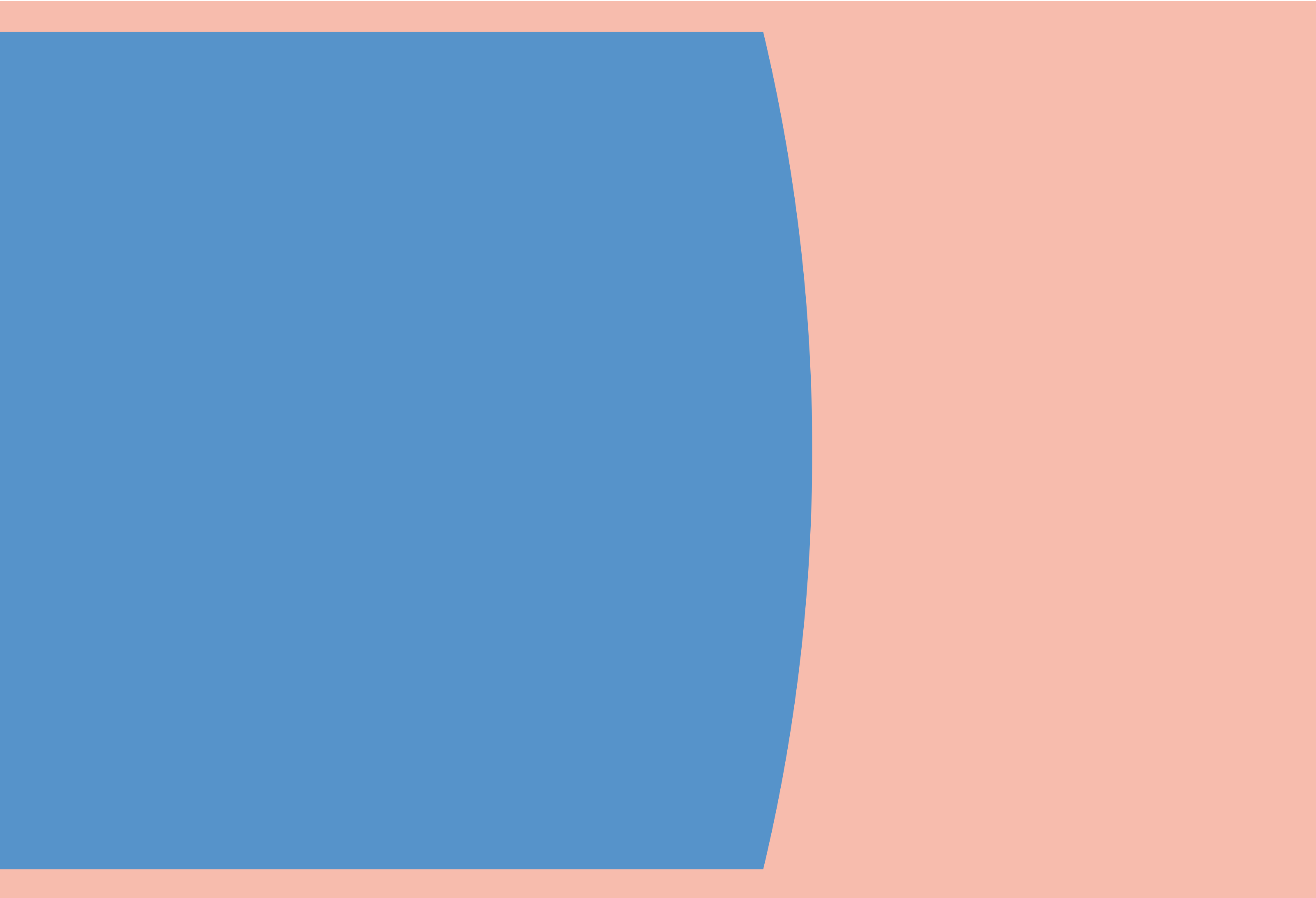
THE NAIROBI WORK PROGRAMME

ON IMPACTS, VULNERABILITY AND ADAPTATION TO CLIMATE CHANGE

# ASSESSING THE COSTS AND BENEFITS OF ADAPTATION OPTIONS

## AN OVERVIEW OF APPROACHES

**United Nations**
Framework Convention on
Climate Change



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# ACKNOWLEDGEMENTS

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# I. INTRODUCTION

As shown in the Fourth Assessment Report (AR4) of the Intergovernmental Panel on Climate Change (IPCC), the global climate is changing at rates unprecedented in recent human history and will continue to change. The associated climate change impacts and risks are global in their nature, geographically diverse and are increasingly being felt and recorded across a range of regions, communities and ecosystems.

Current and projected climate change will exhibit impacts on numerous systems and sectors that are essential for human livelihoods. An increasing number of countries, regions and communities are embarking on adaptation activities. This strengthened demand for adaptation efforts necessitates access to a range of robust and transparent assessment approaches to enable decision makers to efficiently allocate scarce resources. For adaptation to be successful, it should ideally be undertaken within a comprehensive and iterative process of social, institutional and organizational learning and change. Assessing the costs and benefits of adaptation options is an important part of this process, assisting adaptation planners and practitioners to identify the most appropriate interventions for reducing vulnerability, enhancing adaptive capacity and building resilience.

This publication has been developed under the Nairobi work programme on impacts, vulnerability and adaptation to climate change (see BOX I-1 below), and provides an introduction to a range of different assessment approaches and methodologies and shares best practices and lessons learned. It builds upon activities and contributions from the Nairobi work programme and its partners.

This publication aims to:

- Elaborate on the role and purpose of assessing the costs and benefits of adaptation options in the adaptation process;
- Introduce a range of key methodological issues;
- Explain the most commonly used assessment approaches;
- Describe lessons learned and good practices;
- Provide a glossary of the most commonly used terms;
- Provide a bibliography of useful resources and references.

The publication does not, however, claim to be a comprehensive assessment of all possible approaches, recommend one specific assessment technique above another – even though it does illustrate the variety of approaches, including their strengths and shortcomings; nor does it provide answers as to how much adaptation measures might cost – but it does provide support to help choose between numerous possible options.

A diverse range of case studies is presented throughout this publication to illustrate adaptation assessment methods and options (see FIGURE I-1).

**Box I-1.** **The Nairobi work programme on impacts, vulnerability and adaptation to climate change**

The Nairobi work programme on impacts, vulnerability and adaptation to climate change was launched by Parties to the United Nations Framework Convention on Climate Change (UNFCCC) in 2005. Its objective is to assist all Parties, in particular developing countries, including the least developed countries (LDCs) and small island developing States (SIDS) to:

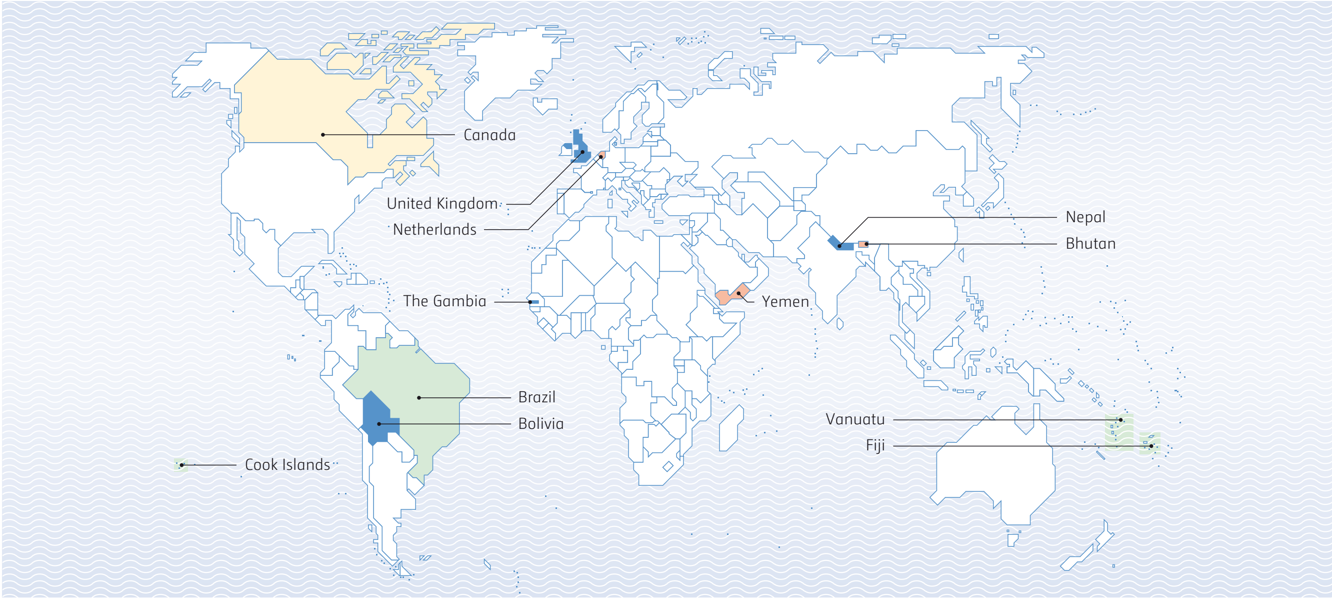
- Improve their understanding and assessment of impacts, vulnerability and adaptation; and
- Make informed decisions on practical adaptation actions and measures to respond to climate change on a sound scientific, technical and socioeconomic basis, taking into account current and future climate change and variability.

Besides Parties to the UNFCCC, many intergovernmental, governmental, and non-governmental organizations, the private sector and individual experts contribute to the Nairobi work programme, including by carrying out mandated and pledged activities. The Nairobi work programme plays an important role in the UNFCCC process through engaging stakeholders, catalyzing targeted action and facilitating knowledge sharing and learning on adaptation.

Relevant activities under the Nairobi work programme on assessing the costs and benefits of adaptation include the preparation of a technical paper reviewing existing literature, submissions by Parties and relevant organizations on efforts undertaken to date, and a workshop on costs and benefits of adaptation options.

More information is available at <http://unfccc.int/nwp>.

Figure I-1. **Global distribution of case studies**




**Types of assessment approaches** Cost–Benefit Analysis Cost–Effectiveness Analysis Multi-Criteria Analysis Risk-based Assessment

## THE ADAPTATION PROCESS AND THE ROLE OF ASSESSING THE COSTS AND BENEFITS OF ADAPTATION OPTIONS

Before elaborating on the different assessment approaches, this section provides an overview on the overall adaptation process and the role of assessing the costs and benefits of adaptation options. The adaptation process can be divided into four stages: (i) assessment of impacts, vulnerability and risks; (ii) planning for adaptation; (iii) implementation of adaptation measures; and (iv) monitoring and evaluation of adaptation interventions (see FIGURE I-2). The findings from stage (iv) feed back into stage (i), ensuring that adaptation action is iterative and dynamic over time.

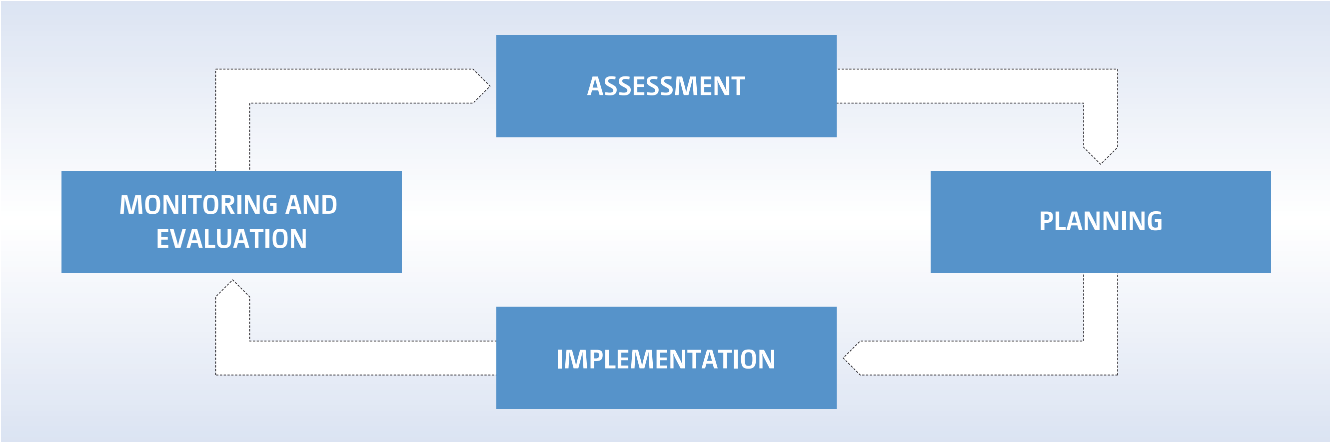
At the outset of any adaptation initiative it is important for adaptation planners to assess the implications of climate change for natural systems (e.g. agricultural productivity, water supply) and human society (e.g. human health, economic activity) to determine whether, and the extent to which, climate change will have an impact, pose a risk or even offer beneficial opportunities. Questions to be addressed during the assessment of risks, impacts and vulnerability include:

- What are the current climate-related hazards and risks? How are they predicted to change over time?
- What are the current and future impacts of these climate-related hazards?
- How vulnerable is the natural or human system currently and what are the main determinants?
- What development trends and socio-economic factors will determine future vulnerability and impacts?

Building upon the assessment of risks, impacts and vulnerability during stage (i), adaptation planners can effectively identify adaptation options in areas and sectors that are the most socio-economically important and/or most vulnerable to climate change during stage (ii). Questions to be addressed during the planning stage include:

- What are the existing strategies for managing climate risks and addressing climate-related hazards (for example, water conservation, integrated coastal zone management, or early warning systems for extreme weather events)?
- Are these viable in the future, can these be built upon, for example, by increasing robustness of infrastructure design of roads or buildings through climate-proofing?
- What other adaptation options can be utilized to reduce impacts and improve resilience, for example, different legislative, regulatory, and juridical instruments (e.g. regulations and standards), financial and market instruments (e.g. licences, user fees or labelling) or education and informational instruments (e.g. public awareness campaigns)?
- What are the costs and the benefits of each adaptation option?

