Valuing the Benefits, Costs and Impacts of Ecosystem-based Adaptation Measures

A sourcebook of methods for decision-making

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Note

This sourcebook appears together with a set of 40 case studies on EbA-relevant valuations that have been implemented globally, over recent years. They are referred to in boxes throughout the text and in Chapter 7, and are directly accessible as PDF files, through links.

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Summary: best practices and lessons learned about EbA valuation

EbA valuation is the process of describing, measuring and analysing how the benefits, costs and impacts arising from the implementation of ecosystem-based approaches to adaptation are generated, received and perceived. While the term valuation is variously understood, there is general consensus that it should be taken to refer to a process of expressing and communicating information about how much something is worth. There are three basic elements of EbA value: benefits, costs and impacts. Benefits are the advantages or positive effects of EbA measures; costs are the resources required to deliver EbA measures, and the disadvantages or negative effects caused by them; and impacts are the effects or changes in situations or circumstances that arise as a consequence of EbA measures having been undertaken. Basically, EbA benefits and costs interact to result in particular impacts.

This sourcebook addresses the topic of EbA valuation. It offers a resource to guide the design, delivery and use of EbA valuation studies to inform and influence decision-making.

EbA valuation does not only refer to monetary measurements, but also the assessment of biophysical effects, economic and livelihood impacts, social and institutional outcomes and even changes in people's knowledge, attitudes and practices. A wide array of methods are available with which to value EbA. These deal with different types of benefits, costs and impacts, have varying data needs, and express their results according to an assortment of metrics. On the one hand, the toolbox of valuation methods that can potentially be applied to EbA is a fairly standard one, and differs little from that which is routinely used to assess other types of adaptation infrastructure (or, indeed, public investments and development projects more generally). However, at the same time, ecosystem-based approaches have a number of special characteristics. These add a level of complexity to EbA valuation which may not be present in more conventional appraisals and analyses.

The sourcebook covers a range of different approaches to valuing EbA benefits, and describes experiences, lessons learned and best practices in how valuation has been applied and used in the real world.

Valuation can provide powerful – and much-needed – arguments for investing in Ecosystem-based Adaptation. Ecosystem-based approaches are now recognised to hold considerable potential to strengthen climate adaption (as well as other, closely related, processes such as disaster risk reduction and nature-based solutions). However, they are still yet to be fully mainstreamed into development policy and practice. One important barrier to uptake is the lack of demonstrable evidence of their effectiveness either in meeting adaptation goals or in delivering the other ecosystem service co-benefits that are claimed for them. Another constraint is that, despite a variety of methods being available (and long been used) to assess the costs and benefits associated with both adaptation infrastructure and ecosystem services, these have as yet seen little application to EbA. A recent review carried out by GIZ found that, despite a growing body of experience and applications, EbA valuation is still yet to reach its full potential.

As outlined in Chapter 1, the sourcebook addresses these methodological and informational gaps, and looks at how valuation can be used to improve the mainstreaming of EbA into adaptation policies, strategies and plans.

Valuation is not an end in itself, but a means to an end – better-informed decision-making which results in the delivery of more effective, sustainable and inclusive climate adaptation solutions.

Summary

However academically interesting it is to estimate the value of ecosystem services or the costs and benefits of EbA, these data mean little unless they actually affect how adaptation is planned and delivered in the real world. Valuation should be understood as a 'knowledge brokerage' process between the science and policy domains. It seeks to inform, influence or otherwise support decision-making, by transforming data on benefits, costs and impacts into information that can be used to support adaptation policy, planning and management in the real world.

Chapter 2 presents the fundamental principles and cross-cutting considerations that underlie EbA valuation, and which shape the sourcebook's focus on the design, delivery and use of EbA valuation studies to facilitate more inclusive, effective and sustainable adaptation planning and implementation.

It is very important to be clear about the purpose and intended outcome of EbA valuation, and ensure that it is fit to purpose in decision-making terms. The range of possible applications of EbA valuation is potentially very broad and context specific. It spans awareness-raising and priority-setting, through project planning and implementation, monitoring and valuation, to the design of broader policy instruments and incentive mechanisms to be used in support of EbA. Good studies do not only require sound technical methods, but also demand intelligent and strategic management, and 'joined-up' thinking. EbA valuation must be designed and conducted in ways that are appropriate to the adaptation decision-making context that it seeks to inform and influence, as well as to the social, economic, institutional and cultural setting in which it is being carried out.

Chapter 3 looks at how to define the practical purpose of an EbA valuation study, as well as the decision questions that it will seek to answer and address. It deals with the five main categories of the valuation purpose: identifying adaptation needs and opportunities, choosing between adaptation alternatives, justifying and making the case for EbA measures, and highlighting needs for instruments to support EbA delivery.

There is no such thing as the 'best' EbA valuation method. Methods generate varying results because they represent different perspectives or focus on different factors. Choosing between methods based on technical considerations alone is unlikely to be sufficient to identify the most appropriate design. An important guiding principle in EbA valuation is that one method is rarely enough: focusing on only a single aspect of values (for example biophysical, economic or social) is unlikely to provide an accurate or useful picture. Adaptation typically has multiple goals (which require different methods to assess them), and involves a diverse range of beneficiaries, costs-bearers and other stakeholders (who have different needs, priorities and perceptions of value). In almost all cases, EbA valuation requires taking a multidimensional, multisectoral and multidisciplinary approach, which combines different methods, perspectives and types of expertise. Valuation is a process of considering, synthesising and communicating different people's understanding and perceptions of EbA benefits, costs and impacts.

Chapter 4 lays out the different approaches and techniques that can be used to value EbA benefits, and presents case studies of how they have been applied. It deals with five main categories of valuation methods: biophysical effects, risk exposure and vulnerability, economic costs and benefits, livelihoods and well-being impacts, social and institutional outcomes. Guidance is also provided on dealing with risk and uncertainty, and identifying the appropriate mix of methods.

Summary

Valuation studies are most likely to be effective and have strategic impact when they manage information generation and dissemination in ways that simultaneously enhance the studies' relevance, credibility, and legitimacy to decision makers. Relevance refers to the applicability of valuation findings to the needs of adaptation planners, managers and policy-makers. Credibility deals with the technical adequacy and believability of the evidence and arguments presented about the effectiveness of ecosystem-based approaches. Legitimacy reflects the perceived validity and trustworthiness of both the EbA valuation process and its results as being fair, unbiased, and respectful of stakeholders' divergent values and beliefs.

Chapter 5 elaborates the four most important considerations in managing the valuation process so as to enhance its strategic impact: embedding the valuation study in real decision processes, defining and engaging the target audience, communicating interesting, appropriate and useful information, and building long-term capacity.

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Most valuation studies follow a logical progression through seven main stages. After framing the need for EbA valuation in the first place, the practical purpose and envisaged outcome of the study should be clearly defined. This also involves clearly specifying the questions that the study aims to answer, the stakeholders it seeks to engage with and the target audience that it intends to communicate with. The next step is to scope the values to be assessed, and identify the benefits, costs and impacts that will be considered in the study, as well as the beneficiaries and cost-bearers. Designing the valuation approach involves elaborating the specific methods and metrics that will be applied to measure EbA values. After collecting the data and analysing the information, the findings can be documented and disseminated.

Chapter 6 presents suggestions on four types of 'things to think about' and 'things to do' when commissioning, designing and implementing valuation studies: the reporting outputs, technical steps, process steps and coordination needs.

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There is a growing body of literature on the benefits, costs and impacts of both ecosystem-based and grey adaptation measures. These cover a wide range of methods, countries, sectors and adaptation measures, and offer important examples, lessons learned and best practices in the use and application of valuation in real-world decision-making contexts.

Chapter 7 provides a list of case studies of how EbA-relevant valuation methods have been applied in practice in adaptation decision-making and elsewhere. These 4-6 page case studies are directly accessible as PDF files, through links.

1 Introduction:

about the sourcebook

1.1

Why focus on valuation?

