Using cost–benefit analysis to inform climate change adaptation projects

Reservoir on Majuro, which is being relined as part of the Marshall Islands PACC project. Photograph: PACC.

KEY MESSAGES

- Cost–benefit analysis (CBA) helps inform decisions about projects, such as whether to proceed with a project or not, which project option to select, and what refinements can be made to improve project design. It contributes to more effective projects that are more likely to meet their development objectives.
- CBA can also help to assess and incorporate the risk and uncertainty of climate variability and climate change into project decision making.
- There is growing interest in the use of CBA in the Pacific region. The Pacific Adaptation to Climate Change (PACC) programme has been supporting this through capacity building and support to PACC country project teams.
- To be most effective, CBA should be included as a key component of the project cycle right from the beginning. It should involve multidisciplinary teams, and support from an experienced economist.

What is cost–benefit analysis?

Cost–benefit analysis (CBA) is a process for identifying, valuing and comparing costs and benefits of projects. It can help inform decisions about whether to proceed with a project or not, which project option to select, and what refinements can be made to improve project design.

CBA is also an effective way to help integrate climate risk considerations into project design, and to engage officials from areas such as planning and finance on climate change related issues.

Used carefully and appropriately, CBA contributes to more effective projects that are more likely to meet their development objectives.

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The CBA process in brief

The CBA process follows a logical sequence which can be represented in seven key steps (Figure 1).

The key features of a CBA are:

- All related costs (losses) and benefits (gains) of an action and/or decision are considered, including potential impacts on human lives, society and the environment;
- Costs and benefits are valued from a whole-of-society perspective, rather than just from one particular individual or interest group;
- Costs and benefits are expressed as far as possible in money terms as the basis for comparison;
- Costs and benefits that are not monetised are still listed and considered during decision making;
- Costs and benefits that are realised in different time periods in the future are aggregated to a single time dimension (discounting).

Costs and benefits are commonly compared in two ways. (1) The total value of the costs is subtracted from that of the benefits to give the net present value or NPV. If the NPV is positive it indicates that the benefits outweigh the costs, and the higher the NPV the greater the returns expected for that action or decision. (2) The benefit–cost ratio, or BCR, is reached by dividing the total value of the benefits by that of the costs. If the BCR is greater than 1 it indicates that the benefits outweigh the costs, and the greater the number the greater the returns expected.

A new resource, *Cost–benefit analysis for natural resource management in the Pacific: A guide*, has recently been produced by partners the Secretariat of the Pacific Regional Environment Programme (SPREP), the Secretariat of the Pacific Community (SPC), the German Society for International Cooperation (GIZ), the Pacific Islands Forum Secretariat (PIFS), LandCare Research NZ and the United Nations Development Programme (UNDP). The guide provides detailed step-by-step guidance on carrying out CBA, illustrated with examples from the Pacific region. The guide will be available for download at http://www.pacificclimatechange.net/index.php/eresources/documents?task=showCategory&catid=121

1. Determine the objective of the cost–benefit analysis
Clarify the questions the analysis seeks to answer. What decision does it seek to inform?

2. Identify the costs and benefits
Identify costs (losses) and benefits (gains) for each option under consideration, including a 'no-project' option

3. Value the costs and benefits
Express (as far as possible) the value of benefits and costs in monetary term, for each option

4. Aggregate the costs and benefits
Sum costs and benefits over time, for each option

5. Perform sensitivity analysis
Assess the importance of major uncertainties associated with the analysis and activity (for example, climate)

6. Consider distributional impacts
Consider who will incur the costs and benefits and what impact this might have for each option

7. Prepare recommendations
Summarise how to proceed from here. Which option should be chosen and why?

Figure 1. The steps in a typical cost–benefit analysis.

Incorporating climate risk and uncertainty in cost–benefit analysis

Climate change adaptation projects usually focus on climate-sensitive sectors. Many other projects that are not explicitly described as climate change adaptation projects also involve climate-sensitive sectors, for example natural resource management and agriculture projects.