Figure I-2. **The adaptation process and its four key components**




- Which suite of options constitutes a comprehensive adaptation strategy that addresses cross-sectoral linkages and establishes priorities within and across sectors?
- Is the adaptation strategy consistent with national, local or sectoral development objectives?
- What aspects of decision making processes pose barriers or present opportunities for integrating climate change risks and adaptation into national, local or sectoral policies and measures?

Assessing the economic, environmental and social costs and benefits of adaptation plays a critical role in informing the second (planning) stage of the adaptation process. Assessment of costs and benefits informs planners about when and where to act and how to prioritize and allocate scarce financial and technological resources. When undertaking such assessments, planners need to consider the main purpose and core objectives of the adaptation options to be assessed. For example, planners must decide if their objective is to:

- Minimize or avoid all or only part of the expected or observed impacts;
- Return levels of human well-being to pre-climate change levels;
- Maintain current levels of risk or as a minimum reduce them cost-effectively within agreed budgets or pre-defined acceptable levels.

In practice, objectives vary between regions, countries and communities, and trade-offs will need to be made between adopting all possible measures, and living with the risks.

In addition, adaptation planners need to identify and agree upon a set of criteria that will be used to assess the identified adaptation options against the agreed objectives. Possible criteria include:

(1) *Efficiency* – are the outputs achieved optimal relative to the resources allocated?
(2) *Effectiveness* – will the option meet the objectives?
(3) *Equity* – will the option benefit vulnerable groups and communities?
(4) *Urgency* – how soon does the option need to be implemented?
(5) *Flexibility* – is the option flexible, and will it allow for adjustments and incremental implementation and reiteration depending on the level and degree of climate change?
(6) *Robustness* – is the option robust under a range of future climate projections?
(7) *Practicality* – can the option be implemented on relevant timescales?
(8) *Legitimacy* – is the option politically, culturally and socially acceptable?
(9) *Synergy/Coherence with other strategic objectives* – does the option offer co-benefits (for example, improving agricultural land management practices could lead to reduced erosion/siltation and carbon sequestration).

When current and projected impacts, vulnerability, risks and planned adaptation options have been assessed, targeted adaptation actions can be implemented (stage (iii)). The monitoring and evaluation of adaptation actions can be undertaken throughout the adaptation process, in addition to after adaptation actions have been implemented (stage (iv)). Knowledge and information gained from monitoring and evaluation of adaptation actions is fed back into the adaptation process to ensure that future adaptation efforts are successful.

# II. APPROACHES FOR ASSESSING THE COSTS AND BENEFITS OF ADAPTATION OPTIONS

When assessing the costs and benefits of adaptation options, adaptation planners can make use of a range of approaches which have proven to be effective decision-support tools in broader development and sectoral planning contexts. This publication focuses on the three most commonly used techniques:

(1) Cost-Benefit Analysis (CBA);
(2) Cost-Effectiveness Analysis (CEA); and
(3) Multi-Criteria Analysis (MCA).

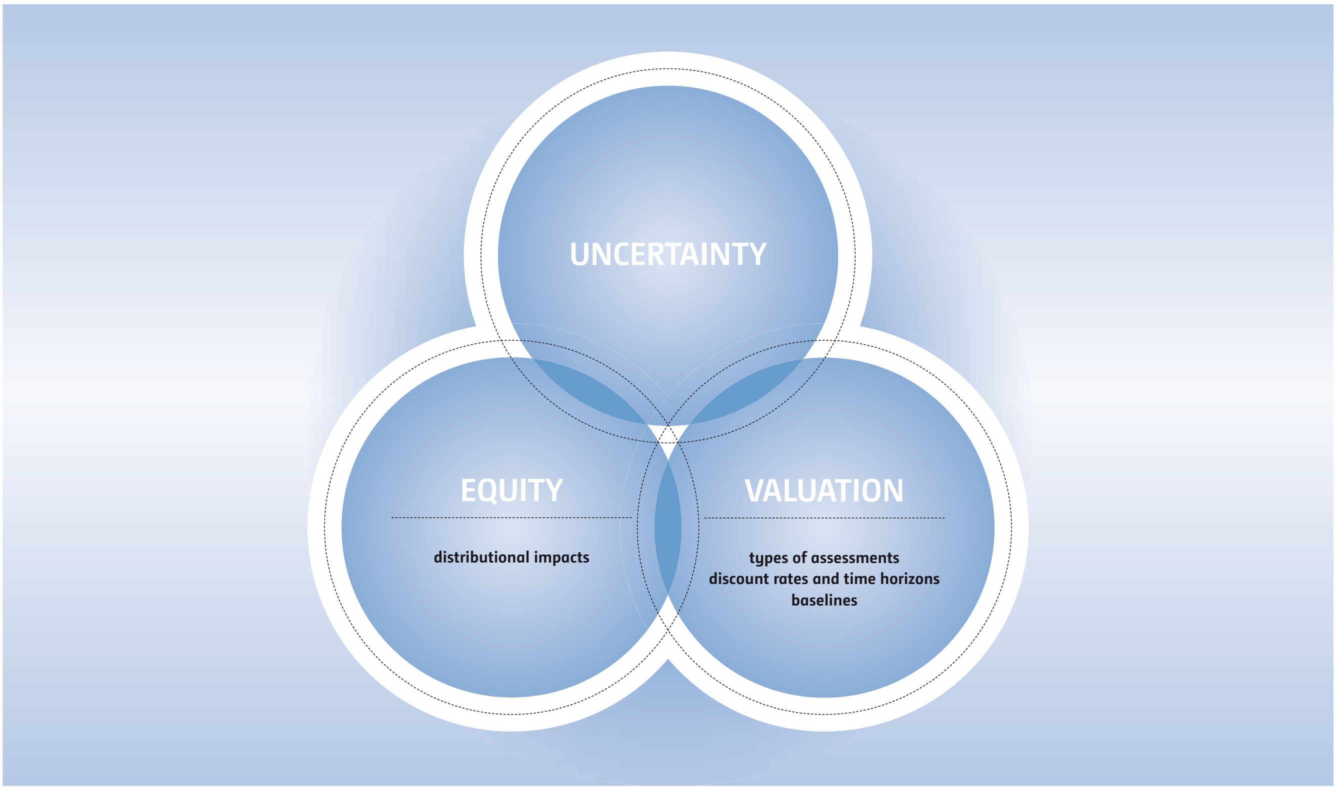
Each approach is explained through the use of case studies. The strengths and weaknesses of each approach are then discussed. In addition, other approaches, including risk assessment, are explained briefly. Before elaborating on these techniques, a brief overview is given on relevant methodological issues.

## 2.1. OVERVIEW OF METHODOLOGICAL ISSUES

The IPCC AR4 defines adaptation costs as "the costs of planning, preparing for, facilitating, and implementing adaptation measures, including transition costs," and defines benefits as "the avoided damage costs or the accrued benefits following the adoption and implementation of adaptation measures". To arrive at an estimate of the benefits of adaptation options relative to a baseline scenario, the projected climate change impacts and the costs of the different options must be examined. Adaptation measures will usually not completely negate the negative impacts of climate change, so the cost of residual damage that remains after implementation of the adaptation option must also be taken into account. After comparing the options, those with the highest estimated net benefits are selected for implementation.

The literature on the costs and benefits of adaptation options raises a number of methodological issues, which can be grouped under the broad themes of uncertainty, valuation and equity, as shown in FIGURE II-3.

Figure II-3. **Main methodological themes concerning costs and benefits of adaptation**



### UNCERTAINTY

Uncertainty surrounding future climate change impacts and future socio-economic development constrains the identification of optimal adaptation options. Even under a specific scenario of future emissions, the range of possible impacts is large. It is important to note though that uncertainties will decline over time as more climatic and socio-economic data becomes available. Adaptation measures should therefore be designed in a flexible manner so that adaptation options can be adjusted or reversed as new information becomes available. This is particularly important for adaptation options that have long-term implications, or for measures that will have a long life span, such as infrastructure. Another aspect of uncertainty relates to data/measurement uncertainty, which can be addressed through having an adequate sample size and measurement approach so that results are robust enough for decision making.

### VALUATION

Assessing the costs and benefits of adaptation options can be undertaken narrowly through *financial assessments* or more comprehensively through *economic assessments*. Financial assessments are usually undertaken within the budgetary framework of the adaptation option under consideration and consider financial costs and benefits only. In contrast, economic assessments consider the wider costs and benefits to the national economy as a whole. In addition, social and environmental costs and benefits may also be assessed (e.g. impacts on availability of jobs, institutional capacity or ecosystem services).

When assessing the costs and benefits of adaptation options, it is important to not only consider market costs and benefits, i.e. costs and benefits that can be easily quantified in monetary terms because they can be traded in markets (e.g. agriculture, fisheries and forestry), but also non-market costs and benefits, i.e. those costs and benefits that are difficult to quantify in monetary terms because they are not traded on markets (e.g. human health and ecosystem services).

Definition of a *baseline* is one of the most important, but also one of the most difficult aspects of estimating the costs and benefits of adaptation options. The baseline should define what would happen to the main variables in the absence of climate change. Significant challenges exist because adaptation assessments must look ahead into the future and analyses must predict levels of development and social changes up to 2030 and beyond. When drawing the baseline, it is important to remember that outcomes may vary and not all plans will always be fully implemented. Given the number of uncertainties, some researchers have proposed the use of multiple baselines when estimating the costs and benefits of adaptation and evaluating adaptation options.

*Discount rates* are commonly used to estimate the present values of the costs and benefits of the adaptation options under consideration because the costs of an option occur earlier in time than the benefits of such an option. Present values are very sensitive to the choice of the discount rate and to any assumption about the consistency of the discount rate over time. There is considerable disagreement among economists about the rate (or rates) at which these future costs and benefits should be discounted. Some studies apply existing discount rates relevant to the country or organization under consideration. Many studies undertake sensitivity analyses to test to what extent the result of the assessment is affected by changes in key variables such as the discount rate. Applying a range of discount rates allows planners to test the validity of results and ensure that the discount rate is not chosen close to a tipping point that reverses the decision, in which case further analysis is applied.

The *time-horizon* of the evaluation is directly linked to the discount rate. The horizon depends on the lifespan of the options under consideration. For example the lifespan of infrastructure projects (e.g. dams and roads) ranges from 50 to 70 years. So, when assessing these options, the totality of costs, including investment and maintenance costs, benefits and expected impacts of climate change over the entire period should be taken into account. In contrast, plans for adapting to health impacts can take a short- to medium-term view (5 to 20 years), which can later be extended to cover longer periods if necessary.

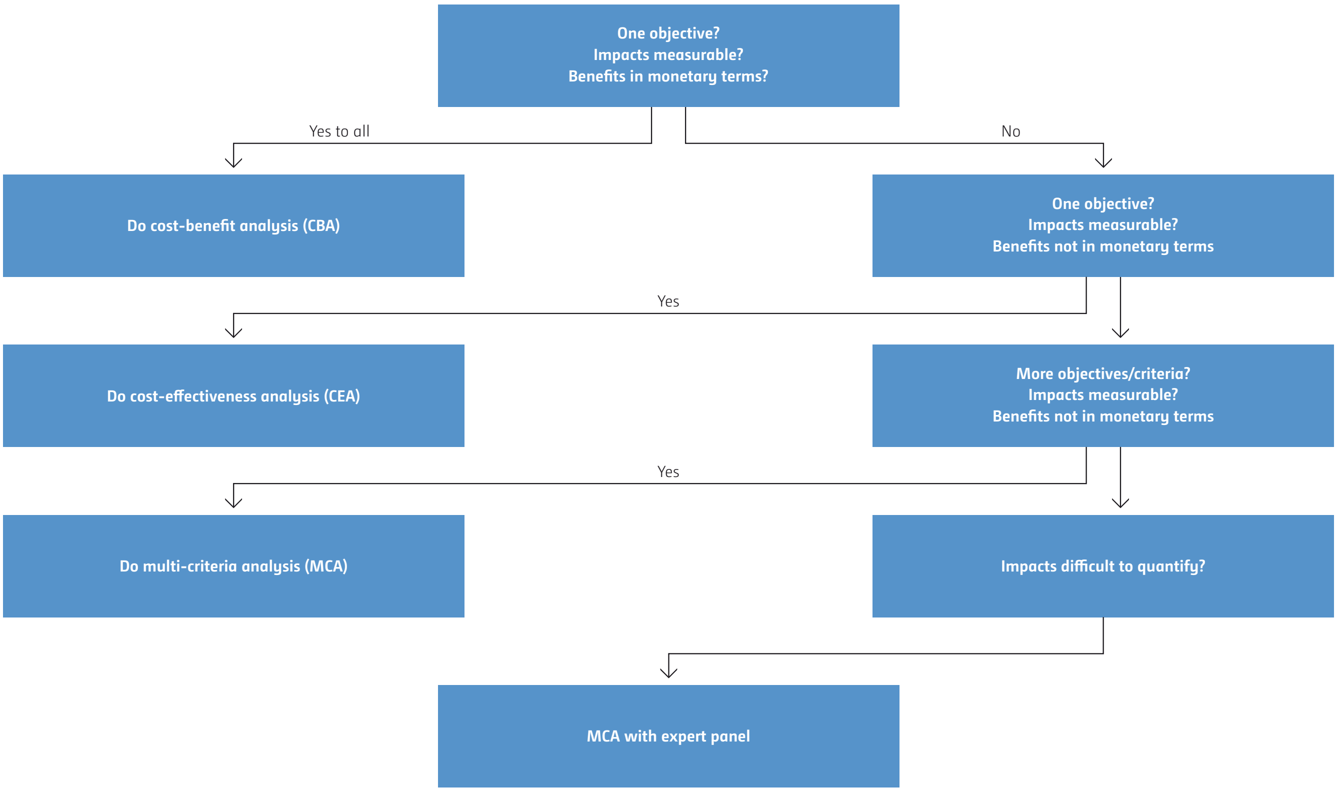
### EQUITY

As pointed out by the IPCC AR4, climate change impacts disproportionately affect vulnerable populations, many of whom are poor. It is therefore important for adaptation planners not only to consider net benefits but also to consider the distribution of the costs and benefits of adaptation options. The distributional aspect of net benefits can be addressed in a number of ways. One is to give weights to different costs and benefits according to who receives the benefits and who bears the cost, for example doubling the benefits for poor people, and halving that for the rich. The difficulty with applying weights is that, in practice, there is a subjective aspect to choosing where the thresholds should lie and what the weighting coefficients should be. An alternative and more popular approach is to present the distributional impacts of adaptation options alongside the aggregate costs and benefits and let the decision be taken by the policymakers.