Few people would dispute that there is an urgent need to find effective, affordable and equitable measures to cope with changing climate conditions, which can enhance the resilience of both human and natural systems in the face of climate-induced risks and stresses. One way of doing this is to draw on the services of the natural environment. Natural forests and wetlands, for example, often play a key role in maintaining dry season waterflow and mitigating flood events, while mangroves help to protect coastal settlements and infrastructure against the effects of storms, tidal surges and sea-level rise. As farming systems become more risky due to unpredictable temperature and rainfall patterns, maintaining the genetic diversity of crops and livestock at the same time as investing in sustainable land and soil management practices can make a substantial contribution towards helping farmers to stabilise, sustain and secure their livelihoods into the future.

Ecosystem-based adaptation (EbA) is defined by the United Nations Convention on Biological Diversity as an approach that "uses biodiversity and ecosystem services ... to help people to adapt to the adverse effects of climate change", and may include "sustainable management, conservation and restoration of ecosystems, as part of an overall adaptation strategy that takes into account the multiple social, economic and cultural co-benefits for local communities" (SCBD 2009, 2010). Even though EbA is now recognised to have considerable potential to strengthen climate adaption as well as other, closely related, processes (such as disaster risk reduction and nature-based solutions), it is still yet to be fully mainstreamed into development policy and practice. 'Green' approaches continue to be considered a low priority as compared to more conventional 'sector-based' or 'grey' measures.

One important barrier to uptake is the lack of demonstrable evidence of either the effectiveness of EbA approaches in meeting adaptation goals, or their delivery of other ecosystem service co-benefits that are claimed for them. Another constraint is that, even though a variety of methods are available (and have long been used) to assess the costs and benefits associated with both adaptation infrastructure and ecosystem services, these have as yet seen little application in the context of EbA. Given these informational and methodological gaps, it is perhaps unsurprising that decision makers often remain unconvinced — or even unaware — about the potential advantages of integrating ecosystem-based measures into adaptation strategies. At the same time, it makes it hard to show that EbA yields a worthwhile return on investment, either in itself, as compared to or in combination with hard engineering options.

Efforts to measure, compare and communicate EbA benefits, costs and impacts (together referred to as "EbA values" in the sourcebook) are key to support better-informed planning and decision-making. In particular, they help to identify where ecosystem-based approaches can contribute towards more effective, inclusive or sustainable adaptation solutions.

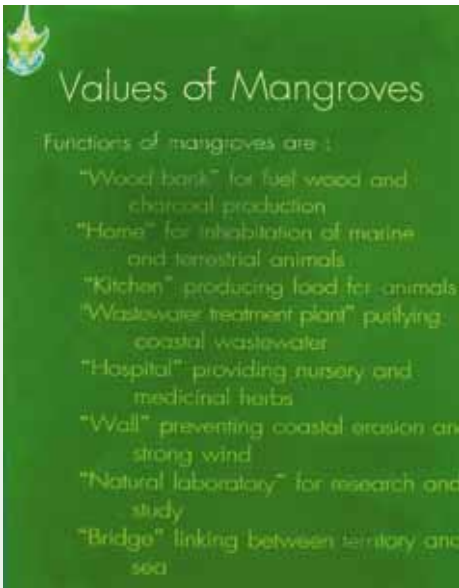
1.2

What does the sourcebook seek to deliver?

This sourcebook addresses the topic of ***EbA valuation***. It offers a resource to guide the design, delivery and use of EbA valuation studies to inform and influence decision-making. The focus is on facilitating more inclusive, effective and sustainable adaptation planning and implementation. It should be emphasised that the sourcebook does not seek to provide an inventory or toolkit of all the valuation methods that might be used to assess, measure, evaluate or make the case for EbA, or to lay out guidelines or a series of steps for carrying out a valuation study. This kind of detailed technical guidance is available elsewhere, and need not be replicated. For this, the sourcebook includes a collection of case studies of how valuation methods have been applied in practice, as well as a comprehensive reference list (see Chapters 7 and 8).

Rather, the sourcebook deals with the process of thinking through how to undertake the process of EbA valuation, and how to use the results effectively and convincingly to strengthen adaptation planning. A recurrent theme is that this does not only require sound technical methods, but also demands intelligent and strategic management, and 'joined-up' thinking. ***EbA valuation must be designed and conducted in ways that are appropriate for the adaptation decision-making context that it is intended to inform and influence, as well as to the social, economic, institutional and cultural setting in which it is being carried out.***

The sourcebook defines valuation not only as the estimation of monetary benefits and costs, but also the assessment of many other different types of impacts and effects, both quantitative and qualitative. ***EbA valuation extends far beyond only looking at economic impacts that are expressed in the market, and is also concerned with non-market economic values, as well as biophysical effects, risk exposure and vulnerability, livelihood and wellbeing impacts, social and institutional outcomes.*** The emphasis of the sourcebook is however primarily on methods to assess socio-economic values. It deals with biophysical assessment methods only as a component or complement in valuing the impacts of EbA on human systems and does not contain detailed guidance on their application.



1.3

How and by whom is the sourcebook intended to be used?

The sourcebook offers a *guidance document* that can be consulted during the course of designing and delivering EbA valuation studies. The intended purpose is to provide information and direction about when and why it might be useful to assess and measure EbA benefits, costs and impacts at different stages of the adaptation planning and implementation cycle.

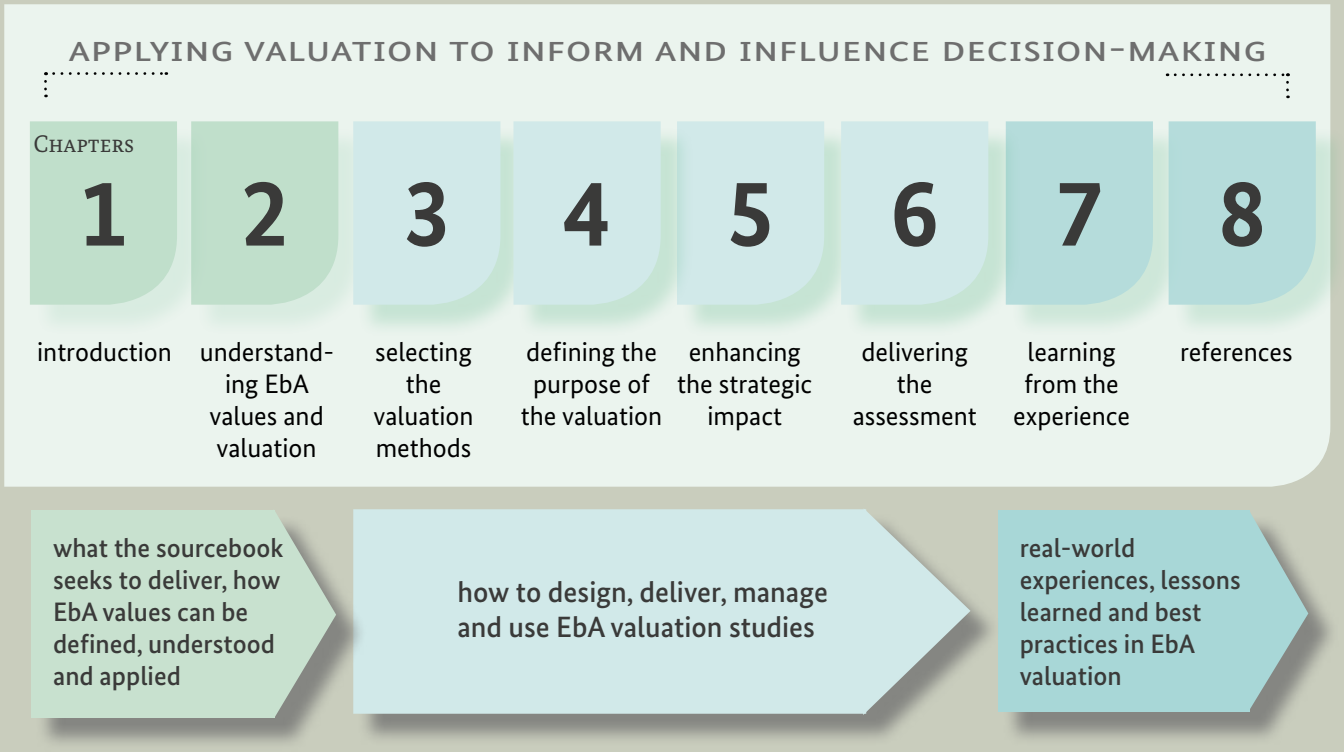
As such, *the sourcebook is targeted at the people that are responsible for commissioning, supervising and using the results of such studies to inform and influence decision-making*. It is not aimed at the technical experts or practitioners that are engaged to carry out EbA valuation. The application of valuation methods requires specialised training and experience, and detailed technical guidance.