Climate variability and climate change add risk to these projects. For example, at the beginning of an agriculture project it is not known whether there will be sufficient rainfall for the crops, or whether there will be extreme rainfall that will wipe out the crops. The risk, and the scale of uncertainty, will change depending on the timescale of the planned project.

CBA helps to assess and incorporate the risk associated with climate, as well as other identified risks faced by projects. The 'sensitivity analysis' step looks at how the costs and benefits might change if certain aspects of the situation change.

For climate, the probability of weather events can be estimated with the help of historical climate data and predictive climate models, and these figures included in a sensitivity analysis. The analysis often considers three options: most likely, worst case, and best case. Comparing costs and benefits under these different scenarios helps decision makers decide whether to proceed or not, that is, whether the risk is acceptable.

Cost–benefit analysis can help to incorporate the risk of drought into project planning. Photograph: Jacob Applebaum.

Cost–benefit analysis in the PACC programme

In the Pacific region, CBA is in its early stages in terms of systematic application in development processes. However, there is a growing interest in CBA and efforts are underway to build capacity so that this tool can be more widely used.

The Pacific Adaptation to Climate Change (PACC) programme has been promoting CBA as a useful tool that contributes to more effective climate change adaptation projects. During 2011 and 2012 the regional programme team carried out a series of CBA activities with the participating PACC countries. The purpose was to help improve selection and design of PACC demonstration projects, as well as to build capacity in the use of CBA. The key elements of the CBA programme were:

1. Training workshops and development of CBA workplans for PACC demonstration projects;
2. Ongoing technical support to help countries implement their CBA workplans (i.e. carry out a CBA of their demonstration project); and
3. A follow-up training and lessons learned workshop.

Because CBA was introduced into PACC two years into the programme, rather than at the beginning, some projects had already progressed too far to usefully apply a CBA to assist with project selection and design. However, seven of the PACC demonstration projects developed CBA workplans and carried out CBAs. Two of these, the CBAs for the water resources management project in the Republic of the Marshall Islands and for the food security project in Solomon Islands, are described in the case studies on the following pages. Lessons learned from the experience of applying CBA to the PACC demonstration projects are summarised on page 4.

Full details of the CBA training and application to the PACC demonstration projects can be found in PACC Technical Reports Nos 1 and 2 – The application of CBA in the PACC programme: Experiences and lessons learned on capacity building and The application of CBA in the PACC programme: Experiences and lessons learned in the application of CBA to PACC demonstration projects.

Lessons learned on the application of CBA to PACC demonstration projects

1. CBA must be introduced and planned for in the early stages of project development if it is to effectively inform decision making. This involves, among other things: educating stakeholders about the purpose of CBA and where it fits into the project cycle; budgeting for time and technical inputs needed to complete an appropriately detailed analysis; and scheduling activities and outputs to communicate the results/findings of the CBA to stakeholders and decision makers.
2. Substantial effort is required to formulate multidisciplinary teams to oversee and conduct the CBA. This should include technical officials such as economists, engineers, sectoral planners and meteorologists as appropriate. This is also important for ensuring that government officials understand the technical elements of the analysis; can communicate and discuss this analysis to stakeholders and decision makers (independent of consultant support); and this knowledge is 'owned' and effectively used.
3. Good knowledge/information management systems within country governments (and regional development partner organisations) make CBA far less resource- and time-intensive, and contribute significantly to more accurate (and hence more useful) CBAs.
4. Situational and problem analyses, such as vulnerability assessments, should be completed thoroughly and systematically prior to starting the quantitative aspects of CBA. This helps to clarify the nature and causes of the project problem, and that identified options to address it are appropriate.
5. CBA provides an important 'gate-keeping' function. The systematic CBA procedure serves to identify key data and knowledge gaps which are important for making sound, evidence-based decisions about project option selection and design.
6. Adequate technical backstopping arrangements are critical. Ideally, country officials should lead on the conduct of analysis and report writing as much as possible, with an experienced economist guiding the process and providing continuous and needs-based mentoring.
7. Communication needs should be a core and prominent part of CBA exercises. These include, but are not limited to: (i) preparing briefing papers on the CBA; (ii) delivering short presentations to decisions makers, including preparations to answer questions and defend the analysis; (iii) incorporating CBA information into Cabinet submissions; and (iv) incorporating CBA information into project proposal documents to be submitted to donors.