### CHOOSING AN APPROACH TO ASSESS THE COSTS AND BENEFITS OF ADAPTATION OPTIONS

Once adaptation planners have identified possible adaptation options, have agreed upon decision criteria, and have considered the different methodological aspects, they can then choose between a number of approaches to assess the costs and benefits of each option. Figure II-4 below provides a schematic of the possible approaches that can be applied and that are elaborated below.

**Figure II-4.** **Decision tree of possible approaches for assessing the costs and benefits of adaptation options**




*Source:* Adapted from Boyd R and Hunt A. 2004. *Costing the Impacts of Climate Change in the UK: Overview Guidelines.* UK Climate Impacts Programme Technical Report.

## 2.2. COST-BENEFIT ANALYSIS

Cost-benefit analysis (CBA) is often used to assess adaptation options when efficiency is the only decision making criteria. A CBA involves calculating and comparing all of the costs and benefits, which are expressed in monetary terms. The comparison of expected costs and benefits can help to inform decision makers about the likely efficiency of an adaptation investment. CBA provides a basis for prioritising possible adaptation measures. The benefit of this approach is that it compares diverse impacts using a single metric.

However, it is important to be explicit about how the costs and benefits are distributed, in addition to their aggregate values. In addition, it can be challenging to include reliable estimates of things that are valuable but not valued in markets: for example, the costs and benefits often associated with issues such as environmental goods and services and social or cultural values. This can mean that non-market costs and benefits are excluded, and consequently the results of the analysis are misleading.

### STEPS IN ASSESSING ADAPTATION OPTIONS USING COST-BENEFIT ANALYSIS

(1) **Agree on the adaptation objective and identify potential adaptation options.** An adaptation objective must be well defined and its attainment must be quantifiable in monetary terms. It can, for example, be defined in terms of reducing vulnerability, such as achieving a particular standard of protection from flood risks in the UK (see CASE STUDY 1).

(2) **Establish a baseline.** It is essential to define a baseline (the situation without the adaptation intervention being carried out) and the project-line (the situation with successful implementation of the adaptation option) to determine the costs and benefits by comparing the two situations. For example, as part of the Nepali case study, information on past disaster frequencies and associated damages was obtained and recorded as part of the baseline vulnerability assessment (see CASE STUDY 3). Likewise, a national cereal balance for The Gambia (see CASE STUDY 4) was calculated using various data and model outputs to allow for comparing a 'with' and 'without' situation rather than comparing a 'before' and 'after' situation, which is often mistakenly done.

(3) **Quantify and aggregate the costs over specific time periods.** Costs of an adaptation action include direct costs (e.g. investment and regulatory) and indirect costs (e.g. social welfare losses and transitional costs).

(4) **Quantify and aggregate the benefits over specific time periods.** Benefits of an adaptation intervention should include the avoided damages from climate change impacts and co-benefits, where relevant. If there is no market for the goods or services provided by the adaptation activity, benefits can be estimated in indirect ways through non-market-based approaches, such as contingent evaluation (see glossary).

(5) **Compare the aggregated costs and benefits.** The bottom line for choosing an adaptation option is the comparison of the monetized elements of costs and benefits. The costs and benefits need to be discounted to properly calculate their present value. Adaptation planners can choose between three indicators of whether their options are efficient:

- The net present value (NPV), i.e. the difference between the present value of the benefits and the present value of the costs. The NPV should be greater than zero for an option to be acceptable. For example, NPVs for installing different irrigation technologies in communities in Bolivia ranged from USD 9,063 to 101,149, indicating that all the options under consideration constituted a very good investment opportunity (see CASE STUDY 2). NPVs can be used to prioritize the allocation of the funds.

- The benefit-cost ratio (BCR), i.e. the ratio of the present value of the benefits to the present value of the costs. Benefits and costs are each discounted at a chosen discount rate. The benefit-cost ratio indicates the overall value for money of a project. If the ratio is greater than 1, the option is acceptable. For example, the BCR for different flood and coastal erosion management options in the UK ranged from 2.46 to 5.15 indicating that benefits exceed economic costs for the different options under consideration. The BCR can also be used to prioritise the allocation of finite adaptation funding.

- The internal rate of return (IRR), i.e. the discount rate that makes the NPV equal to zero. The higher an option's IRR, the more desirable it is. For example, the internal rates of return for the different disaster reduction measures in Nepal ranged from 22.2 % to 26 %, which is significantly higher than discount rates regularly used in CBA, thus indicating high desirability.

### STRENGTHS AND WEAKNESSES OF CBA

CBAs are appealing because it is possible to compare and/or aggregate many different categories of benefits or costs into a single value.

A limitation of CBA is that it requires all benefits to be measured and expressed in monetary terms and that there is a particular emphasis on efficiency. CBA does not address those equity considerations related to the distribution of the costs and benefits of adaptation options across stakeholder groups, for example, by not including whether those who benefit from the policy can afford to pay for it. The argument that projects or policies with the best BCR are socially desirable rests on the assumption that those who gain can in principle compensate those negatively impacted by a project or policy, and still be better off. However, whether such compensation actually takes place is dependent upon the design of the adaptation policy. Another complexity of CBA is that it must monetize categories of costs and benefits that are experienced at different times. This entails the need for discounting costs and benefits incurred in the future to compute their present value, but doing so requires choosing a discount rate with the difficulties discussed above.

## CASE STUDY 1.
## UNITED KINGDOM: INFORMING ADAPTATION DECISIONS FOR FLOOD AND COASTAL EROSION MANAGEMENT USING COST-BENEFIT ANALYSIS

### OVERVIEW

Flooding is one of the main natural hazards faced by the UK. Climate change is expected to increase the potential magnitude of flood risk in the future. Funding for flood and coastal erosion management is predominantly provided by central government and CBA guides the allocation of funding between schemes and the choice of options. Redcar, a town in North-East England, foresees its defences overtopped and damaged during larger storm events with flooding and erosion damage becoming more severe and frequent. Coastal modeling has demonstrated that the existing standard of defence is 1 in 10 years (10 % risk of being flooded in one year), and has identified 978 residential and 209 commercial properties within the flood risk area. A CBA was undertaken to select options for replacing Redcar's flood alleviation and coastal defence scheme.

### ADAPTATION OPTIONS CONSIDERED

(1) Do-Nothing (to provide a base line);
(2) Do-Minimum;
(3) Do-Something (Seawall Improvements and Groyne Maintenance at various standards to defend along the existing line).

The consequences of climate change were considered, including the adoption of precautionary and managed adaptive approaches. The options were designed to provide a particular standard of protection (SOP) for 50 years after which adaptive/management measures will be required to address climate change. These measures were accounted for in whole-life cost calculations of the interventions.

### COSTS AND BENEFITS OF CONSIDERED OPTIONS

Maintenance and future costs were derived from the contractor's estimate and current cost databases for civil engineering works. These costs include:

- Replacement of items that reach the end of their design life, such as groynes, revetment and handrails on the new seawall;
- Completing the seawall in year 10;
- Maintenance works to the retained boat ramps, handrails and drainage;
- Advance works (e.g. utilities diversions and structural surveys); and
- Measures to address climate change, using either a precautionary or managed adaptive approach.

Benefits are understood as avoided damages from flooding through overtopping. The present values of costs and damages for the various options are included in table II-1.

The option with the highest benefit-cost ratio was the one which gave a 1 in 300 (0.33 %) standard of protection using a managed adaptive approach (see table II-2). This option was selected and is currently being implemented, with work expected to be complete by 2013.

### LESSONS LEARNED

Cost-benefit analysis provided a consistent framework for comparing the various options, and the underlying approach was able to incorporate the effects of climate change. For the results to be robust, it is necessary to have values for the range of impacts. In the UK, this has been facilitated by the existence of a large body of detailed guidance and standardised values for different impacts. The treatment of uncertainty about climate change depends upon the scale of the project. In this case, climate projections were used to add an allowance for sea level rise, and adaptive approaches were adopted.

**Source:** *"Project Appraisal Report – Redcar Flood Alleviation Scheme".* Environment Agency (UK), Yorkshire and North East Region, Scheme reference IMNE000524, August 2009. Available on request from the Environment Agency.

**References and additional information**

- Detailed information on the appraisal of flood risk management schemes is available at <http://archive.defra.gov.uk/environment/flooding/documents/policy/guidance/erosion-manage.pdf>.
- The UK Government's framework for appraising programmes, projects and policies is set out in the HM Treasury "Green Book" available at <http://hm-treasury.gov.uk/data_greenbook_index.htm>.
- Supplementary guidance, which explains how to address the impacts of climate change within the "Green Book" framework, is available at <http://archive.defra.gov.uk/environment/climate/documents/adaptation-guidance.pdf>.
- Detailed guidance on the appraisal of flood and coastal erosion management schemes is called FCERM-AG, and available at <http://publications.environment-agency.gov.uk/pdf/GEHO0310BSDB-e-e.pdf>.

Table II-1. **Overview of present value costs and damages**

| Option | | | Present value cost | Present value damage | | |
|---|---|---|---|---|---|---|
| | | | | Flooding | Erosion | Total |
| Do-Nothing | | | 0 | 28,832 | 120,502 | **149,334** |
| Do-Minimum | | | 16,032 | 109,954 | 0 | **109,954** |
| Do-Something<br>Seawall improvements and groyne maintenance | 1 in 100 (1%) SoP | Precautionary | 30,744 | 2,107 | 0 | **2,107** |
| | | Managed adaptive | 27,995 | 7,676 | 0 | **7,676** |
| | 1 in 200 (0.5%) SoP | Precautionary | 31,233 | 1,669 | 0 | **1,669** |
| | | Managed adaptive | 28,383 | 3,408 | 0 | **3,408** |
| | 1 in 300 (0.33%) SoP | Precautionary | 31,395 | 1,573 | - | **1,573** |
| | | Managed adaptive | 28,520 | 2,425 | 0 | **2,425** |
| | 1 in 500 (0.2%) SoP | Precautionary | 31,720 | 1,489 | 0 | **1,489** |
| | | Managed adaptive | 28,794 | 1,489 | 0 | **1,489** |

Present values in thousand GBP

Table II-2. **Summary of the costs and benefits**

| | Do-Nothing | Do-Minimum | Improve – Managed Adaptive | | | |
|---|---|---|---|---|---|---|
| | | | 1 in 100 (1%) | 1 in 200 (0.5%) | 1 in 300 (0.33%) | 1 in 500 (0.2%) |
| Total present value of costs | - | 16.03 | 27.99 | 28.38 | 28.52 | 28.79 |
| Total present value of residual damages | 149.33 | 109.95 | 7.68 | 3.41 | 2.43 | 1.49 |
| Total present value of benefits (reduction in damage relative to Do-Nothing baseline) | | 39.38 | 141.66 | 145.93 | 146.91 | 147.85 |
| Net present value | | 23.35 | 113.66 | 117.54 | 118.39 | 119.05 |
| Average benefit/cost ratio | | 2.46 | 5.06 | 5.14 | 5.15 | 5.13 |

Present values in million GBP

## CASE STUDY 2.
## BOLIVIA: ASSESSING ADAPTATION OPTIONS IN THE WATER SECTOR USING COST-BENEFIT ANALYSIS

### OVERVIEW

The Plurinational State of Bolivia is already suffering from climate change impacts, in particular reduced water supply as a result of glacial retreat. As agriculture is the main source of community income and sustenance, water availability is the key constraint for crop production. Following a CBA, Bolivia implemented pilot adaptation measures in three communities, which are expected to serve as lessons for the formulation of public policy in water-stressed regions of Bolivia. The pilot projects focussed on technical solutions to increase water supply for irrigation during the dry season and drought periods and to increase land area under crop production, for both traditional (e.g. potatoes, wheat, corn or Fava beans) and new crops (e.g. onions and peas) (see table II-3).

### COSTS AND BENEFITS OF CONSIDERED OPTIONS

Water management alternatives and technologies for water harvesting and collection in all three case studies were evaluated using CBA based on social evaluation, according to regulations for use of public funds of the government of Bolivia. All projects and their technical alternatives were evaluated using both financial and social assessments: Financial assessments only considered the financial returns of the investment, i.e. immediate outputs. Social assessments, however, considered financial, economic and social returns of the investment, i.e. broader outcomes such as increased social capital as a result of a decrease in migration following an increase in income. Social project evaluation tests were conducted on profitability using discount rates and shadow prices, used by the Vice ministry of Public Investment of Bolivia.

Table II-3. **Adaptation options considered**

| Community | Characteristics | Adaptation options |
|---|---|---|
| Lumbre Abra in the Municipality of Pojo, department of Cochabamba | – Spring water is only used for human consumption;<br>– Agriculture depends on precipitation. | – Increase water availability through constructing *Atajados* (artificial water reservoir used to harvest rainwater, which is independent from springs and uses micro-irrigation to make efficient water use compared to traditional flood irrigation);<br>– Two options differing in the water capacity of each reservoir (2,000 vs 1,500 cubic meters), second option chosen due to budget constraints. |
| Vilaque and Santa Maria in the Municipality of Pazña, department of Oruro | – Existing irrigation system, which is composed of a series of canals that draw water from nearby rivers, is unable to fulfil agriculture needs;<br>– Situation expected to worsen with climate change. | – Improve the water intake system through installing pipes and reinforcing/water-proofing the canals to eliminate water losses from filtration and reduce erosion processes;<br>– Install two purification chambers to provide potable water throughout the year to the communities. |
| Cohana and Pajichiri in the municipality of Pucarani near Lake Titicaca | – No existing irrigation system, agriculture depends on precipitation;<br>– In recent years, periods of intermittent drought have increased vulnerability because sowing based on early rainfall is no longer certain;<br>– More frequent crop losses have forced population to migrate to cities like El Alto. | – To reduce water restrictions three options were considered: The first two solutions involved the construction of a storage tank, the first solution with a system for water distribution, the second without. The third solution involved the construction of a pumping system, which avoided the need for a storage system, and took advantage of the proximity of Lake Titicaca;<br>– The communities and its authorities chose the third option, as water storage was too costly. |

All alternative options evaluated were presented to the local communities and authorities. This allowed them to choose the best solution, both based on the technical (hydrological) studies as well as their own constraints (mainly monetary). Data collection and dissemination was done through surveys in-situ with the communities and beneficiaries and was supported by census information. The results are displayed in the table II-4 below.