The primary audience for the sourcebook is therefore the staff of government institutions, development agencies and non-government organisations that are responsible for planning, appraising and implementing adaptation measures, and those from environment and development sectors who have an interest in promoting ecosystem-based approaches. Readers are assumed to already be familiar with the principles of ecosystem services and climate change adaptation: the sourcebook does not provide a general background to EbA, only to its valuation.

The sourcebook deals mainly with climate change adaptation activities that are being carried out in support of public interest or triple bottom-line goals. Corporate and private sector planners and managers are not the main intended audience. This is because assessing and measuring EbA benefits from a purely financial or private viewpoint requires a slightly different approach, conceptual basis and logic, even though it may use similar methods to those laid out in the sourcebook.

EbA valuation methods

FIGURE 1: Content of the sourcebook



1.4 What is the content of the sourcebook?

The sourcebook contains three main sections, organised into eight chapters (FIGURE 1).

The first section (CHAPTERS 1 and 2) covers the background and introduction to what the sourcebook seeks to deliver, why valuation can be useful, and how EbA values (i.e. benefits, costs and impacts) should be defined and understood.

The second section (CHAPTERS 3 - 6) provides guidance on how to design, deliver, manage and use valuation studies. CHAPTER 5 (which deals with tools to enhance the strategic impact of valuation) provide information which cross-cuts other chapters (on designing and delivering the assessment or study). CHAPTER 6 combines the insights of the previous chapters into a series of checklists for the design and planning of EbA valuation studies.

The third section (CHAPTERS 7 and 8) lays out real-world experiences, lessons learned and best practices in EbA valuation and assessment. These feed into the topics covered in other chapters of the sourcebook. As well as a reference list, this comprises a series of case studies of how valuation has been used to measure EbA costs, benefits and impacts in practice, using different methods, for various purposes, and across a range of sectors, biomes and countries.

Summary of Chapter 2

Key points to bear in mind when designing and delivering EbA valuation studies

The following chapter presents the fundamental principles and cross-cutting considerations that underlie EbA valuation, and which shape the sourcebook's focus on the design, delivery and use of EbA valuation studies to facilitate more inclusive, effective and sustainable adaptation planning and implementation. To these ends, it emphasises the following points:

- EbA valuation can be defined as the process of describing, measuring and analysing how the benefits, costs and impacts arising from the implementation of ecosystem-based adaptation approaches are generated, received and perceived.
- There are three basic elements of EbA value: benefits, costs and impacts. **Benefits** are the advantages or positive effects of EbA measures; **costs** are the resources required to deliver EbA measures, and the disadvantages or negative effects caused by them; and **impacts** are the effects or changes in situations or circumstances that arise as a consequence of EbA measures having been undertaken.
- It is not necessary to always assess or value each and every type of cost, benefit and impact. What is included in any given valuation study will vary, depending on its purpose and context.
- EbA valuation almost always involves dealing with multiple, often divergent and sometimes conflicting values that cannot be reduced to a single metric or numeraire. Wherever possible, valuation studies should attempt to adopt the concept of multiple values.
- EbA valuation is not an end in itself, but a means to an end — better-informed decision-making which results in the delivery of more effective, sustainable and inclusive climate adaptation actions.

2 The basics: understanding EbA values and valuation

While the term valuation is variously understood, there is general consensus that it should be taken to refer to a process of expressing and communicating information about how much something is worth, and is usually carried out to inform decision-making in some way (see, for example Berghöfer et al. 2015, 2016, GIZ 2012, Gómez-Baggethun and Martín-López 2015, Millennium Ecosystem Assessment 2005, TEEB 2008, 2010).

The sourcebook therefore takes a working definition of EbA valuation as ***the process of describing, measuring and analysing how the benefits, costs and impacts arising from the implementation of ecosystem-based adaptation approaches are generated, received and perceived***. Valuation may take a variety of forms and areas of focus. It does not only refer to the estimation of monetary benefits and costs, but also incorporates the assessment of biophysical effects, economic and livelihood impacts, social and institutional outcomes and even changes in people's knowledge, attitudes and practices.

Before planning or conducting EbA valuation, it is important to be clear about what is to be assessed or valued. While this will of course depend on the intended purpose and target of the study (see Chapter 3) as well as the decision-making context, project planning or investment appraisal procedures it is being fitted into (see Chapter 5), it is useful to think through the scope of the valuation exercise and be aware of the possible range of items to be included. This will have an important influence on the selection of methods to be used (Chapter 4) as well as the processes of stakeholder engagement to be followed during the valuation exercise (see Chapter 5). It will, of course, also need to be reflected in the terms of reference that are prepared to guide the delivery of the study (see Chapter 6).

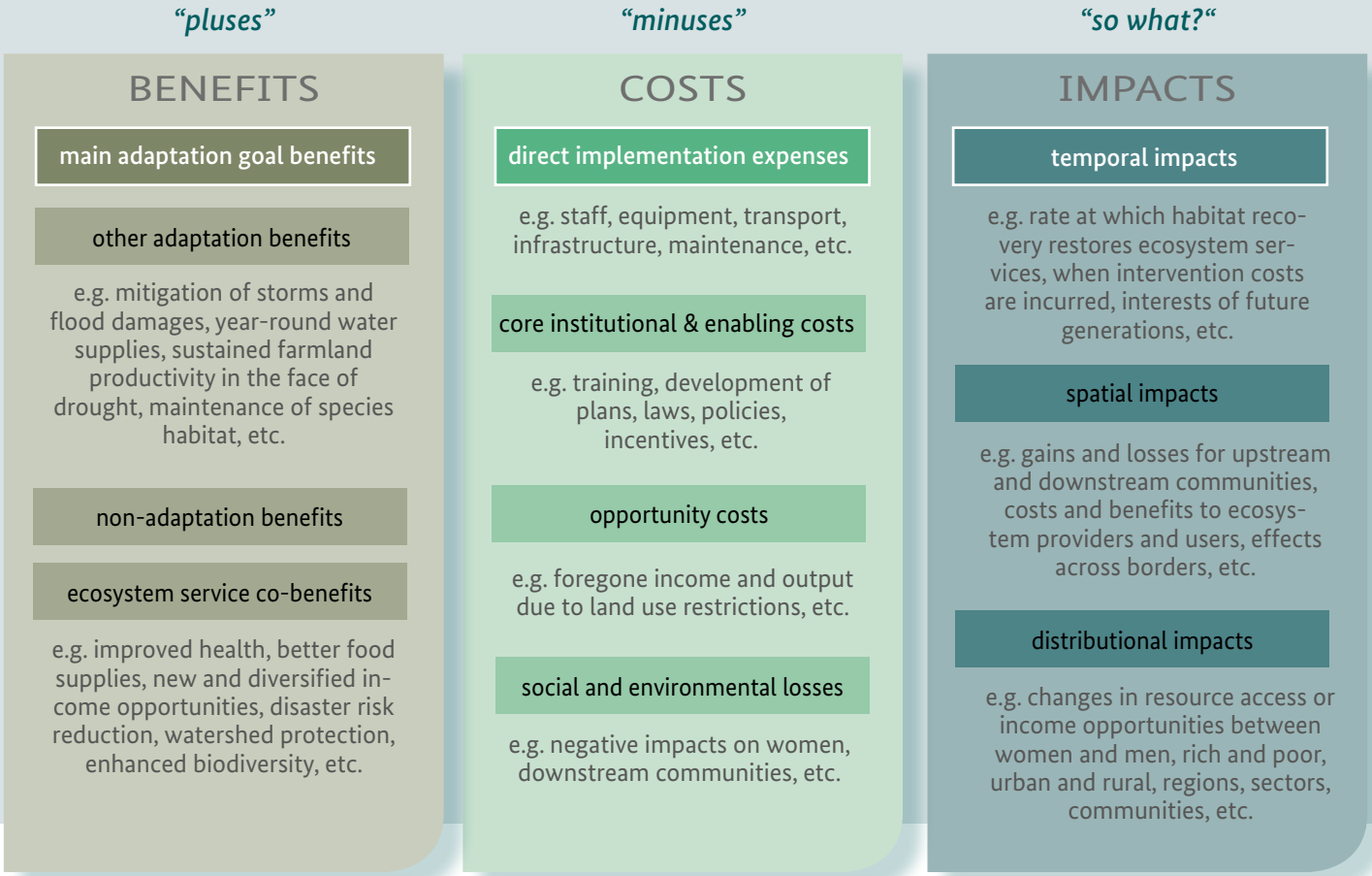
2.1 Thinking through what is to be valued

There are three basic elements of EbA value: benefits, costs and impacts.