PACC CASE STUDY

CBA of the Marshall Islands PACC project

Photograph: Marshall Islands PACC project

The Marshall Islands PACC project addresses water security for the communities of Majuro, the main atoll. Water is provided from a mix of public and private (household rainwater tanks) systems. The main public source is the airport catchment. Water is collected from the paved runway and stored in reservoirs, treated using sand filtration and chlorination, and then pumped to the communities. However, in recent years there have been water shortages, particularly during drought periods. This could worsen with changes in rainfall patterns due to climate change.

The PACC project team identified five possible options for improving the public water supply:

1. Reline the storage reservoir to reduce losses;
2. Install an evaporation cover on the storage reservoir to reduce losses;
3. Repair and/or replace leaking distribution pipes;
4. Improve the airport runway catchment by: (a) improving valves in the runway; (b) repairing cracks in the runway;
5. Increase the size of the airport catchment from the planned runway expansion; for this option, two different construction material options were considered: (a) geomembrane and (b) asphalt.

The purpose of the CBA was to inform the decision on which option or options to pursue.

The costs considered were construction and maintenance costs, including capital, equipment, materials and labour. The benefit streams were considered as two main categories: the benefits from additional water supply, and the benefits due to lower incidences of water-related health problems such as gastroenteritis. In fact, it was not possible to quantify in monetary terms the second category benefits, but it was acknowledged that there would be additional health benefits.

Once the costs and benefits of the project options had been identified and quantified, the figures were used to determine the net present values (NPVs) and benefit–cost ratios (BCRs) for the different options. The results are shown below.

Summary of the results of the Marshall Islands PACC project CBA

	PROJECT OPTIONS				
	1. Reline reservoir	2. Evapora-tion cover	3. Repair and replace leaking pipes	4. Airport runway maintenance (a) Valves (b) Cracks	5. Expand airport catchment (a) Geomembrane (b) Asphalt
Value of costs (2012 US$) (1)	125,130	53,383	2,029,619	(a) 56,026 (b) 135,345	(a) 801,510 (b) 2,024,658
Value of benefits (2012 US$) (2)	10,829,855	1,019,567	18,805,024	(a) 205,111 (b) 490,446	(a) 3,471,456 (b) 3,471,456
NPV (2 – 1)	10,704,724	966,185	16,775,406	(a) 149,085 (b) 355,101	(a) 2,669,947 (b) 1,446,799
BCR (2/1)	86.55	19.10	9.27	(a) 3.66 (b) 3.62	(a) 4.33 (b) 1.71

The preliminary results of the CBA indicated that all options would generate net benefits for the communities, but options 1, 2 and 3 would generate the greatest net benefits.

The CBA team then carried out a sensitivity analysis to see how changing the key variables might affect the results. The variables included changing cost of water during drought and non-drought periods, changes to future rainfall, and changes to the expected life of the infrastructure under the different options. The results of the sensitivity analysis suggested that options 4 and 5 would be more attractive if the value of water changed; however, more research was needed to clarify this, and was beyond the scope of the CBA.

The fact that the PACC project budget limit was $800,000 also had to be taken into consideration.

The final recommendations from the CBA were that options 1, 2 and 3 represented the most worthwhile use of resources (with option 3 amended to repairing part of the pipeline rather than the entire pipeline). The PACC team took on board the advice and these options are now being implemented.