As a result of implementing the various measures, all three communities saw an increase in irrigated area ranging from 14 to 61 hectares. As a result, crop yields increased as did household income albeit to varying degrees across the communities.

### LESSONS LEARNED

- Water rights are an important factor that must be taken into account in any assessment. In the case of Cohana and Pajichiri, the use of water from Lake Titicaca is well regulated. An important step was to ensure water use from the lake by the pumping system.
- Differentiation of crop production for consumption by the communities and crops to be sold in regional markets affects the estimate of household income.
- Communities must establish a proper monitoring process and ensure that irrigation techniques and management of agricultural production remain optimal for long-term success.

**Source:** Escobar Llanos J. 2011. *Diseños finales de Proyectos Piloto de Adaptación al Cambio Climático.* Banco Inter-Americano de Desarrollo, proyecto BOL-G1001. La Paz, Bolivia.

**Additional information** on the project is available at the Inter-American Development Bank <http://iadb.org/en/projects/project,1303.html?id=BO-G1001>.

**Table II-4.** **Summary of the cost-benefit analysis**

| | Lumbre Abra | Vilaque and Santa Maria | Cohana and Pajichiri |
|---|---|---|---|
| Increase in water supply ($m^3$) | 72,000.0 | | |
| Increase in irrigated area (ha) | 61.4 | 20.9 | 13.8 |
| Income per household (% increase) | 560.0 | 368.0 | 80.0 |
| Financial internal rate of return (%) | 14.8 | 12.8 | 40.6 |
| Social internal rate of return (%) | 13.8 | 17.4 | 39.4 |
| Financial net present value (USD) | 15,639.0 | 114.0 | 97,515.0 |
| Social net present value (USD) | 9,063.0 | 18,096.0 | 101,149.0 |

**Image II-1.** **Indigenous people washing clothes in Bolivia**

*Source:* World Bank.

## CASE STUDY 3.
## NEPAL: ASSESSING LIVELIHOOD-CENTRED DISASTER REDUCTION MEASURES USING COST-BENEFIT ANALYSIS

### OVERVIEW

Practical Action, with funding from UKAid, undertook the "Mainstreaming Livelihood-Centred Approaches to Disaster Management" project in Nepal between 2007 and 2010. In the course of the project Practical Action worked in five villages with a total population of 718 families (about 3,500 individuals) to increase the capacity of coping with natural disasters induced by climate change. A CBA was undertaken following the implementation of the project, which focused on community-level project activities and did not include indirect long-term benefits that could arise. Practical Action chose to use a discount rate of 10% to assess the project and as part of the sensitivity assessment also carried out calculations based on a 5 and 15% discount rate.

### ADAPTATION OPTIONS IMPLEMENTED

Various adaptation measures were implemented, including:

- Investment in irrigation facilities to reduce drought sensitivity;
- Installation of electrical fencing to reduce wildfire intrusion risks;
- Flood risk reduction investments;
- Crop farming skill enhancement and capacity building initiatives;
- Investment and training in livestock husbandry;
- Livelihood diversification measures such as off-farm income generation;
- Support for Community Saving Schemes.

### COSTS AND BENEFITS OF CONSIDERED OPTIONS

The costs included the direct project costs and the opportunity costs of human and material resources contributed by the target households and other local stakeholders. Benefits were measured by comparing the present value of real income gains to a 'no-project' baseline. The CBA included the whole expected future stream of real income gains relative to this baseline and as a result took into account projected future gains as well as those which were currently observable. Table II-5 below shows the summarised results of the CBA. The present value of the benefits was always higher than the present costs. The central social discount rate of 10% showed benefit-cost ratios from 1.27 to 1.5 which indicates an excess of the economic benefits to the economic costs. Furthermore, the internal rate of return ranged from 22.2% to 26.% (significantly higher than the discount rates regularly used in CBA).

Table II-5. **Main results of the cost-benefit analysis (value in GBP)**

| **10 year horizon** | **r = 5%** | **r = 10%** | **r = 15%** |
|---|---|---|---|
| Present value of benefits | 383,764 | 306,287 | 250,831 |
| Present value of costs | 265,253 | 241,527 | 221,657 |
| Net present value | 118,511 | 64,760 | 29,174 |
| Benefit-cost ratio | 1.45 | 1.27 | 1.13 |
| Internal rate of return 22.2% | | | |
| **20-year horizon** | **r = 5%** | **r = 10%** | **r = 15%** |
| Prevent value of benefits | 611,774 | 393,484 | 310,501 |
| Present value of costs | 300,235 | 261,717 | 233,688 |
| Net present value | 311,539 | 131,767 | 76,812 |
| Benefit-cost ratio | 2.04 | 1.5 | 1.33 |
| Internal rate of return 26.3% | | | |

LESSONS LEARNED

In order to assess the benefits of reducing damage from future climate-related disasters as part of pre-project CBA assessment, it is advisable to obtain and record information on past disaster frequencies and associated damages as part of the baseline vulnerability assessment. Gaps in official statistics on this type of information are likely at the community level so that participatory methods will be required to obtain the necessary information.

Undertaking the CBA after implementing the projects was helpful as it showed that the project was beneficial for the communities involved. To identify the total benefits it would moreover be advisable to undertake another CBA in a couple of years.

**Source:** Willenbockel D. 2011. *A Cost-Benefit Analysis of Practical Action's Livelihood-Centred Disaster Risk Reduction Project in Nepal.* Brighton: IDS. Available at <http://community.eldis.org/?233@@.59ecc208!enclosure=.59ecc20e&ad=1>.

Image II-2. **Men installing a shallow tube well**

*Source:* Practical Action.

## CASE STUDY 4.
## THE GAMBIA: ASSESSING ADAPTATION OPTIONS IN THE AGRICULTURE SECTOR USING COST-BENEFIT ANALYSIS

### OVERVIEW

Climate change and increasing climate variability is a major threat to food security in The Gambia. Historically, The Gambia has been dependent on commercial imports and food aid to address production shortfalls. Adaptation options to increase The Gambia's resilience to climate change and improve food security were examined with a CBA. Cost-competitiveness was further assessed and the benefits of adaptation measures were compared to the costs of food imports and food aid during drought periods.

### ADAPTATION OPTIONS CONSIDERED

Enhancing irrigation for millet was identified as the preferred adaptation option. After identifying the different types of sources of water for irrigation and assessing the crop water requirement, two different options of water delivery were determined:

- Pumping of groundwater using energy either from solar panels or from diesel engines; and
- Catchment of surface water through constructing dams and pumping using diesel engines.

### COSTS AND BENEFITS OF CONSIDERED OPTIONS

Annual costs for each of the options were calculated combining investment, operation, maintenance and replacement costs as reported by suppliers and developers at a discount rate of 9%, with a 60 year project horizon. As the cost of water obtained from the dam (per $m^3$) was lower than the cost of water obtained from groundwater pumping, construction of dams was further assessed. Benefits of irrigation were calculated using specific agriculture models and scenarios. Increased production arising from irrigation was hypothetically traded on the cereal market at constant dollar values of USD 150 per metric ton (mt). Irrigation using dam water increased the annualised average yield from 1.1 to 3.1 mt/ha. This would result in an increase in market value per hectare from USD 165 to USD 465. Irrigation would almost triple the annual crop yield and related income.

The next step was to assess costs and benefits. The net benefit of irrigation (total annual costs minus the total annual benefits) was always negative even under changing discount rates. For example the net benefits for millet (USD/ha) were -2,933 for a 14% and -1,871 for a 3% discount rate. Likewise the benefit-cost ratio was closer to zero than to one indicating a lack of profitability.

However, the aim of the study was not merely to do a narrow CBA but rather to compare the costs of adaptation, i.e. food security, with the costs of commercial imports of rice (substitute for millet) and food aid. Based on a cereal balance established for the period 1961–1990 using nutritional requirements, population, cultivated area, yield data from agriculture models, and agricultural statistics kept by the Department of State for Agriculture in The Gambia, it was estimated that irrigation could have eliminated the need for commercial cereal import/food aid and that foreign exchange savings of over USD 22 million could have been made (see table II-6 below).

### LESSONS LEARNED

The analysis showed that it makes sense not to rely on a CBA alone, but to also look at the economy at large. Even though the CBA of irrigation was negative, the additional cost-competitiveness study showed the positive long-term effect of the adaptation option in particular in light of rising global food prices. The case study showed that whilst preliminary results indicate substantial benefits from irrigation at a macro economic level, increased income from irrigation is not matched by costs incurred by farming households, suggesting the need for further policy measures to support irrigation.

**Source:** Nkomo JC and Gomez B. 2006. *Estimating and Comparing Costs and Benefits of Adaptation Projects: Case Studies in South Africa and The Gambia.* Available at: <http://aiaccproject.org/Final%20Reports/Final%20Reports/FinalRept_AIACC_AF47.pdf>.

Table II-6. **Socio-Economic Impacts of Irrigation for the Period 1961–1990**

| | Without irrigation | With irrigation |
|---|---|---|
| Commercial Import/Food Aid (mt) | 49,196 | 0 |
| Commercial Import/Food Aid (USD) | 7,379,383 | 0 |
| Crisis years | 20 | 0 |
| Foreign exchange savings (USD) | -7,379,383 | 22,582,350 |

All values except crisis years are averages over 30 years. Assumed per capita cereal consumption is 250kg/person/year.
Crisis years defined as years when food stock-to-utilization ratio falls below the food security threshold.

## 2.3. COST–EFFECTIVENESS ANALYSIS

Cost-effectiveness analysis (CEA) is used to find the least costly adaptation option or options for meeting selected physical targets. Given that CEA is performed when the objectives of the adaptation measures have been identified and the remaining task is to find the lowest-cost option for meeting these objectives, it does not evaluate whether the measure is justified (e.g. by generating a certain benefit-cost ratio or IRR). CEA is applied in assessing adaptation options in areas where adaptation benefits are difficult to express in monetary terms, including human health, freshwater systems, extreme weather events, and biodiversity and ecosystem services; but where costs can be quantified. For example, given the necessity for water, the aim of an assessment is not to find alternative adaptation options that might yield higher adaptation benefits, but to find those options that ensure sustainable water quality and quantity for vulnerable communities (see CASE STUDY 5 for examples in three Pacific islands).

### STEPS IN ASSESSING ADAPTATION OPTIONS USING COST-EFFECTIVENESS ANALYSIS

(1) **Agree on the adaptation objective and identify potential adaptation options.** An adaptation objective must be well-defined and its attainment must be measurable. It can either be defined in terms of reducing vulnerability (e.g. controlling vectors to reduce the burden of Dengue in Brazil, see CASE STUDY 6) or achieving a certain level of adaptive capacity or resilience (e.g. extent of Mangroves for coastal protection). Options identified must be expected to reasonably achieve the adaptation objective (e.g. installing water tanks to harvest rainwater in CASE STUDY 5).

(2) **Establish a baseline.** A baseline is necessary to analyse whether the objective has been met, and to understand how far away the target is (e.g. current water availability or current Dengue burden). The baseline can either be the status quo or a projected baseline which should be based on a 'business a usual' or 'do nothing' scenario. In addition, planners need to agree on a set of indicators for evaluating and tracking benefits in non-monetary terms over time against the baseline (e.g. litres of water to measure water availability or disability-adjusted life-years (DALYs) to measure the burden of disease).

(3) **Quantify and aggregate the various costs.** All costs of each option need to be quantified and aggregated, including direct and indirect costs over the life-cycle of each option. Similar to CBA, all costs should be discounted to their present value by using an agreed discount rate.

(4) **Determine the effectiveness.** The definition of effectiveness depends on the adaptation objective and the established baseline. In the case of water resources an option can be effective if it yields a certain amount of water.

(5) **Compare the cost effectiveness of the different options.** Cost-effectiveness can either be compared overall or in incremental terms. An overall cost-effective analysis simply compares the cost per unit of effectiveness for each adaptation option (e.g. USD per 1 litre of water). In contrast, an incremental cost effectiveness analysis considers the difference in costs divided by the difference in effectiveness that result from comparing one adaptation option to the next most effective policy measure (or a baseline situation). An incremental cost effectiveness ratio is expressed by (Cost Option A – Cost Option B)/(Effectiveness of A – Effectiveness of B), where A is the more effective policy measure and B is the second most effective.

Using an overall CEA is appropriate in cases where only one adaptation option will be implemented, which would be the option with the lowest cost-effectiveness ratio (least cost per unit of effectiveness) as seen in CASE STUDY 5. In cases where a single adaptation measure may not be sufficient, so that a combination of different options will make up the adaptation policy (e.g. larvae and adult control of Dengue vectors in CASE STUDY 6) use of an incremental CEA is more appropriate. The lowest incremental cost-effectiveness ratio indicates that policy A (the more effective measure) dominates policy B (the second most effective) in terms of cost-effectiveness. To maximise cost-effectiveness, adaptation planners should implement policy A until its marginal cost-effectiveness is dominated by that of another policy measure. In this sense, narrowly choosing a single option will rarely be the most cost-effective policy, and the preferred option will be a combination.

### STRENGTHS AND WEAKNESSES OF CEA

CEA is a useful alternative to CBA in areas where benefits cannot be quantified monetarily to compare alternative adaptation options with a view to identifying the option which can reach a well defined objective in the most cost-effective way. However, CEA is often not used as a stand-alone tool for decision support as the benefits are defined in one single dimension only (e.g. cost-effectiveness). Other dimensions such as equity, feasibility or co-benefits are not considered in the primary analysis but could be considered during the selection process of the chosen options. For example, in CASE STUDY 5, issues such as awareness-raising, gender or networking were considered in parallel.