Benefits are the advantages or positive effects of EbA measures; ***costs*** are the resources required to deliver EbA measures, and the disadvantages or negative effects caused by them; and ***impacts*** are the effects or changes in situations or circumstances that arise as a consequence of EbA measures having been undertaken. Basically, EbA benefits and costs interact to result in particular impacts. The process of EbA valuation or assessment usually seeks to describe, measure and analyse all three elements of this equation: the 'pluses', the 'minuses' and the 'so what?' or the consequences of the action in terms of how it affects different components of socio-ecological systems.

Each element of EbA value has a range of possible components (Figure 2). These are described in more detail in the paragraphs below.

FIGURE 2: EbA benefits, costs and impacts



It should however be noted that not all of these items are relevant to every situation: ***it is not necessary to always assess or value each and every type of cost, benefit and impact. What is included in any given valuation study will vary, depending on its purpose and context.*** Conventionally, and at a minimum, most studies would consider the main adaptation goal benefits, direct implementation expenses and/or temporal impacts. The inclusion of additional costs, benefits and impacts will depend largely on the study purpose, the decision-making process that it seeks to inform or influence, and on the interests and mandates of the organisation that is carrying it out.

For example, adaptation projects that have an overriding concern with targeting the poorest groups or with fostering green economy and growth outcomes would typically consider a far broader range of costs and benefits than those which are focused strictly on achieving a single climate adaptation goal. Incorporating ecosystem service values alongside adaptation benefits is almost always a core part of EbA studies (see Box 1).

Benefit and cost items are also not always additive. For instance, core institutional costs may be included alongside direct implementation expenses in the budget for implementing the EbA measures (for example technical training and capacity-building), or the main adaptation goal benefits may actually be those associated with a particular ecosystem service (for example flood protection or maintaining soil fertility and moisture).

Many EbA-related benefits are actually merely the inverse of climate losses or damages, and so to value both as separate items might result in double-counting. Items may also be expressed in terms of metrics that cannot be compared. Some values may be able to be monetised (such as the dollar value of project costs), others quantified only in physical terms (such as square kilometres of flood-impact zone), and others only described qualitatively (such as improvements in social empowerment and wellbeing or changes in policy and institutional settings). Indeed, this is one of the reasons that a range of different methods and technical approaches are required to value EbA benefits.

Box 1:

Valuing the costs and benefits of coastal adaptation options in the USA

One of the features of EbA is that it frequently offers an opportunity to not just secure climate adaptation outcomes, but to also generate a range of other ecosystem service-related social, economic and biophysical benefits. It is therefore particularly important to make sure that valuation studies are as comprehensive as possible in describing benefits, whether in monetary or non-monetary, quantitative or qualitative.

A study to investigate the effectiveness of alternative adaptation options in addressing coastal erosion, flooding hazards and sea level-rise in southern Monterey Bay, USA, identified a wide range of benefits associated with EbA.

Transgress conventional models for an accurate picture

It explicitly aimed to go beyond conventional appraisal and evaluation models which consider only a very narrow range of direct, physical costs and benefits and which therefore may not give an accurate picture of the relative viability and profitability of different adaptation options.

An integrated methodology was applied, which combined hazard projections with biophysical modelling and economic analysis, with the intention of allowing decision makers to compare how different adaptation strategies would impact their jurisdiction economically as well as physically.

Several different coastal protection measures were identified, both structural and non-structural (land use based), including beach nourishment, shoreline armouring, elevating infrastructure, property acquisition and conservation easements. The physical costs of implementing different adaptation options were estimated using market prices and budgets from actual projects. This incorporated a number of elements.

Costs for engineering measures and property purchase

For structural interventions, construction and maintenance, costs were included for new engineering measures, as well as the costs of structural modification of roads and buildings and replacement costs for any infrastructure (such as sewer lines and pump stations) that would be damaged or have to be moved. For the land use-based alternatives, the costs associated with the purchase of property or a right to that property were used.

Benefits were calculated by looking at damage costs avoided, based on an economic analysis of the private and public property, infrastructure, recreational and ecosystem service values associated with the coastal and inland resources that would be affected by coastal hazards. An asset register was compiled, and GIS was used to evaluate the exposure of assets to coastal hazards. The economic damages

See case study 39:
Integrated biophysical and economic valuation to weigh up coastal adaptation options in the USA

from storm events were estimated using depth-damage curves, coastal erosion damages were estimated by relating the landward extent of erosion to the market value of the land and/or structure at each exposed parcel. Losses to physical property and infrastructure (such as buildings, roads and water supplies) were valued at replacement cost, applying actual market prices.

Recreation value assessed

The study also valued key ecosystem services that would be secured by ecosystem-based (although not necessarily grey) adaptation measures. One of the most significant benefits was beach and coastal recreation, which was measured using a benefits transfer model which showed the change in value that would occur as beach width decreases or increases due to erosion. In addition, a range of other market and non-market ecosystem services were considered. A replacement cost analysis was carried out, based on reported costs of nearby coastal restoration.

A relative ranking of ecological value for each beach within the study area was then developed, scored for present conditions and then calculated for the changes in ecological conditions which would result from each adaptation strategy. This used several metrics to score the physical, biotic, and human impacts conditions of one square kilometre beach blocks.

Beach ecological index score

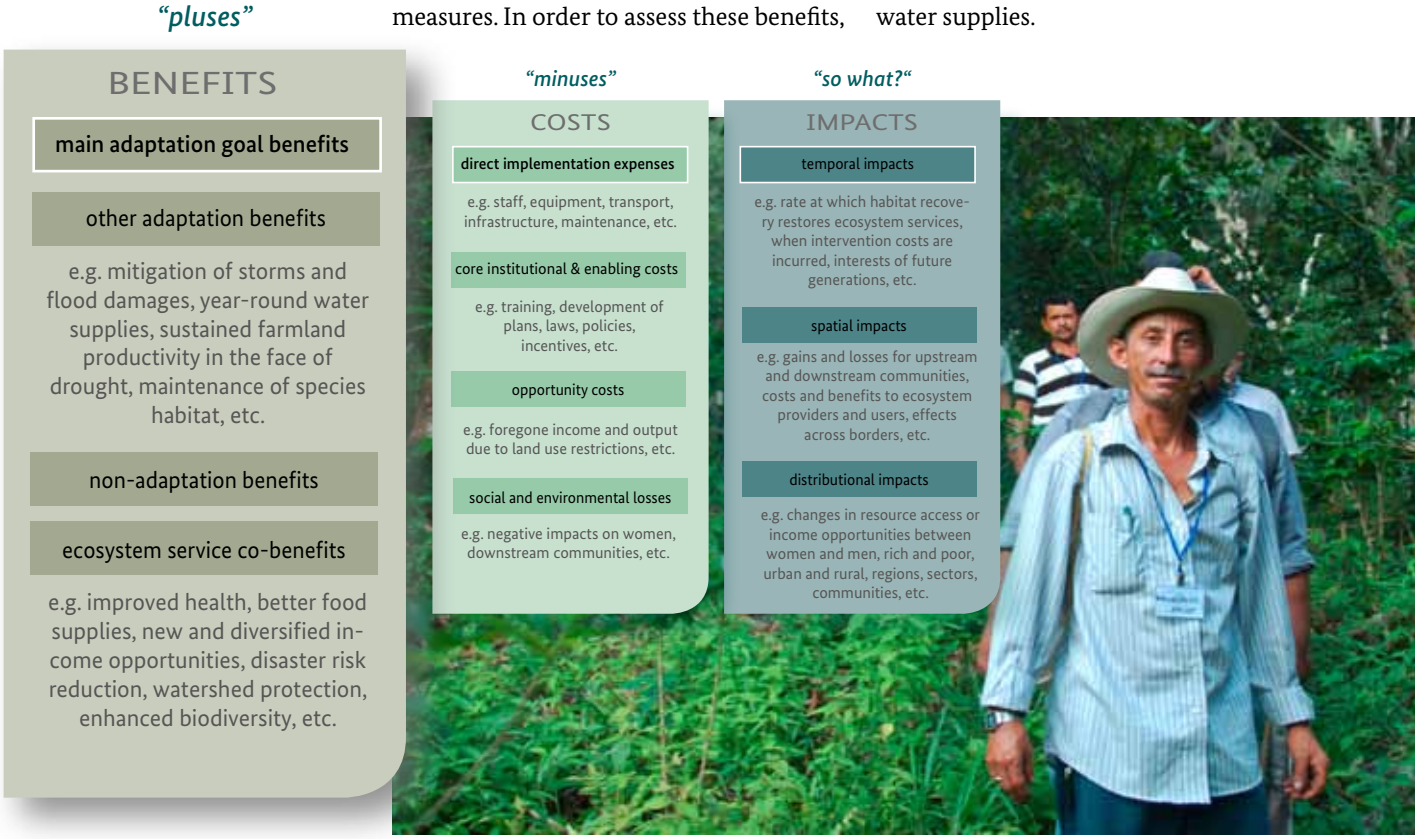
The resulting beach ecological index score was then combined with estimates of beach restoration (replacement) costs to provide a monetised ecological value. This assumed a 3:1 replacement cost for a beach with a 'perfect' ecological index score of 100, and scaled beaches with lower scores proportionately.