Lessons learned:

- One difficulty experienced for this CBA was that there was very little time available to carry out the analysis and to effectively communicate its findings and recommendations. This was because the project was under pressure to start implementation, and the CBA had not been properly planned for at the inception of the project. There were also limited financial resources available to support (longer term) technical assistance.
- Another difficulty was that the core team formed to carry out the CBA did not include any technical government officials, such as economists or water engineers. Among other things, this is important for ensuring that government officials understand the technical elements of the analysis, and can communicate and discuss this analysis to stakeholders and decision makers.

This is a very simplified version of the Marshall Islands PACC project CBA. For more information, and the full CBA report, please contact the Marshall Islands PACC project coordinator Mr Joseph Cain, jsphcain4@gmail.com

PACC CASE STUDY

CBA of the Solomon Islands PACC project

The PACC project in Solomon Islands focuses on food security in the low-lying outer atolls of Ontong Java. The project is particularly looking at the declining production of the staple crops giant swamp taro (*Cyrtosperma merkusii*) and 'taro tru' (*Colocasia esculenta*). One reason for the decline is saltwater incursion into garden plots from rising sea level and high tide events, which is degrading the soils and reducing yields.

Three broad project options were identified by the PACC project for tackling this issue:

1. Taking measures to reduce saltwater contamination in food production areas;
2. Introducing root crop varieties that have tolerance to salinity; and
3. Modifying the soil and food production environment.

Only option 3 was assessed in the CBA. This was due to resource constraints, and because option 3 was judged by the CBA consultant and three Pacific root crop experts to be the option with the highest probability of success in the timeframe of the PACC project. The purpose of the CBA was therefore to decide whether this option would be worthwhile and produce net benefits for Ontong Java communities.

Option 3 involves a combination of the following measures:

- Improved composting techniques;
- Agroforestry, including introducing nitrogen-fixing trees and legumes;
- Growing vegetables in raised beds and containers (including hydroponics) and improved home gardening techniques;
- The establishment of small nurseries to supply high quality vegetable seedlings and agroforestry planting materials; and
- The introduction of the 'soils school' extension methodology so people understand their soil and how best to manage it for sustainable food production.

Photograph: Solomon Islands PACC project

The costs considered in the CBA related to collection of baseline information, construction costs and operational activities, as well as a 15% contingency provision.

The benefit streams were considered as three separate categories. The first related to the additional taro production that would be generated. The quantity of additional taro produced was calculated as the quantity of taro produced with the project minus the quantity produced without the project. The second benefit category considered was health benefits from substituting taro for imported grain. In principle, these benefits can be quantified, e.g. through avoided health costs and avoided lost income, however due to limited time and resources this was beyond the scope of this study. The third benefit category considered was avoided costs associated with relocation to another area. While such benefits are expected to be substantial, these were also beyond the scope of the CBA.

Once costs and benefits of option 3 were quantified, the data were used to calculate the net benefit of the project in terms of net present value (NPV) and benefit–cost ratio (BCR). The results are presented below.

Summary of the results of the Solomon Islands PACC project CBA (option 3)

Value of costs (2012 Solomon Island dollars, SBD) (1)	2,637,792
Value of benefits (2012 SBD) (2)	
Increased taro production	6,359,840
Improved health	Not valued
Reduced out-migration	Not valued
Total	**6,359,840**
NPV (2 – 1)	3,722,049
BCR (2/1)	2.4

A sensitivity analysis was also carried out. The sensitivity tests involved changing the magnitude of key variables and measuring impact on the NPV and BCR. Key variables tested were the rate of taro decline for the without-PACC intervention scenario, and the effectiveness of the adaptation measures in increasing taro production. Three alternative


Photograph: Solomon Islands PACC project

scenarios were modelled to test the effectiveness of the adaptation measures in increasing taro production, in part to reflect uncertainties related to future extreme tide hazards under climate change. The results of the sensitivity analysis indicated that the project would generate net benefits even under these changed conditions.

