benefits but which disadvantages key stakeholders in the process is likely to be culturally unacceptable and/or politically difficult to sell; and
- a project that offers a relatively poor pay off may nevertheless be important to support for non economic reasons such as to prevent social break down or to ensure continuity and trust.

The economic value of an activity thus needs to be considered in the context of other critical issues including, for example, the sustainability of project impacts, environmental impacts, cultural impacts and the distribution of wealth (equity). As indicated, economic considerations can feed into the decision making process (such as voting or consensus) but would be unlikely to be the sole determinant of whether an activity should be/should have been pursued.

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## ANNEX

## SELECTED EXAMPLES OF PACIFIC COST-BENEFIT ANALYSES

| Study | Topic | Country | Year |
|---|---|---|---|
| McKenzie 2004 | Investments in the black pearl industry | Tonga | 2004 |
| Pesce et al. 2004 | Investments in sustainable forestry (certification) | RMI | 2004 |
| Greer 2005 | Investment in a bridge for rural development | PNG | 2005 |
| Lal et al. 2005 | Costs of coral reef extraction | Fiji | 2005 |
| Lal et al. 2006 | Investments in liquid waste management | Tuvalu | 2006 |
| McKenzie et al. 2006 | Costs of erosion from coastal mining | Cook Islands | 2006 |
| Greer 2007 | Prevention of coastal erosion | Kiribati | 2007 |
| Woodruff 2007 | Investments in renewable energy | Niue | 2007 |
| Zieroth et al. 2007 | Biofuel from coconut resources | Samoa | 2007 |
| Holland 2008 | Benefits of flood warning | Fiji | 2008 |
| Woodruff 2008 | Benefits of flood intervention | Samoa | 2008 |
| Ambroz 2009 | Benefits of coastal protection | Tuvalu | 2009 |
| Ambroz 2010 | Least cost analysis of water supply options | Niue | 2010 |
| Gerber 2010 | Economic assessment of water safety planning | Palau | 2010 |
| Gerber 2011 | Economic assessment of IWRM | RMI | 2011 |
| Gerber et al. 2011 | Economic assessment of water improvements to adapt to climate change | Tuvalu | 2011 |
| Talagi 2011 | Economic assessment of water safety planning | Solomon Islands | 2011 |