Benefits

Benefits are the advantages or positive effects of EbA measures. There are four basic benefit components that might be addressed in an EbA valuation study: the main adaptation goal benefits, other adaptation benefits, non-adaptation benefits, and ecosystem service co-benefits.

The primary concern is usually to value the ***main adaptation goal benefits***. These are the adaptation effects that the measure or intervention is concerned with generating in the first place. For example: improvements in farm production from climate-smart agricultural practices, or the reduction in damage to property, loss of human life and incidence of disease that is achieved by urban flood mitigation measures. In order to assess these benefits, it is necessary to have a clear idea of the adaptation goal that the EbA measure seeks to contribute to, as well as of the indicators that are being used to measure progress towards this goal.

In addition, the EbA measure may generate ***other adaptation benefits***, over and above its direct target or goal. For example, climate-smart agriculture interventions that aim to enhance crop yields may be based around sustainable land management, and also result in better water conservation practices which improve farmers' resilience to cope with the effects of drought. In a similar vein, flood control systems may also serve to enhance water storage and thus stabilise dry season water supplies.



A third item to consider is the ***non-adaptation benefits*** that result from the EbA action. For example, by changing crop mix and income, climate-smart agriculture may also result in improved child nutrition and reduced illness. Urban flood mitigation measures may lead to better year-round income security and transport links because of the reduced disruption to people's mobility.

One important – and often unique – feature of EbA measures is that they typically generate a range of ***ecosystem service co-benefits***. Ecosystem services are defined as the benefits people obtain from ecosystems (Millennium Ecosystem Assessment 2005), and include a wide range of valuable services which contribute towards human wellbeing. For example, climate-smart agricultural practices based on sustainable land management may also help to reduce erosion in watersheds and thereby stabilise downstream waterflow and quality. Wetland-based flood mitigation measures might also support fishing and recreational activities, store and sequester carbon, or provide habitat for rare or endangered bird and animal species.

Costs

Costs are the resources required to deliver EbA measures, and the disadvantages or negative effects caused by them. There are four basic cost components that might be addressed in an EbA valuation study: direct implementation expenses, core institutional and enabling costs, opportunity costs and social/environmental losses.

The ***direct implementation expenses*** are the immediate physical costs of carrying out the EbA measure, including both capital and recurrent costs. They will usually be calculated based on the budget that has been prepared for the action or project under consideration. For example, climate-smart agriculture interventions might involve the purchase of tractors, hoes and seeds, as well as farmer training and the establishment of model farms. Wetland-based flood mitigation measures could include the restoration and rehabilitation of degraded marshes, labour to carry out the removal of invasive alien species, as well as investments in basic infrastructure and spending on conservation management activities that are required to establish and run a wetland reserve.

Core institutional and enabling costs are the outlays that must be made on establishing broader support structures for the EbA activity. These can be significant, because EbA (and adaptation more generally) often requires the establishment of new agencies, capacities, laws, policies and incentive systems. These costs are often not included in the direct budget for the adaptation measure or action, because they are not being financed by the main project proponent, donor or investor. The introduction of climate-smart agriculture may, for example, also require that local extension agents are trained in new techniques and that farm subsidies are reoriented. The establishment of a wetland reserve might also necessitate the development of new legal instruments and management plans, and the deployment of additional field staff.

Opportunity costs are the potential gains from other, alternative, activities that are foregone or diminished by choosing to implement an EbA measure. This may be felt as a loss in output, income, jobs, food, fuel or any other product or service. Opportunity costs are often particularly relevant to EbA, because many ecosystem-based approaches involve restoring, conserving or setting aside a natural area which is being used for other purposes (or might have the possibility of being used in the future). As many EbA measures are also implemented as community-based projects or collaborative actions, they may also incur substantial time costs on the part of project participants (these costs are sometimes distinguished as 'transactions costs', but are grouped together with opportunity costs in this sourcebook because they primarily relate to the reallocation of time required to participate in

EbA, or the diminution of time available for other productive activities).

For example, the opportunity cost of climate-smart agriculture may be the production and income losses arising from a shift away from the intensive production of cash crops, as well as the additional time required for farmers to engage in village-level planning and information exchange. Wetland-based flood mitigation measures would typically preclude draining and conversion of the wetland for settlement and industry. They might also be accompanied by the introduction of restrictions on land and resource uses in the wetland reserve, as well as requiring the participation of local community members in wetland patrols, tree planting, awareness events and joint management committees.

A wide variety of ***social and environmental losses*** may result indirectly or as knock-on effects from the EbA action that is being valued (or from the other adaptation options that are being considered alongside it). Like ecosystem service co-benefits, these effects are often remote from the EbA measure that is being assessed in terms of where, by whom and when they are experienced – but, nonetheless, should be considered as part of the costs of undertaking it. For example, climate-smart agriculture may entail a shift to non-food cash crops which favours male farmers and traders, thereby impacting on women's income as well as children's nutritional status. Wetland-based flood mitigation measures may, by changing regional inundation patterns, result in reduced groundwater recharge and the drying-up of downstream flood-dependent pasture, riverbank farms and fishing lakes.

Impacts

Impacts are the effects or changes in situation or circumstances that arise as a consequence of EbA measures. There are three basic impact components that might be addressed in an EbA valuation study: temporal, spatial and distributional.

Temporal impacts refer to how benefits and costs accrue over time. They are often particularly important in relation to EbA because, while the adaptation effects of ecosystem-based approaches may often take a relatively long-time to become apparent, they can typically be sustained in perpetuity. For example, it might take several years for soil fertility and crop productivity to be restored after the introduction of climate-smart agriculture, but, once accomplished, these effects will continue (and even increase) as long as these farming practices are maintained. Similarly, wetlands flood control, and fisheries services will likely re-emerge gradually, only after revegetated areas have become sufficiently established to enable the resumption of these functions. In turn, other services such as the return of migratory birds and the development of a viable eco-tourism industry, depend on the restoration of these natural habitats and the species that inhabit them.

Spatial impacts refer to where benefits and costs accrue in the landscape. One of the key features of ecosystem services (and many other adaptation benefits) is that there is a mismatch between where an action is undertaken or where a service is generated, and where its effects are felt (see Fisher et al. 2009). For example, while climate-smart agriculture involves a series of actions that are implemented on farms, the watershed protection benefits arising from more sustainable land management practices are felt in downstream areas. Meanwhile, the primary impact zone of flood mitigation services may comprise settlements and infrastructure that is located at some physical distance from the wetland itself.