## CASE STUDY 5.
## PACIFIC ISLANDS: ASSESSING ADAPTATION OPTIONS FOR FRESHWATER RESOURCES USING COST-EFFECTIVENESS ANALYSIS

### OVERVIEW

Climate change is already having major impacts on many small islands in the Pacific. As part of the Capacity Building to Enable the Development of Adaptation Measures in Pacific Island Countries project (CBDAMPIC), adaptation measures were implemented at nine pilot sites on four islands in the Pacific (Cook Islands, Fiji, Samoa and Vanuatu) following intensive community consultations and CEAs.

Communities in the pilot sites identified water resources as their greatest concern. Vulnerabilities were noted not only in terms of immediate quality and quantity, but also in terms of the sustainability of supply. Fresh water resources are threatened by increasing salinity of mains water due to up-welling and saltwater-intrusion and the length of dry periods. Communities are suffering because inhabitants, in particular women and children, have to spend a considerable amount of their day fetching water. Health problems are also increasing and agricultural yield is decreasing.

### ADAPTATION OPTIONS CONSIDERED

Given the necessity of water resources, the aim of the project was not to find adaptation options that might yield higher adaptation benefits, but to find options that will ensure sustainable water quality and quantity for vulnerable communities. The following options were identified by three communities:

- Installation of desalinisation systems;
- Upgrading of existing mains systems;
- Rainwater harvesting;
- Using brackish or seawater for appropriate systems;
- Watershed protection measures, including contour farming, planting trees on hillsides, planting fruit trees within crop plots to provide shade for the plants or reinforcing salt tolerant vegetation buffers;
- Improving sanitary condition, for example by installing compost or flush toilets (however, the latter would increase water consumption); and
- Awareness-raising on water issues and installation of radio and internet communications.

### COSTS AND EFFECTIVENESS OF CONSIDERED OPTIONS

All three communities selected rainwater harvesting as their preferred adaptation option. It was deemed to be the most cost-effective option (i.e. yielding the desired quantity and quality of water at the least cost). In addition, rainwater harvesting was determined to be the most practical, easily implemented, and sustainable measure. Other measures were either too expensive, such as desalination systems, or did not promise the desired quality and quantity of water, such as watershed protection measures.

The size of tanks for storing harvested rainwater in different communities was determined by annual rainfall, water use per person, available funds and the number of households (expected) to be served. The equipment and cost details for each community are included in table II-7 below.

Table II-7. **Summary of the cost-effectiveness analysis**

| Community | Rainwater harvesting equipment | Total project costs | Cost-effectiveness (Cost per person/water harvesting potential in litres per person) |
|---|---|---|---|
| Aitutaki, Cook Islands | 246 household tanks of 2,000 litres and 12m of gutters for each household | USD 233,155 | USD 259/547 litres |
| Tilivalevu, Fiji | Two communal tanks, a new piping system and upgraded dams | USD 63,431 | N.A. |
| Luli, Vanuatu | 24 household tanks of 2,400 litres, each combined with a catchment area of ca. 20m$^2$ | USD 100,480 | USD 334/192 litres |

LESSONS LEARNED

All communities would have preferred larger tanks and catchment areas as they perform better on the historic rainfall time-series and are more robust to climate change effects. However, the additional acquisition and transport costs were prohibitive. Nonetheless the project was deemed a success by communities both in terms of improvement in their living conditions and in terms of increased awareness and networking.

**Source:** Kouwenhoven P and Cheatham C. 2006. *Economic Assessment of Pilots. Final report to SPREP. CBDAMPIC.* Available at <http://.sprep.org/att/IRC/eCOPIES/Pacific_Region/173.pdf>.

**Additional information** on follow-up activities under the Pacific Adaptation to Climate Change Project is available from the Pacific Regional Environment Programme (SPREP) at <http://sprep.org/climate_change/pacc/index.asp>.

Image II-3. **House with old water tank on Aitutaki, Cook Islands**

*Source:* Government of the Cook Islands

## CASE STUDY 6.
## BRAZIL: ASSESSING DENGUE CONTROL OPTIONS USING COST-EFFECTIVENESS ANALYSIS

### OVERVIEW

An estimated 2.5 billion people in the metropolitan areas of Latin America and the Caribbean are at risk of dengue. As concluded by the IPCC AR4 the burden of dengue is likely to increase with climate change. Dengue control relies mainly on insecticides targeted at larval and adult mosquitoes. However, evolution of insecticide resistance can lead to the failure of dengue control programmes.

This study carried out epidemiological and economic assessments of 43 different insecticide-based vector control strategies for a 5-year period in Rio de Janeiro, Brazil. The authors developed a dynamic model of dengue transmission that assessed the evolution of insecticide resistance in mosquito populations and dengue immunity in human populations.

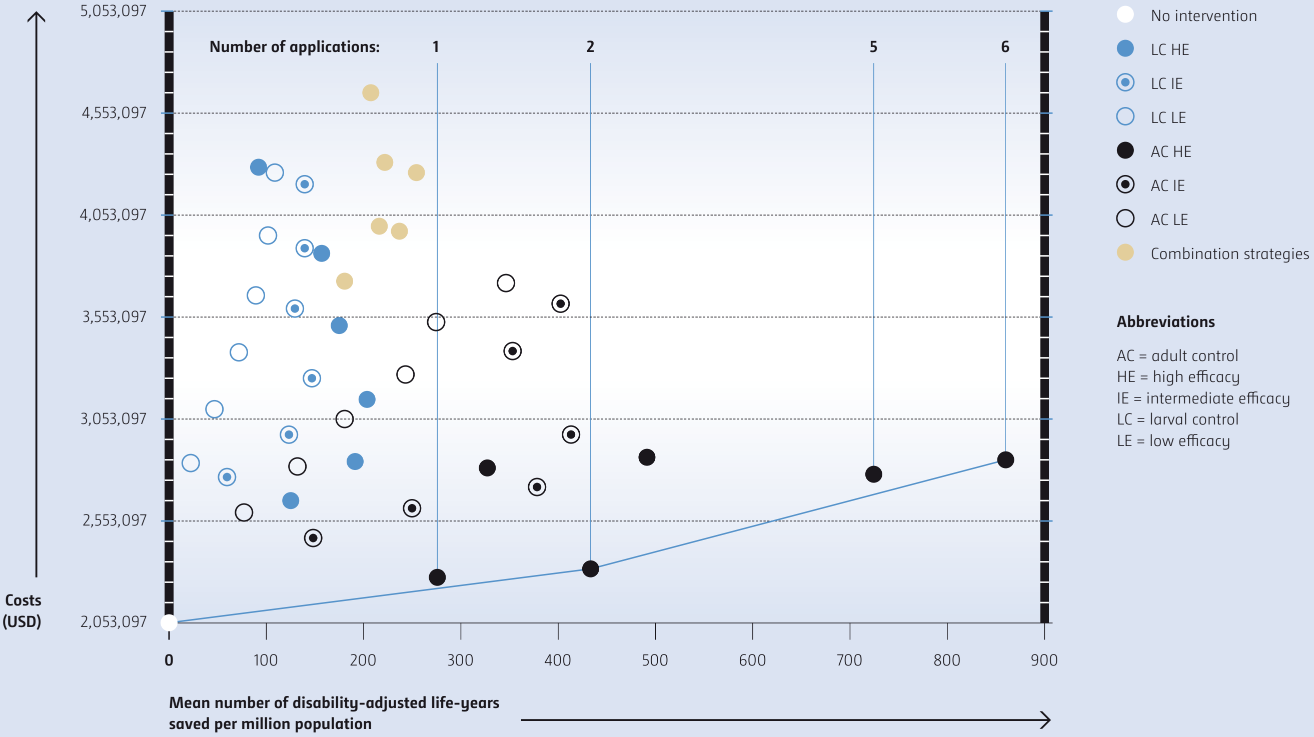
### OPTIONS CONSIDERED

The model compared different combinations of vector targeting strategies (larval vs. adult control), number of applications of insecticide per year (between 1 and 6), and different intervention efficacies (positive impact on mortality).

### COSTS AND EFFECTIVENESS OF CONSIDERED OPTIONS

The analysis was conducted from a societal perspective. It assessed direct medical and non-medical costs and indirect costs from workdays lost because of dengue. Costs were expressed in USD for the year 2009. Future costs were discounted at a yearly rate of 3%. Dengue health burden was measured in terms of disability-adjusted life-years (DALYs) lost. DALYs are a generic measure of health that enables comparison of reductions in health burdens across different disease conditions as well as combining morbidity and mortality effects in the same index. For the study, Brazil-specific thresholds for cost-effectiveness were defined based on the criteria of the WHO Commission on Macroeconomics and Health: less than USD 24,660 per DALY saved was deemed a 'cost-effective' intervention, and less than USD 8,220 per DALY saved was deemed a 'very cost-effective' intervention.

**Figure II-5.** **Cost-effectiveness of different dengue control strategies**



All interventions caused the emergence of insecticide resistance which will increase the magnitude of future dengue epidemics when combined with the loss of community immunity. The model showed that one or more applications of high-efficacy larval control reduced dengue burden for up to 2 years, whereas three or more applications of adult vector control reduced dengue burden for up to 4 years.

Figure II-5 shows all 43 interventions in the cost-effectiveness plane, which depicts the difference in costs and effectiveness between the strategies. The incremental cost-effectiveness ratios of the strategies for two high-efficacy adult vector control applications per year was USD 615 per DALY saved and for six high-efficacy adult vector control applications per year was USD 1,267 per DALY saved.

Probabilistic sensitivity analysis showed that use of six applications of adult control would meet WHO's standard for 'cost effective' intervention with a probability of 99% and the standard for 'very cost effective' intervention with a probability of 89%. Threshold analysis showed that only once the cost of adult control was greater than 8.2 times the cost of larval control, did it become more cost-effective to focus on larval control.

LESSONS LEARNED

This study draws attention to the importance of acknowledging both the evolution of insecticide resistance in mosquito populations, and community immunity in the human population when considering insecticide-based vector control strategies for dengue. Year-round larval control is used in many settings where dengue transmission occurs. However, these analyses indicate that strategies based on continuous larval control could be counterproductive. Initially, such strategies reduce the mosquito population and suppress dengue transmission. However, as insecticide resistance evolves and, consequently, the effect of vector control decreases, the mosquito population recovers. Additionally, the suppressed dengue transmission during the initial years of control results in a loss of community immunity in the human population. Growth of insecticide-resistant mosquito populations coupled with the loss of community immunity increases the magnitude of the eventual epidemic.

**Source:** Mendes Luz P, Vanni T, Medlock J, Paltiel AD, Galvani AP. 2011. *Dengue vector control strategies in an urban setting: an economic modelling assessment.* The Lancet, Volume 377, Issue 9778, Pages 1673–1680. Reproduced with kind permission of *The Lancet* journals.

Image II-4. **A public health worker checks a sellers blood pressure, Brazil**

*Source:* Alejandro Lipszyc/World Bank

## 2.4. MULTI-CRITERIA ANALYSIS

Multi-criteria analysis (MCA) allows assessment of different adaptation options against a number of criteria. Each criterion is given a weighting. Using this weighting, an overall score for each adaptation option is obtained. The adaptation option with the highest score is selected. MCA offers an alternative for the assessment of adaptation options when only partial data is available, when cultural and ecological considerations are difficult to quantify and when the monetary benefit or effectiveness are only two of many criteria. MCA essentially involves defining a framework to integrate different decision criteria in a quantitative analysis without assigning monetary values to all factors. MCA was the method of choice for least developed countries (LDCs) in preparing their national adaptation programmes of action (NAPAs). For an example, see CASE STUDY 7 for the Bhutanese NAPA.

The robustness of an MCA result depends on the (un)certainty of the information regarding the selected criteria, the relative priorities given to various criteria (the weights or scores) and the extent to which the weights are commonly agreed upon by stakeholders. Sensitivity analysis can be used to check the robustness of the result for changes in scores and/or weights.

### STEPS IN ASSESSING ADAPTATION OPTIONS USING MULTI-CRITERIA ANALYSIS

(1) **Agree on the adaptation objective and identify potential adaptation options.** In contrast to CBA and CEA, an MCA can be conducted in cases where multiple adaptation objectives and criteria exist. For example, the Yemen case study (CASE STUDY 8) set out to evaluate which adaptation policy option, or package of options, could build on current measures to best manage scarce water resources, whilst at the same time taking into account Yemen's other development priorities.

(2) **Agree on the decision criteria.** Each criterion needs to be described, including the unit and span of possible scores, so as to ensure that those involved in the assessment process have a shared understanding. For example, as part of developing a national adaptation agenda, the Netherlands assessed adaptation options against their importance, their urgency, whether they represented no-regret options, and whether they had ancillary benefits and mitigation linkages (see CASE STUDY 9).

(3) **Score the performance of each adaptation option against each of the criteria.** Once this is completed, standardization is required in case scores of the various criteria differ in units (e.g. monetary or qualitative values) or spans (e.g. 1–5 or 0–100). Transformation of scores into similar units allows for effective comparison of the criteria. Standardization is completed through a value function or standardization procedure where scores lose their dimension along with their measurement unit. For example, Bhutan had to standardize scores for options on a scale from 0 to 1 to proceed with its analysis and allow costs to be included.

(4) **Assign a weight to criteria to reflect priorities.** In case some criteria are perceived to be more important than others and the priorities are known, criteria can be assigned different weights, thus indicating their relative importance. For example, while the Netherlands assigned 20 percent to the criteria 'urgency' it only assigned 10 percent to 'mitigation effect'. Bhutan in its NAPA weighted options with national benefits higher than options with only local benefits.

(5) **Rank the options.** A total score for each option is calculated by multiplying the standardized scores with their appropriate weight. Finally, weight-adjusted scores are aggregated and compared.

The main result of an MCA is a rank order of adaptation options and an appreciation of the weaknesses and strengths of the attributes of each of the options. An MCA can also be conducted in conjunction with other assessment approaches (CBA and CEA) to provide a more solid foundation for informed decision making.

### STRENGTHS AND WEAKNESSES OF MCA

MCA helps to structure the challenge of selecting an adaptation option by outlining the various objectives of a programme and the criteria to measure those objectives in a transparent manner. MCA can accommodate quantitative as well as qualitative information and helps to communicate the strengths and weaknesses of each adaptation option. In addition, MCA allows for direct stakeholder engagement by allowing the beneficiaries of the adaptation options to be involved in choosing them, which is crucial for creating ownership and subsequent implementation of the adaptation measures.