The results of the CBA indicated that the proposed package of measures to improve the soil and food production environment on Ontong Java would generate net benefits for the Ontong Java community. It was therefore recommended that these measures be progressed as part of the Solomon Islands PACC project, and these are now under way.

Lessons learned:

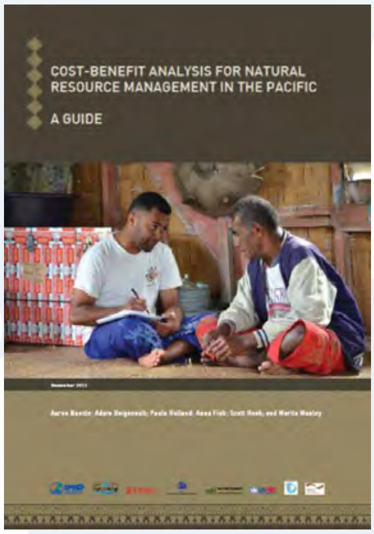
- A success factor of the Solomon Islands PACC CBA was the agricultural knowledge and the extensive Pacific experience of the economic consultant engaged to help conduct the CBA. Among other things, this helped to fill gaps in the Solomon Islands PACC (CBA) team relating to technical inputs.
- Another success factor was the completion of a good-quality vulnerability and adaptation assessment prior to the start of the CBA. Information in this assessment provided very useful inputs to the CBA and helped to complete the CBA in a timely and efficient manner.
- A difficulty experienced for the Solomon Islands PACC CBA was that technical officials from the Solomon Islands Government (agronomists, meteorologists, etc.) did not actively participate in the planning or carrying out of the analysis. This resulted in low understanding of the quantitative elements of the CBA which in turn may lead to some of the recommendations relating to implementation (e.g. collection of baseline data) not being followed.

This is a very simplified version of the Solomon Islands PACC project CBA. For more information, and the full CBA report, please contact the Solomon Islands PACC project coordinator Mr Casper Supa, ckasie@gmail.com

Conclusion

Cost–benefit analysis has the potential to be more widely used in the Pacific region, and to improve the effectiveness of climate change adaptation and other projects. Further capacity building is needed across the region, supported by commitment from Pacific island governments to build this useful tool into project requirements.

A new publication, *Cost–benefit analysis for natural resource management in the Pacific: A guide*, provides detailed step-by-step guidance on carrying out CBA, illustrated with examples from the Pacific region. The guide will soon be available for download at http://www.pacificclimatechange.net/index.php/eresources/documents?task=showCategory&catid=121.



Resources/further reading

Cost–benefit analysis for natural resource management in the Pacific: A guide [will be available for download at www.pacificclimatechange.net/index.php/eresources/documents?task=showCategory&catid=121]

PACC Technical Report No. 1 – The application of CBA in the PACC programme: Experiences and lessons learned on capacity building [download at https://www.sprep.org/attachments/Publications/CC/PACCTechRep1.pdf]

PACC Technical Report No. 2 – The application of CBA in the PACC programme: Experiences and lessons learned in the application of CBA to PACC demonstration projects [download at https://www.sprep.org/attachments/Publications/CC/PACCTechRep2.pdf]

The 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 building 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.

Building and sharing knowledge under the PACC programme

The PACC Experiences series covers topics where PACC is building experience and knowledge. Aimed at national and regional decision makers, climate change practitioners, and concerned communities and individuals, each one explains a key issue relevant to climate change adaptation in the Pacific, and draws on experiences within the PACC projects to describe the practical realities, lessons learned, and implications for both policy and practice. PACC Experiences includes webspace at www.sprep.org/pacc/experiences where additional experiences, case studies and lessons learned are available on the different topics.

The PACC Experiences series is complemented by the PACC Technical Report series. This series is a collection of the technical knowledge generated by the various PACC activities at both national and regional level, and is aimed at climate change adaptation practitioners in the Pacific region and beyond.

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