Distributional impacts refer to how different groups incur costs and receive benefits. They are closely linked to the issue of spatial impacts, because EbA beneficiaries and cost-bearers are often also physically remote from each other or scattered across the landscape. Distributional im-

EbA valuation

pacts are particularly important to consider in instances where EbA measures are being implemented as part of broader poverty alleviation or social inclusion strategies, where a project has an explicit equity focus, or in instances where there may be additional mechanisms need to set in place to redistribute funding or incentives in order to enable or sustain the EbA measures over the long-term.

For example, while it is local farmers that bear the on-site costs (as well as some of the gains) from climate-smart agriculture, many of the ecosystem service co-benefits accrue to far-off water users, hydropower facilities and irrigation schemes. Yet downstream water users rarely pay for these services, or contribute funding to sustainable land management activities in the watersheds they depend on. Similarly, neither the government parks authority that manages a wetland reserve nor the local communities who must restrict their land and resource activities in the adjacent area may benefit directly from flood mitigation measures – rather, it is more distant urban residents, their property and infrastructure that reap the main advantages in terms of reduced flood-related damages.

methods 2.2

The concept of multiple values

One of the defining characteristics of EbA is that it positions people at the centre of the adaptation process, and involves community-based and participatory approaches (IIED 2016, SCBD 2009, 2010). For this reason, the concept of value pluralism or multiple values has emerged as a key issue in EbA valuation (and in ecosystem assessment more generally). ***Wherever possible, efforts at EbA assessment and valuation should attempt to adopt the concept of multiple values.***

A first and very basic aspect to be considered is that value should be understood to refer to importance, rather than just monetary price (Gómez-Baggethun and Martín-López 2015). This is a key point in relation to EbA, because many of the benefits extend beyond goods and services that are traded in formal markets. Most of the appraisal and analysis processes that have traditionally been used to inform adaptation decision-making are based on monetary or – to a slightly lesser extent – biophysical valuation techniques and

metrics, and thus automatically undervalue ecosystem-based approaches (this issue will be considered further below, in Section 2.3). Not only does this kind of one-dimensional view of value reflect a particular economic paradigm which assumes that the market can accurately (and universally) assign values to all goods and services, but it also cannot present a balanced or comprehensive picture of EbA costs, benefits and impacts to decision makers. Rather, value should be seen as referring to a principle associated with a given worldview or cultural context, a preference someone has for a particular state, the importance of something for itself or for others, or simply a measure (Pascual et al. 2017).

EbA assessment thus almost always involves dealing with multiple, often divergent and sometimes conflicting values that cannot be reduced to a single metric or numeraire. Referring back to the definition presented at the beginning of this chapter, it is important to remember that valuation is a process of considering, synthesising and communicating different people's understanding and perceptions of benefits, costs and impacts. The concept of multiple values reflects on how differently people value ecosystem services and other benefits, depending on the natural space they live, their cultural and institutional backgrounds, as well as their worldviews, principles and preferences. In turn, a pluralistic or multi-

Box 2:

Measuring farmers' preferences for sustainable land management and climate-smart agriculture in Malawi and Tanzania

See case study 19:
Participatory mapping and valuation of farmers' land management costs, benefits and preferences in Malawi and Tanzania

Adaptation projects are often designed based on what scientists and external experts considered to be the 'best' technical and technological solutions. For example, many of the socio-economic and biophysical studies that are carried out to inform the design of agricultural adaptation interventions assess the benefits of different land management options according to externally-driven indicators of value, not in the light of what farmers themselves perceive as the main costs and benefits. It is perhaps hardly surprising that there are often contradictions between what research recommends, projects promote and donors invest in as being the most effective adaptation measures, and those which farmers actually carry out.

A more participatory, locally-driven approach was used to assess community perceptions and preferences for sustainable land management (SLM) and climate-smart agriculture (CSA) practices in Malawi and Tanzania. First of all, focus group discussions were held at the village level, in order to build up a picture of the social,

Participatory resource mapping

economic, institutional and biophysical context in which farmers operate and to identify key land management needs and challenges. Next, a participatory resource mapping exercise was carried out, where different groups such as men, women and youth showed how and by whom land was used and managed, and which resources were the most important to

dimensional approach to valuation involves recognising, making visible and respecting these diverse perceptions (IPBES 2016). It also typically requires a broad suite of methods to be employed to capture these multiple values, and a high level of stakeholder engagement to ensure that no perspective is misrepresented, marginalised or ignored (see Box 2).

different groups at different times and in different places.

Building on this information about how farmers differentially manage, use and depend on land, resources and ecosystem services in the face of climate change, the next stage of the study focused on establishing how farmers valued different land management alternatives. This used the Evaluating Land Management Options (ELMO) tool, a novel method that had been developed to investigate farmers' own perceptions and explanations of the costs and inputs, benefits and outcomes, advantages, disadvantages associated with different land management choices. The study yielded a number of interesting insights, which would have been unlikely to have been revealed by more conventional socio-economic and biophysical survey techniques. One key finding was that local perceptions of ecosystem service benefits, and how

Structural issues at stake

these change over time, vary widely between different stakeholders. The implication is that, if CSA or SLM interventions are being evaluated or planned, then they need to address the specific constraints that different types of farmers face, so that measures can be better targeted. These go far beyond just technical, technological or knowledge issues, and extend to structural issues in the laws, policies, markets and institutions that govern people's access to land, resources and livelihoods.

Meanwhile, ELMO made it clear that many of the CSA or SLM techniques that are most commonly practised and which farmers express the greatest preference for are not those which yield the highest production gains, generate the greatest income, or entail the lowest costs. This stands in stark contrast to the types of adaptation measures and land management measures that conventional agronomic, soil science and economic analysis would point to as being the most desirable intervention options. Farmers make decisions based on a wide range of on-farm and off-farm monetary and non-monetary costs, benefits, risks and opportunities which are not captured well by traditional survey techniques and analytical models.

2.3

Why under-valuation is often a problem

As mentioned above, there is no fixed formula to determine which benefits, costs and impacts should be included in EbA assessment or valuation. This depends largely on the reasons for the study, and the context in which it is being carried out. However, traditionally, the appraisals and assessments that are used to guide adaptation planning (or project planning and investment appraisal more generally) have tended to conceptualise intervention costs as comprising just the direct physical expenditures required to implement adaptation activities, and have measured benefits only in terms of the extent to which the main adaptation goal is delivered and impacts on direct, easily-measurable monetary benefits and physical impacts.

In this respect, the problem of under-valuation poses a recurrent problem for EbA. The main advantage of EbA measures tends to lie in their ability to simultaneously generate multiple adaptation benefits and co-benefits (including those associated with ecosystem services), deliver cost-effective long-term solutions, and maximise distributional and equity goals. Thus, failing to count the full range of (direct and indirect, monetary and non-monetary) benefits, costs and impacts automatically prejudices against EbA in adaptation decision-making processes. It also typically marginalises the needs and interests of the groups that stand to benefit from the provision of these wider goods and services (or will be negatively impacted by their loss) – often the poorest and most vulnerable groups who are unable to access or afford them elsewhere.

As is the case for many environmental and social projects, the more comprehensive a valuation or assessment is, the better it is likely to represent the advantages of EbA. Thus, in most cases, ***EbA assessment and valuation studies should explicitly seek to be as inclusive as possible in terms of their scope and coverage***. The intention is to demonstrate the wide-ranging advantages that can be gained from adopting and ecosystem-based approach, which will simultaneously benefit a diversity of groups and sites, and contribute towards several different adaptation and development goals.

2.4

Valuation as a means to an end

However academically interesting it is to estimate the value of ecosystem services, or the costs and benefits of EbA, these data mean little unless they actually affect how adaptation is planned and delivered in the real world. ***EbA valuation is not an end in itself, but a means to an end – better-informed decision-making which results in the delivery of more effective, sustainable and inclusive climate adaptation actions.***

The fact that EbA valuation will almost always be carried out in a decision-making context (and in support of a particular goal or desired outcome) provides much of the motivation for this sourcebook. The intention is to provide a basic reference on the issues that need to be considered in the design and delivery of a practical and policy-relevant study: how to undertake the process of EbA valuation, and to use the results effectively and convincingly. It is also the reason that the sourcebook emphasises topics such as defining the purpose of the valuation study (Chapter 3), enhancing its impact on decision-making, and managing the process in terms of stakeholder engagement, participation and capacity (Chapter 5). In many respects, these aspects of valuation planning are as – or even more – important than the question of which is the 'best' technical method or data source to use.