Difficulties associated with MCA include assigning weights, especially if the number of criteria is large and the criteria are very different in character, and standardizing scores, which leads to loosing some information that could be valuable in later stages. Explicit statement of the weight assigned to each criterion can enhance public debate. Since it is not always easy to reach agreement among stakeholders on criteria and their relative importance, it is advisable to conduct a sensitivity analysis to determine if the ranking is sufficiently robust to withstand scrutiny.

## CASE STUDY 7.
## BHUTAN: ASSESSING ADAPTATION OPTIONS USING MULTI-CRITERIA ANALYSIS

### OVERVIEW

Bhutan assessed its vulnerability to climate change and possible adaptation options during the development of its National Adaptation Programme of Action (NAPA). A task force team consisting of representatives from key sectors including agriculture, biodiversity and forestry, natural disaster and infrastructure, health, and water resources identified and ranked possible priority adaptation projects using MCA. In the beginning, the NAPA team identified the most likely and severe climate related hazards and detected high risk groups:

(1) Hazards, such as increased Glacial Lake Outburst Floods (GLOF), landslides and flash-floods;
(2) Most vulnerable sectors, such as agriculture and hydropower;
(3) Most vulnerable communities, such as the rural poor.

### ADAPTATION OPTIONS CONSIDERED

In the beginning, a total of 17 adaptation options were identified based on the framework of climate-induced hazards. Bhutan then utilized and adapted the following four criteria recommended by the LDC Expert Group to create a short list of nine priority adaptation options:

- Convincing threats of climate and climate change/ level or degree of adverse effects of climate change;
- Demonstrates fiscal responsibility (or cost effectiveness);
- Level of risk (by not choosing to adapt);
- Complements country goals such as: overcoming poverty, enhancing adaptive capacity, or other environmental agreements.

### RANKING OF OPTIONS

The nine shortlisted options (see table II-8) were ranked based on the following four criteria (the first three constitute benefits and the last costs):

- Human life and health saved/protected by the intervention;
- Arable land with associated water supply (for agriculture/ livestock) and productive forest (for forestry/forest products collection) saved by the intervention;
- Essential infrastructure saved by the intervention such as existing and projected hydropower plants, communication systems, industrial complexes, cultural and religious sites and main tourist attractions;
- Estimated project cost.

Initially, the benefits of the different adaptation projects were scored to be able to rank them. To do this the team was divided into three sub-teams, each consistently ranking the projects on a scale from 1 to 5, where 5 represented the greatest achievable benefit. The rankings from the sub-teams were then used to identify mean scores. Following that, the scores were standardised on a scale from 0 to 1 to proceed with the analysis and to allow costs to be included. The last step of the MCA was assigning weights to different benefits. The task force team decided to weigh the criteria differently according to the needs of Bhutan and the geographical scale of the projects (projects with national outreach were given greater weight than projects with local impact only). Table II-8 shows the standardized scores, the general and local weighing and the final ranks.

**Image II-5.** **Glacial lake in the Himalayas, Bhutan**

*Source:* C. Norbu

LESSONS LEARNED

Following the completion of its NAPA, Bhutan was the first country to receive funding for implementing its first two priority projects from the LDC Fund. Including stakeholders from all concerned ministries during the assessment of the adaptation options resulted in broad acceptance of the NAPA as a key guiding and planning tool in Bhutan.

**Source:** National Environment Commission, Royal Government of Bhutan. 2006. *Bhutan National Adaptation Programme of Action.* Available at <http://unfccc.int/resource/docs/napa/btn01.pdf>.

Table II-8. **Results of the ranking of prioritized adaptation options**

| Options | Criteria | Estimated cost | Human life/ health saved | Arable land, water supply etc. saved | Essential infrastructure and monuments saved | Summary of weighing | Initial rank | National (N) Regional (R) Local (L) | Adjusted ranking |
|---|---|---|---|---|---|---|---|---|---|
| | Weights to be multiplied with standardised results | 0.20 | 0.33 | 0.27 | 0.20 | | | N +15% R +/- 0% L -15% | |
| (1) Disaster Management Strategy (Food Security and Emergency Medicine) | | 0.71 | 1.00 | 0.75 | 0.25 | 0.7245 | 2 | N 0.833175 | 1 |
| (2) Landslide Management & Flood Prevention | | 0.56 | 0.75 | 0.75 | 0.50 | 0.662 | 4 | R 0.662 | 4 |
| (3) Rainwater Harvesting | | 0.56 | 0.75 | 0.50 | 0.00 | 0.4945 | 7 | N 0.568675 | 6 |
| (4) Weather Forecasting System to Serve Farmers and Agriculture | | 0.81 | 0.75 | 0.50 | 0.25 | 0.5945 | 5 | N 0.683675 | 3 |
| (5) Artificial Lowering of Thorthomi Glacier Lake | | 0.26 | 1.00 | 0.75 | 1.00 | 0.7845 | 1 | R 0.7845 | 2 |
| (6) Installation of Early Warning System on Pho Chu Basin | | 0.85 | 0.75 | 0.00 | 0.25 | 0.4675 | 8 | R 0.4675 | 8 |
| (7) Promote Community-based Forest Fire Management and Prevention | | 0.81 | 0.25 | 0.50 | 0.25 | 0.4295 | 9 | R 0.4295 | 9 |
| (8) GLOF Hazard Zoning | | 0.93 | 050 | 0.25 | 0.50 | 0.5185 | 6 | R 0.5185 | 7 |
| (9) Flood Protection of Downstream Industrial and Agricultural Area | | 1.00 | 0.75 | 0.25 | 1.00 | 0.715 | 3 | L 0.60775 | 5 |

## CASE STUDY 8.
## YEMEN: ASSESSING WATER MANAGEMENT AND ADAPTATION OPTIONS USING MULTI-CRITERIA ANALYSIS

### OVERVIEW

The Sana'a basin in Yemen is home to both extensive irrigated agriculture and the rapidly growing capital city. The region is already suffering from extreme water stress and modern pumping technology has created competition to exploit limited groundwater reserves. Forecasts show that aquifers within the basin could be exhausted within two to three decades and climate models predict that this scenario is going to further deteriorate under the impacts of climate change. This creates important implications for water resource demand and management.

Using the methodology developed under UNEP's *MCA4 climate initiative*, this case study set out to evaluate which adaptation policy option, or package of options, could build on current measures to best manage scarce water resources, whilst at the same time taking into account Yemen's other development priorities.

### ADAPTATION OPTIONS CONSIDERED

Adaptation options to improve water security in the Sana'a basin were broken down into three groups:

(1) Basin-wide adaptation policies consisting of three options:

- Strengthening existing basin-wide water planning and governance, through measures such as establishing limits on total water use by area and type, enhancing the power and responsibilities of water use associations etc.;
- Establishing natural and scenic land programmes to retire lands from agricultural use;
- Integrating land and water management by instituting low-cost loans and grants to maintain and restore terraces for soil and water conservation.

(2) Urban water adaptation policies consisting of three options:

- Protecting the quality and usability of existing water resources;
- Constructing a solar power desalinisation plant and transport infrastructure to pump desalinated sea-water to the Sana'a basin;
- Improving water pricing, for example, by reforming public water tariffs and metering methods, billing and revenue collection.

(3) Rural water adaptation consisting of two options:

- Creating incentives for a more efficient use of agricultural water, for example, by eliminating subsidies and other incentives for farmers;
- Creating incentives to promote demand-side technology uptake.

A central component of the *MCA4 climate initiative* is the generic criteria tree for policy evaluation (see figure II-6). At the highest level this takes into account inputs into a policy action (costs or efforts required to implement a climate policy option), and outputs of a policy action (the effects, be they positive or negative of a particular policy option). These criteria are not meant to be exhaustive, but simply to provide a guiding framework to support pro-development climate policy planning.

### RANKING OF OPTIONS

Having defined the policy options and the criteria against which they were to be evaluated, each policy option was then scored according to how well it performs against each criterion. Because of time constraints, the scoring was based on guess-estimates by the expert group assembled. To assign weights to the different criteria, the swing weight method was used. This approach first identifies the criterion which gives the greatest 'value added' in moving from the least preferred policy option to the most preferred. The relative value added associated with each of the other criteria is then considered and values assigned to reflect this.

With scoring and weighting completed, it was possible to see how each of the water adaptation policy options put forward for the Sana'a basin performed against the MCA4 climate criteria. Although it is possible to determine a measure of 'overall' performance for each option, it is more informative to consider outputs against inputs, highlighting those options which represent 'best value' relative to input. In the initial analysis, the first basin-wide option *Water planning and governance*, and the second rural water adaptation option *Creation of incentives to promote the uptake of demand side technology* were identified as the best options.

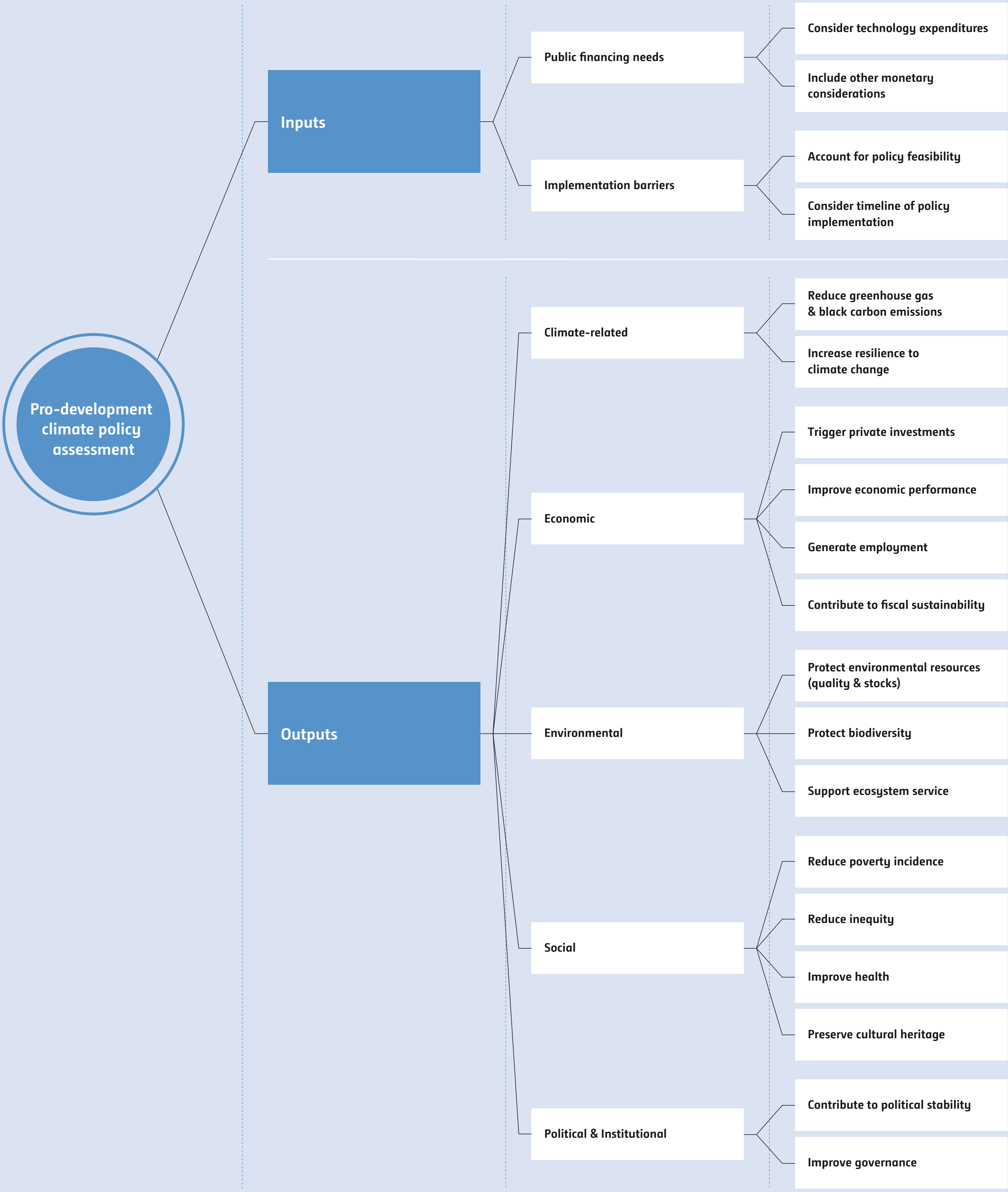
### LESSONS LEARNED

One of the lessons learned was that certain adaptation policy options perform better if they are implemented with other options. For example, if governmental reforms are taken as given, then the performance of some of the other policy options against the criteria was found to shift significantly. To address this, further analysis was conducted which evaluated portfolios of policy options rather than individual options.

**Source:** Miller K and Belton V. 2011. *Water Resources Management and Climate Change Adaptation in the Sana'a Basin, Yemen. Contribution to the MCA4 climate initiative.* Available at <http://mca4climate.info/_assets/files/Sana_basin_case_study_final.pdf>.

**Additional information** on the MCA4 climate project, including practical guidance on how to deal with a range of key issues such as discounting, macroeconomic assumptions and no-regrets options is available at <http://mca4climate.info>.

Figure II-6. **Generic criteria tree used to assess adaptation policy options**



## CASE STUDY 9.
## NETHERLANDS: ASSESSING ADAPTATION OPTIONS USING MULTI-CRITERIA ANALYSIS

### OVERVIEW

The Netherlands developed a national adaptation agenda through its national programme "Adaptation, Spatial Planning and Climate" (ARK), the aim of which is to provide a systematic assessment of potential adaptation options to respond to climate change in the Netherlands in connection to spatial planning. As part of the assessment, a detailed analysis of adaptation options using MCA was undertaken by the 'Routeplanner' group.

### ADAPTATION OPTIONS CONSIDERED

Following a literature review and stakeholder consultations, the group constructed a database of adaptation options and the associated effects for a variety of sectors, including agriculture, nature, water, energy and transport, housing and infrastructure, health, and recreation and tourism.