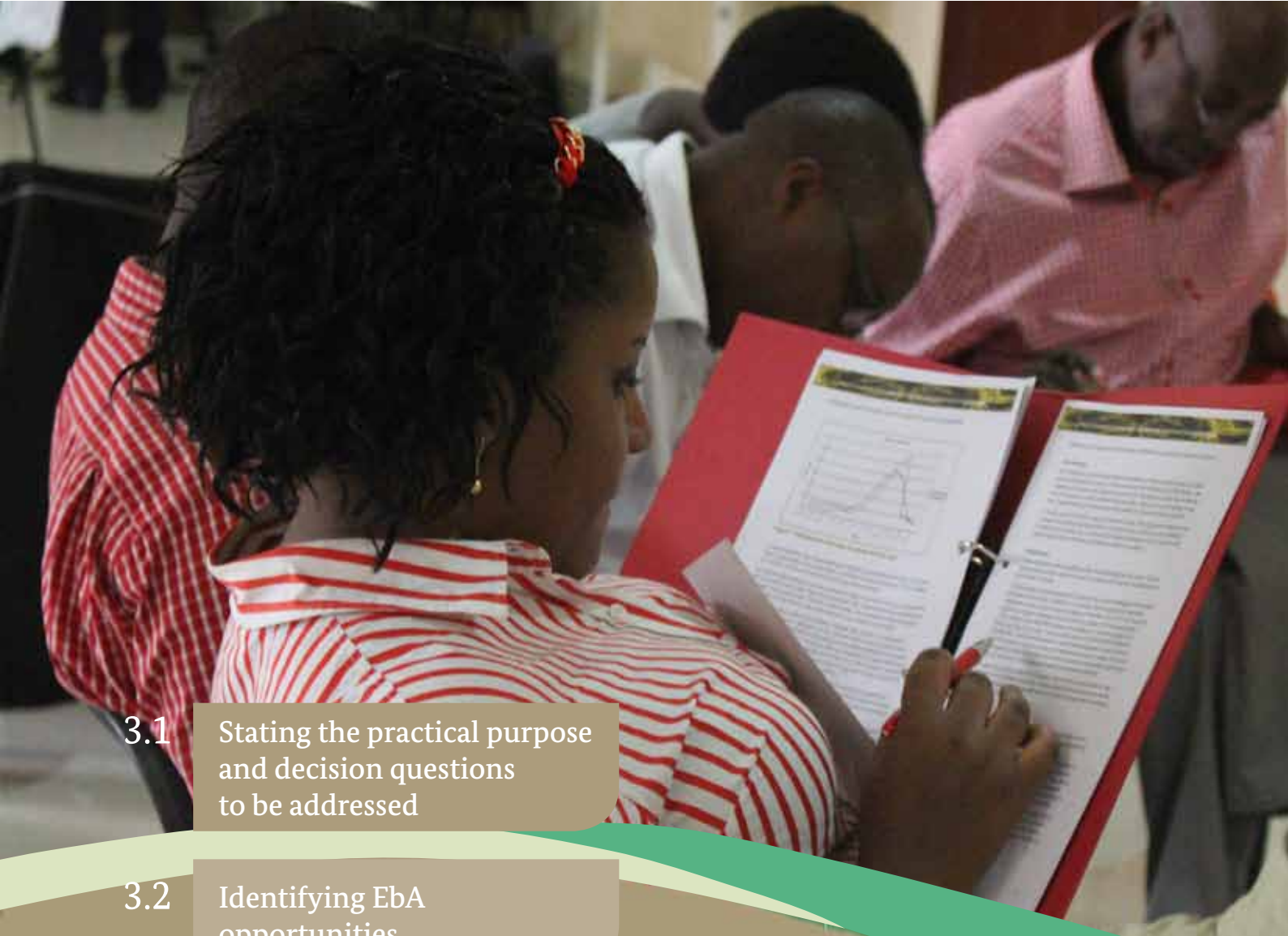
EbA valuation methods

Summary of Chapter 3

Key points to bear in mind when designing and delivering EbA valuation studies

The following chapter looks at how to define the practical purpose of an EbA valuation study, as well as the decision questions that it will seek to answer and address. It deals with the five main categories of valuation purpose: identifying adaptation needs and opportunities, choosing between adaptation alternatives, justifying and making the case for EbA measures, and highlighting needs for instruments to support EbA delivery. To these ends, it emphasises the following points:

- It is very important to be clear about the purpose and envisaged outcome of EbA valuation from the start, before the study has been designed or its methods selected, so as to be able to align it with the intended use (and users) of its results, and to ensure that it is fit to purpose.
- Having defined the purpose of carrying out EbA valuation, it is also necessary to articulate the questions that it will address and attempt to answer.
- Five broad categories of purpose can be identified, based on the stage of the EbA mainstreaming cycle at which valuation are being applied and its intended area of decision-making influence. These are:
  - identifying adaptation needs and opportunities,
  - choosing between adaptation alternatives,
  - justifying and making the case for EbA measures,
  - highlighting needs for instruments to support EbA delivery, and
  - monitoring and evaluating EbA implementation.



3 Defining the purpose:

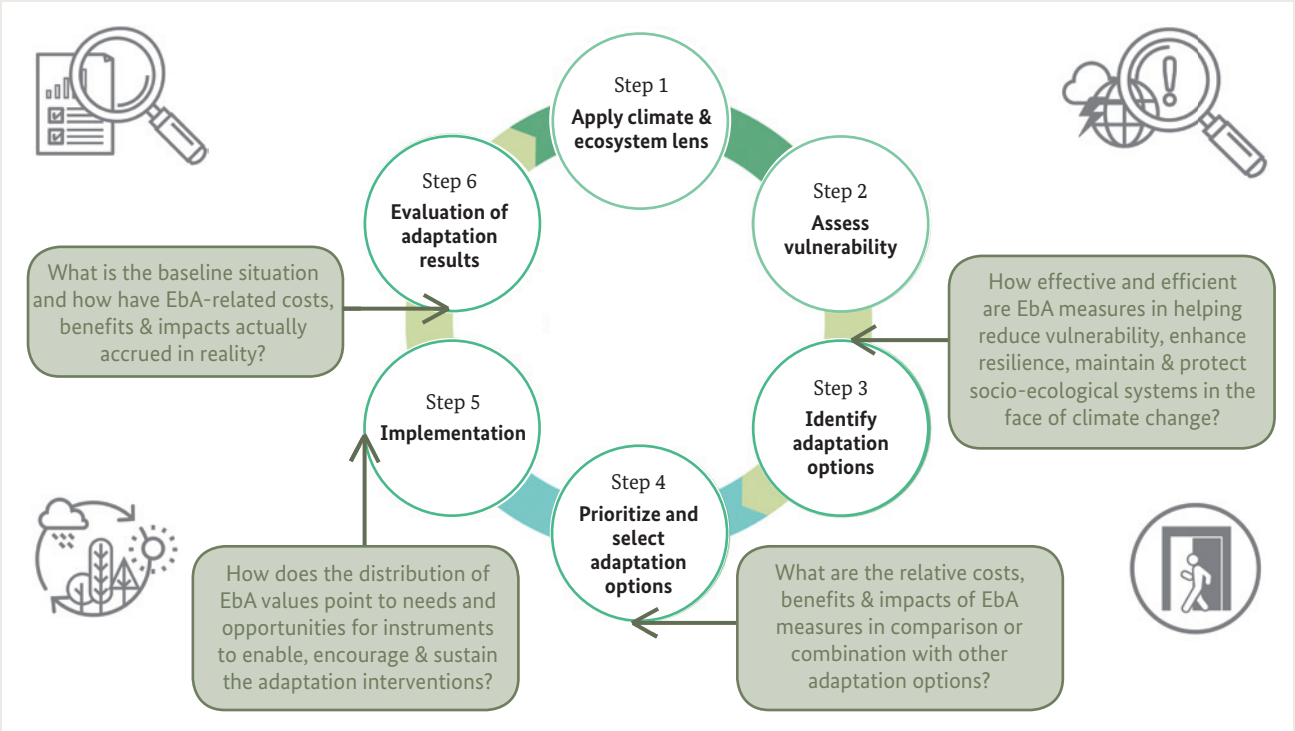
why and when to value EbA benefits

As mentioned at the beginning of Chapter 2, valuation involves describing, measuring and analysing EbA costs, benefits and impacts so as to inform, influence or otherwise support adaptation decision-making. As such, it feeds into several stages of the EbA mainstreaming cycle (Figure 3) – a systematic approach which explains how to integrate ecosystem-based approaches into a project, policy or planning process (GIZ 2013, 2016).