### RANKING OF OPTIONS

The group then identified evaluation criteria for a qualitative assessment of adaptation options, including (in order of importance):

(1) The importance of an option, reflecting the level of necessity for implementation;
(2) The urgency of the option, relating to the need to implement the adaptation option immediately compared to the possibility of deferring the action to a later point in time;
(3) No-regret options, which are those for which non-climate related benefits, such as improved air quality, will exceed the costs of implementation; they will therefore be beneficial irrespective of future climate change;
(4) Ancillary benefit options, which are specifically designed to reduce climate-change related vulnerability while also producing benefits that are not related to climate change;
(5) Mitigation linkages, as certain adaptation options will also induce a reduction of GHG emissions, and thus score very high on mitigation effect.

Different options were scored so that they could be ranked. The scoring scale ranged from 1 to 5, 1 indicating a low priority and 5 indicating the highest. To make the scores more robust and provide a broad overview, experts from many different sectors were invited to give their input. Furthermore, the scores were validated with external experts. Adaptation options that scored 'very high' (5) on the four most important criteria, include for example:

- Integrated nature and water management;
- Integrated coastal zone management;
- Water retention and storage.

There were also some options that scored (very) low on all criteria and therefore rank very low, including:

- Subsoil drainage of peatlands;
- Reclamation of (part of) the Southern North Sea;
- Abandoning of the whole of the low-lying Netherlands.

What these options have in common is that they are relatively far-fetched and costly, and should only be implemented when climate damages turn out to be extremely high.

Besides an equal weights ranking, the group assessed the options using different weighting of the criteria: 40 % weight for importance, 20 % weight for urgency, 15 % weight for no-regrets, 15 % weight for ancillary benefits and 10 % weight for mitigation effect to produce a weighted sum for each option. The choice of the weights did not affect the top options, as these scored very high on most criteria and high on the other.

Moreover, in order to properly inform policymakers, the feasibility of the different options was assessed using three different criteria:

- Technical complexity: technical difficulties and challenges which accompany the realisation of the option;
- Social complexity: involves the diversity of values which are at stake when the option will be implemented, the changes which are necessary in the perceptions of stakeholders, the necessity of their cooperation and so on; and
- Institutional complexity: the more institutions involved the higher the bureaucracy.

The scoring scale for the feasibility criteria also ranged from 1 to 5, whereby 1 indicated a low complexity and 5 indicated the highest complexity. The results of the feasibility scoring were also weighed to generate a ranking. The weights were distributed as follows: technical complexity (20 %), societal complexity (40 %), institutional complexity (40 %). While high scores in the first assessment indicated a high importance and desirability, high scores in the feasibility assessment indicated a high complexity to implement the option thus a low feasibility.

The initial plan was to include a supplementary CBA in the findings. However, due to a lack of monetary information about the costs and especially the benefits of all the options, the team was not able to fully finalise this portion of the project.

LESSONS LEARNED

The analysis revealed a slight relation between the feasibility of adaptation options and their ranking on importance, urgency, no regrets, ancillary benefits and mitigation effect. The feasibility analysis showed that many important and significant adaptation options encounter huge institutional complexity. That underlines the necessity of investing in more institutional flexibility.

The results of the assessment were used by the ARK programme in preparing the Dutch national adaptation strategy and agenda. Examples of suggested activities include Central government to take the effects of climate change into account when drawing up strategic national plans and implementing existing plans, the Ministry of the Interior to prepare disaster emergency plans that factor in weather conditions and the Association of Provincial Authorities to draw up a list of case studies to serve as demonstration projects for locations where climate change has to be taken into account.

**Source:** van Ierland EC, de Bruin K, Dellink RB and Ruijs A (eds.). 2006. *A Qualitative Assessment of Climate Adaptation Options and Some Estimates of Adaptation Costs.* Available at <http://promise.klimaatvoorruimte.nl/pro1/publications/show_publication.asp?documentid=1503&GUID=daf2fdee-fc8f-4966-ba80-a69e42145082>.

**Additional information** on adaptation efforts and economic valuation in the Netherlands is available at <http://climatechangesspatialplanning.climateresearchnetherlands.nl/themes/adaptation>.

Image II-6. **Dyke protecting settlement in Zeeland, Netherlands**

*Source:* Amina Laura Schild

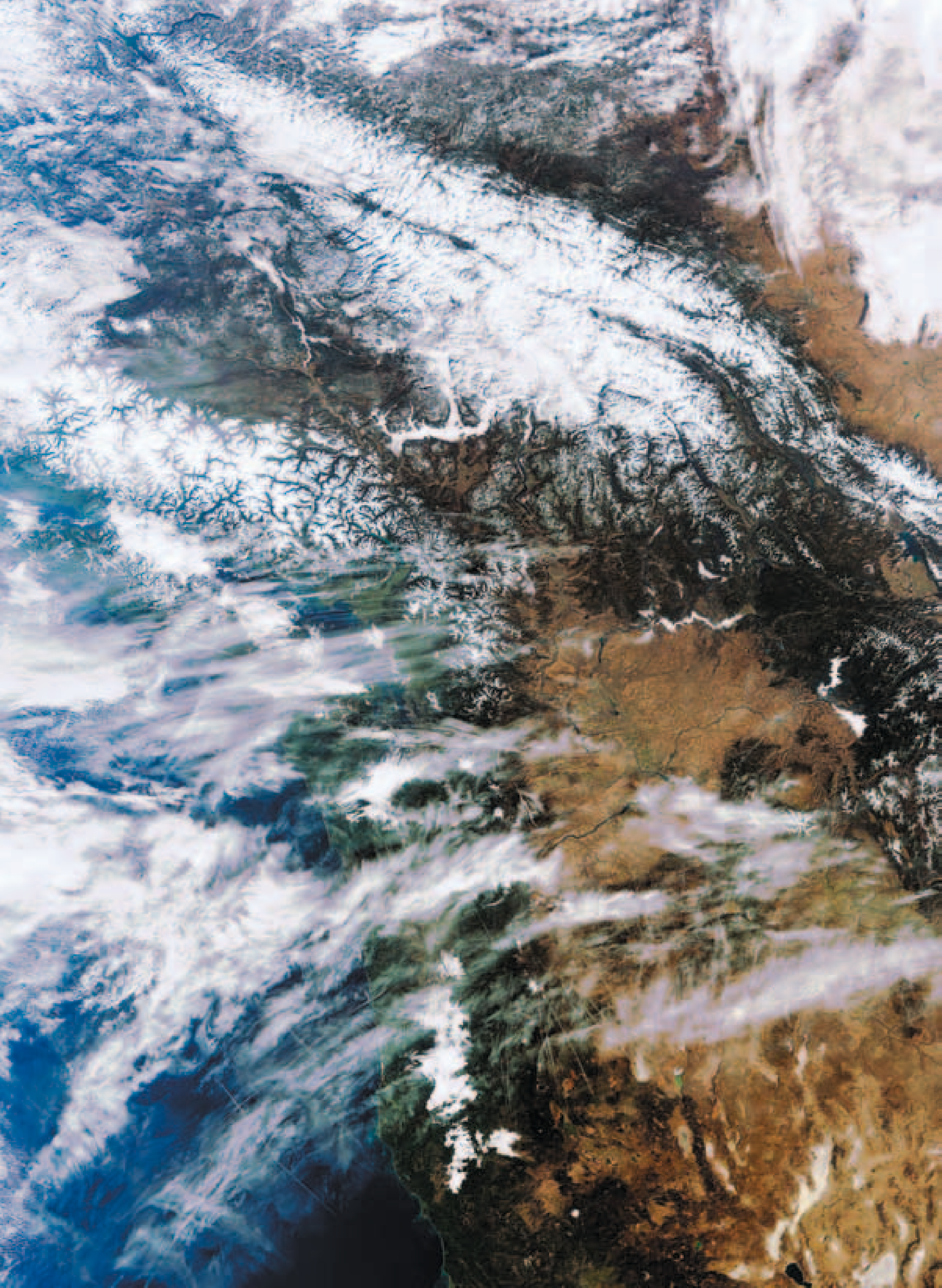
## 2.5. OTHER ASSESSMENT APPROACHES

Besides CBA, CEA and MCA, a number of other approaches can be used to support adaptation planning. These include, but are not limited to, environmental assessments, expert panels or risk-based approaches in which options that achieve an acceptable risk level are selected.

Risk assessments can be appropriate for long-term planning as they identify programmes, infrastructure or populations most at risk. They combine the likelihood and consequence components of climate-related impacts, and can assess risks for both current and anticipated impacts. Climate change risks are assessed alongside other non-climate related risks, ensuring that any identified action is fully integrated into ongoing planning efforts. For example, the Canadian community of Elkford developed its Adaptation Strategy concurrently with the update of Elkford's Official Community Plan, allowing the two to be fully integrated (see CASE STUDY 10). Risk assessments often lead to no-regrets, low regrets or win-win options. They can also lead to a single option that may have a cost, but is deemed a social/political priority and is hence implemented. In many cases they will identify several complementary options that together work towards achieving an agreed adaptation goal. If several options are identified and only one can be implemented, planners could subsequently undertake a CBA, CEA or MCA.

If no or only insufficient information on the costs and benefits is available, the Delphi method can be applied, whereby a structured iterative group communication is conducted to collect opinions and feedback from selected experts. First, the opinions of the different experts are collected by carrying out surveys using a questionnaire. The results of the survey will then be presented to the group and another questionnaire will be provided to the group building upon the results of the first survey. This way, opinions can be exchanged equally, and results cannot be influenced by more vocal stakeholders as could be the case in face-to-face conversations. A Delphi survey can be undertaken via mail, online or face-to-face.

Strategic environmental assessments (SEA) are another planning tool. SEAs systematically assess environmental effects of strategic land use related plans and programmes. SEAs are usually undertaken in transportation, waste management, regional planning, tourism and energy sectors. While SEAs are directed at strategic plans and programmes, environmental impact assessments (EIAs) are aimed at the project level and analyze possible negative or positive impacts that a project might have on the environment. Here, natural, social and economic aspects are accounted for to ensure that decision makers consider the environmental impacts before selecting an option. EIAs are usually undertaken in conjunction with other approaches such as CBA, MCA and various participatory tools.



## CASE STUDY 10.
## CANADA: ASSESSING ADAPTATION OPTIONS USING RISK-BASED PLANNING

### OVERVIEW

This case study highlights the ability of a small community to efficiently enhance resilience to climate change by integrating results of a simple risk-based assessment of vulnerability into standard community planning processes. The District of Elkford is a small community (population 2,500) in the rugged Rocky Mountains of British Columbia, Canada. Historically, Elkford has dealt with significant climate-related hazards, including flooding, drought and wildfires. A changing climate serves as a magnifier of all of these risks, including:

- Drier and warmer summers make forests more susceptible to wildfires and insect infestations;
- Receding glaciers, declining snowpack, and shifts in timing and amount of precipitation limit water supply during the peak summer demand period;
- Increased winter rain and changes in forest hydrology due to pine beetle infestation increase the risk of flooding.

In 2008, Elkford with support of the Columbia Basin Trust, a provincial Crown corporation, developed a local Adaptation Strategy that assessed the risks posed by climate change and identified corresponding adaptation measures. The Adaptation Strategy was developed concurrently with the update of Elkford's Official Community Plan (OCP), allowing the two to be fully integrated. A Community Advisory Committee provided guidance and ensured community priorities were reflected throughout the process.

### RISK-BASED ASSESSMENT

Foundational analysis of existing information on climate change impacts and projections was used to develop risk scenarios identifying physical and ecological impacts of climate change and associated socio-economic impacts on the community. A public survey, open house discussions, and input from municipal staff helped determine community adaptation priorities.

The methods for assessing risks were adopted from multiple sources, broadly following the framework for risk management described in the Canadian national standard "Risk Management: Guidelines for Decision makers". The risk evaluation framework (see table II-9 and figure II-7) includes examination of vulnerability (exposure, sensitivity and adaptive capacity) as a necessary precursor to evaluation of risk (function of vulnerability and probability).

Elkford used the probability of occurrence of each impact over the 20 year period covered by the OCP. Probability is based on historic occurrence, climate trends and, to the degree possible, climate projections. Once a risk level had been established, the community as a whole also had to determine what level of risk it was willing to accept (risk tolerance). In Elkford, the critical step in the risk assessment process was a one-day facilitated workshop involving municipal staff, councillors and the Mayor, as well as the Community Advisory Committee.

### ACTION PLANNING

For each climate change issue of concern to the community, adaptation goals and objectives were identified, and adaptation actions were formulated. The Adaptation Strategy defined a total of four overarching goals, nine objectives, and 26 actions. These were integrated directly into the OCP, which was adopted by the council in May 2010. Consideration of climate change in all decision making is one of the OCP's eleven guiding principles. As a result, adaptation is included throughout the document. For example, the OCP sets out a Wildfire Protection Zone and requires developers to submit fire hazard and risk assessments conducted by certified professionals prior to a development permit being issued.

District staff are now updating Elkford's development regulations and bylaws. The Zoning and Subdivision Servicing (infrastructure) bylaws are viewed as being particularly important in enhancing resilience to climate change. For example, the new floodplain development bylaw may include increased set-back requirements to reduce flood risks.

### LESSONS LEARNED

This case study demonstrates how a small community with limited capacity can efficiently address adaptation through existing planning processes. In Elkford, the process of assessing risk and incorporating the findings into the OCP took about one year and cost just over CAD 31,000 (plus significant volunteer time). The community has identified a number of lessons learned that are being shared to assist other communities undertaking similar adaptation plans and strategies. These include:

- The benefits of modifying existing adaptation risk assessment and decision-support tools and processes, rather than developing something completely new;
- The critical role of public engagement in the planning process;
- The value of placing initial focus on 'no-regrets' actions that enhance community resilience;
- The importance of integrating adaptation into a community's existing planning policy and regulations;

- That community plans, including those for upgrading and new infrastructure, require forward looking information in addition to historical information; and
- That effective strategies can include a range of actions that complement each other in the achievement of a defined goal, rather than defining adaptation 'options' that require choosing between actions.

**Source:** Gorecki K, Walsh M and Zukiwsky J. 2010. *District of Elkford. Climate Change Adaptation Strategy.* Available at <http://elkford.ca/include/get.php?nodeid=93>.

**Additional information and resources:**
Official Community Plan of Elkford available at <http://elkford.ca/official_community_plan>.

Table II-9. **Risk evaluation framework**

| | |
|---|---|
| Sensitivity and exposure | Current and expected risk |
| | Expected climate and non-climate changes |
| Adaptive capacity | Potential adaptation actions |
| | Barriers |
| Risk evaluation criteria | (1) Degree of sensitivity (low, medium, high) |
| | (2) Adaptive capacity (low, medium, high) |
| | (3) Probability of occurrence in 20 years planning period ('unlikely' to 'occurs frequently') |
| Overall risk ('negligible' to 'extreme') | |

Figure II-7. **Risk evaluation matrix**

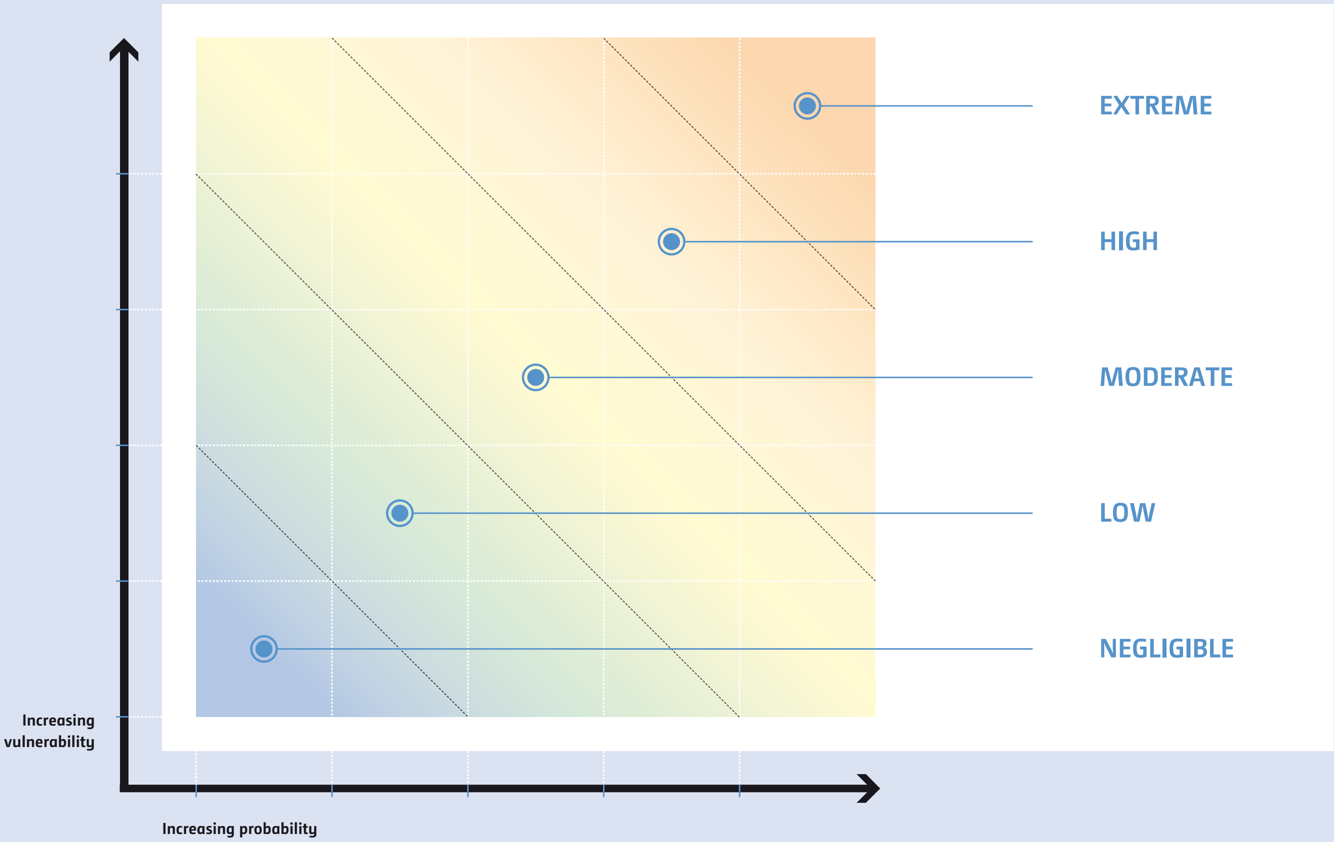


**Image II-7.** **Elkford in British Columbia, Canada**

*Source:* Kevin Shepit

# III. BEST PRACTICES AND LESSONS LEARNED

Adaptation planners should consider the strengths and weaknesses of the various approaches for assessing adaptation options vis-à-vis their objectives and circumstances. In some situations a number of approaches could be applied in a complementary fashion.

Table II-10 clusters the different assessment approaches and their main strengths and weaknesses.

Regardless of which assessment approach the adaptation planner chooses, each should be:

(a) *Practical*, i.e. approaches have to be appropriate for a given cultural and socio-economic setting and take into account data constraints. For example if the benefits cannot be quantified monetarily it is not advisable to undertake a CBA;

(b) *Relevant*, i.e. results should be presented in a timely manner and in a format that is compatible with existing decision making. For example, if public policy options are usually assessed using CBA, assessing adaptation options using CEA may be less acceptable;

(c) *Robust*, i.e. approaches should be transparent and consistent within and across sectors regarding the underlying climatic and socio-economic assumptions, expert judgments and uncertainties such as discount rates and be explicit about inherent uncertainties;

(d) *Comprehensive*, i.e. approaches should assess a wide range of options, including inaction, action outside sectoral boundaries and co-benefits; and

(e) *Proportional*, i.e. the depth of the selected approach should be driven by the decisions to be made and not by the aim for the perfect decision.

Many best practices and lessons learned have been illuminated throughout this publication. Adaptation planners should:

- Assess the costs and benefits of adaptation options following solid impact and vulnerability assessments as highlighted by the British and Nepali case studies;

- Consider short and long-term adaptation options in the broader development and planning context, as seen in The Gambia case study, and should identify a holistic adaptation portfolio rather than stand alone adaptation interventions, as shown by the Yemen case study;

Table II-10. **Assessment approaches and their main strengths and weaknesses**

| Approach | Description/outputs | Case studies |
|---|---|---|
| Cost-benefit analysis | CBA assesses benefits and costs of adaptation options in monetary terms. Outputs include net present values, internal rates of return or benefit-cost ratios. | Bolivia, The Gambia, Nepal and UK |
| Cost-effectiveness analysis | CEA identifies the least-cost option of reaching an identified target/ risk reduction level or the most effective option within available resources. | Brazil and Pacific islands |
| Multi-criteria analysis | MCA assesses adaptation options against a number of criteria, which can be weighted, to arrive at an overall score. | Bhutan, the Netherlands and Yemen |
| Risk assessment | Risk assessment analyzes current and future risks and identifies options to address the greatest threats. | Canada |

- Take into account distributional effects, i.e. the assessment needs to consider which sectors, groups or communities will bear the cost and which will enjoy the benefits of the adaptation option under consideration;

- Undertake sensitivity analyses, including variation of the discount rates, to investigate the robustness of the results as demonstrated by the Nepali and Brazilian case studies;

- Adopt, where possible, multiple approaches for assessing adaptation options, as linking these together would provide a greater evidence base. It can be almost impossible to see how one single approach could capture the complexities of the methodological underpinnings, the diversity of circumstances in which adaptation takes place and the variety of objectives with which adaptation is undertaken. For example, in the Dutch case study, MCA and a feasibility assessment were undertaken;

- Involve stakeholders in the assessment through surveys or workshops in order to create ownership and increase the chance of implementing selected adaptation options, for examples see the Bhutanese, Bolivian or Canadian case studies;

- Embed the assessment of adaptation options into the broader planning process and create vehicles or processes to ensure that results are integrated into national, subnational or sectoral policies, as shown in the British, Canadian and Dutch case studies; and

- Undertake evaluations following the implementation of selected adaptation option to assess whether the initial costing was higher or lower than the real costs and to assess the range of direct to more indirect benefits, as seen in the Nepali case study.

| Strengths | Weaknesses |
|---|---|
| CBA can provide concrete quantitative justification for adaptation options rather than just relative information. It allows for a comparison between different aspects using a common metric (e.g. USD). | CBA focuses on efficiency, when other criteria may be important (e.g. uncertainty or equity). It has difficulties with non-monetised costs and benefits and may need a subjective input into the choice of discount rate. |
| CEA can assess options, using units other than monetary units, thus it is good for effects that are difficult to value. It can be applied within the context of routine risks (e.g. health effects) as well as major climate risks. | CEA is unable to offer an absolute analysis or common metrics. It deals insufficiently with uncertainty or equity. The selection of thresholds or target risk levels is not always easy or objective. |
| MCA can consider monetised and non-monetised costs and benefits together. It also allows for considering a wide range of criteria including equity. | Scoring and ranking of options in MCA is subjective and not easily comparable. |
| Risk assessments can address issues surrounding uncertainty and allow for mainstreaming of adaptation. | Risk assessments require sufficient data and valid assumptions about the likelihood of various events occurring. |

# IV. CONCLUSIONS

Assessing the costs and benefits of different policy options is not unique to adaptation actions. Governments, businesses and communities have applied assessment approaches such as CBA, CEA and MCA, along with other tools to support their decision making and allocate scarce funds. Issues related to uncertainty, valuation and equity have often necessitated adjusting those approaches to the adaptation context.

The value of such assessments goes beyond attempting to quantify the costs and benefits. They can stimulate debate among stakeholders on the overall objective of adaptation and underlying climate-related and socio-economic assumptions and value judgments as well as assist in creating ownership and responsibility for implementation.

Given the increasing need for adaptation, assessments of the costs and benefits of adaptation options should support decisions rather than be seen as a prerequisite or reason to delay implementing urgent adaptation measures.

Assessing the costs and benefits does not end when adaptation measures are implemented. Costs and benefits should be monitored and evaluated during and after implementation. Monitoring and evaluation results should feed back into the adaptation policy process with a view to generating and applying new information and knowledge to continuously improve adaptation planning and implementation.

# ANNEX I. GLOSSARY

| | |
|---|---|
| **Adaptation assessment** | The practice of identifying options to adapt to climate change and evaluating them in terms of criteria such as availability, benefits, costs, effectiveness, efficiency and feasibility. |
| **Adaptation benefits** | The avoided damage costs or the accrued benefits following the adoption and implementation of adaptation measures. |
| **Adaptation costs** | Costs of planning, preparing for, facilitating, and implementing adaptation measures, including transition costs. |
| **Benefit-cost ratio (BCR)** | The ratio of the present value of the flow of benefits to the present value of the flow of costs of a measure. Benefits and costs are each discounted at a chosen discount rate. The benefit-cost ratio indicates the overall value for money of a project. If the ratio is greater than 1, the adaptation measure makes a positive net contribution to welfare. |
| **Contingent evaluation** | A non-market based approach used to provide an estimate of the economic value of non-traded goods, such as environmental effects, for which there is no direct market information. It estimates willingness to pay based on stated preferences of beneficiaries of adaptation measures. |
| **DALYs** | Disability-adjusted life years are a generic measure of health that enables comparison of reductions in health burdens across different disease conditions as well as combining morbidity and mortality effects in the same index. |
| **Discount rate** | A percentage rate representing the rate at which the value of equivalent benefits and costs decrease in the future compared to the present. The rate can be based on the alternative economic return in other uses given up by committing resources to a particular adaptation measures (opportunity costs), or on the preference for consuming benefits today rather than later. The discount rate is used to determine the present value of future benefit and cost flows. |
| **Inflation** | Rise in the level of prices of goods and services over a period of time. It results in a decrease of the purchasing power. Inflation is measured in the inflation rate, the annualised percentage change in a general price index. |
| **Interest rate** | A rate/fee at which a borrower pays for the use of money that they borrowed from a lender. |
| **Internal rate of return (IRR)** | Rate of return used to determine and compare profitability of investments.<br>While the NPV calculation finds the net present value using a predefined discount rate, the IRR finds the discount rate that makes the NPV equal to zero. The higher the internal rate of return of an adaptation measure, the more desirable it is. The measure with the highest IRR that is higher than the discount rate would be considered the best and undertaken first. |
| **Market-based approaches** | Methods used to value assets, goods or services on the basis of the prices at which similar items are available or traded in a free price system of supply and demand. |
| **Net present value (NPV)** | The difference between the present value of the benefit flows and the present value of the cost flows for an adaptation measure. The net present value should be greater than zero for a measure to be economically acceptable. |
| **Non-market approaches** | Methods used to value assets, goods or services that are not traded in competitive markets such as health assets or environmental services. The purpose of these approaches is to obtain data suitable for input into cost-benefit analyses, which are used to compare the values from alternative ‘uses’ of a resource. |
| **No-regret option** | Adaptation measures that would be justified under all plausible future scenarios, including the absence of climate change impacts such as floods or droughts. |
| **Opportunity cost** | Cost of any activity compared to its best alternative use. Assessing opportunity costs is important to find out the real cost of an activity. |
| **Present value** | The current value of a future sum or flow of money discounted at a specific discount rate. The higher the discount rate, the lower the present value of the future cash flows. |
| **Risk assessment** | Evaluation of the quantitative or qualitative value of risk related to a concrete hazard. Quantitative risk assessments include two components: the magnitude of the potential loss and the probability that it will occur. |
| **Sensitivity analysis** | Analysis of how the result of an adaptation assessment such as the NPV is affected by changes in key variables such as the discount rate. Where the measure is shown to be sensitive to the value of a variable that is uncertain, that is, where relatively small and likely changes in a variable affect the overall result, it is advisable to ensure flexibility and/or consider implementing a pilot first. |
| **Willingness-to-pay** | The maximum amount a consumer is prepared to spend, sacrifice or exchange in order to consume a particular good or service or to avoid something undesired, such as environmental pollution. |
| **Win-win options** | Adaptation measures that contribute to adaptation, wider development objectives and/or other defined policy objectives. For example, sustainable water management measures enhance climate resilience and contribute to poverty reduction. |

# ANNEX II. BIBLIOGRAPHY AND ADDITIONAL INFORMATION

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For further information see <http://unfccc.int/adaptation>

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