It is self-evident that EbA valuation primarily relates to the stages of the mainstreaming cycle that involve the identification, selection, design and implementation of actual adaptation interventions. This is because it is concerned with looking at the costs, benefits and impacts of EbA measures. Other valuation and assessment tools might be used to help to employ a climate and ecosystem lens or to assess vulnerability, but these are not the focus of the sourcebook (see for example GIZ 2012, 2013, 2014. IIED 2009, IFRC 2006, Kosmus et al. 2012, ULI 2015, UNFCCC 2005).

For example, being able to determine how effective and efficient EbA is in reducing vulnerability and protecting socio-ecological systems in the face of climate change helps to identify the most suitable adaptation options, and can be used to make a convincing case for the inclusion of ecosystem-based approaches. Weighing up the costs and benefits of EbA alongside other adaptation options permits it to be considered on equal terms when interventions are prioritised and selected. Analysing the way in which EbA costs and benefits are distributed between different groups or locations can help to highlight instances where additional incentives, financing or other instruments might be required to support and sustain the adaptation implementation. Last but not least, valuation typically plays a key role in establishing a baseline and then in monitoring and evaluating adaptation efforts.

Figure 3: Assessment and valuation in the EbA mainstreaming cycle



Adapted from GIZ (2016)

3.1

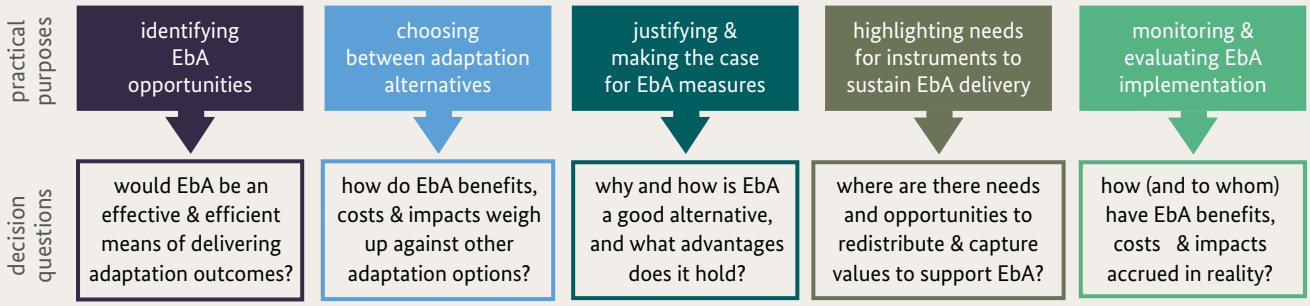
Stating the practical purpose and decision questions to be addressed

The range of possible applications of EbA valuation is thus potentially very broad. It spans awareness-raising and priority-setting, through project planning and implementation, monitoring and valuation, to the design of broader policy instruments and incentive mechanisms to be used in support of EbA. ***It is very important to be clear about the purpose and envisaged outcome of EbA valuation from the start, before the study has been designed or its methods selected, so as to be able to align it with the intended use (and users) of its results, and to ensure that it is fit to purpose.***

As mentioned at the end of Chapter 2, there is little merit in conducting a valuation study just 'for valuation's sake', and in practice there is no one-size-fits-all assessment approach. The study design must be matched to the context in which the valuation is being carried out, and tailored to its practical purpose (Berghöfer et al. 2015). It is of course also important to ensure that both the process of EbA valuation and its results are clearly embedded in (and relevant to) actual adaptation planning, policy and decision-making frameworks – this is closely linked to the issues of relevance, credibility and legitimacy (dealt with further below, in Chapter 5).

Five broad categories of purpose can be identified, based on the stage of the EbA mainstreaming cycle at which valuation are being applied and its intended area of decision-making influence (Figure 4). These are: identifying adaptation needs and opportunities, choosing between adaptation alternatives, justifying and making the case for EbA measures, highlighting needs for instruments to support EbA delivery and monitoring and evaluating EbA implementation.

Figure 4: EbA valuation practical purposes and decision questions



In turn, each of these purposes is associated with a different set of questions relating to EbA decision-making. ***Having defined the purpose of carrying out EbA valuation, it is also necessary to articulate the questions that it will address and attempt to answer.*** These elaborate the specific decision-making topics and challenges that the valuation exercise seeks to inform or influence. Doing this ensures that the valuation exercise has a clear focus and objective, which is rooted in real-world adaptation planning and implementation.

For example, if the purpose of the EbA valuation is to compare green options with other adaptation alternatives so as to make the case to urban planners for investing in mangrove restoration as part of a coastal protection strategy, then the decision questions might include: What level of storm protection and erosion control will the given area and quality of mangroves provide? What is the likely future trajectory of coastal erosion, storm severity and incidence under climate change? How many people, hectares of crops, units of industrial production, houses, roads, bridges and other infrastructure assets stand to be affected, and to what extent would they be protected? What would be the annual damage costs avoided? What other co-benefits would be generated by mangrove restoration? How long would it take before these benefits would be realised? What would be the costs of restoring the mangroves? How do these costs, benefits and effects stack up, and how do they compare to those associated with the other, grey adaptation options that are being considered?

3.2 Identifying EbA opportunities

Valuation can play an important role in helping to identify opportunities to use EbA in support of a given adaptation goal. Specifically, it offers a framework for assessing how effective and/or efficient ecosystem-based measures are in reducing vulnerability, enhancing resilience, or maintaining and protecting human and natural systems in the face of climate change. In this context, valuation would focus primarily on the potential benefits and impacts of EbA in addressing the selected climate issue or risk, as the intention is to identify whether (and/or which) ecosystem-based options might be worth considering as part of an adaptation strategy. It would typically be carried out as part of a scoping exercise, pre-feasibility study or project identification mission.

3.3 Choosing between adaptation alternatives

Most externally-funded projects and public investments are required to undergo some kind of a formal assessment process which compares various intervention alternatives, in order to select the 'best' option (see Section 5.2). The criteria for selecting the 'best' option will, of course, vary in different situations. Valuation offers a means of measuring the relative costs, benefits and impacts of EbA, in comparison or combination with other adaptation options, and identifying and evaluating potential trade-offs between them. It would typically be carried out as part of a project analysis or investment appraisal process, or to generate information to feed into social, environmental or other impact assessments.

3.4 Justifying and making the case for EbA measures

The generally low knowledge and awareness of EbA among both decision makers and adaptation beneficiaries means that it is often necessary to provide some kind of justification in order to get ecosystem-based approaches onto the agenda in the first place, before any more detailed appraisal or analysis is carried out. Even when EbA emerges as the 'best' intervention choice, it is often still necessary to explain further why it is a good alternative and to articulate the additional advantages it holds over other adaptation options. Information on benefits, cost-effectiveness and potential returns can provide a powerful – and often much-needed – argument for EbA. It may be carried out in a wide variety of contexts: for example, as part of a general public awareness campaign, in order to convince specific decision makers, project partners or stakeholders, as part of a funding proposal, or alongside the submission of a budget request.

3.5 Highlighting needs for additional instruments to sustain EbA delivery

As with any intervention, it may be necessary to set in place additional incentives, financing mechanisms or other instruments (such as training, co-management arrangements or supplementary livelihood activities) in support of EbA. For example, there may be a lack of long-term resources with which to sustain the EbA measures after project funding ends, local communities may require additional livelihood support to offset the opportunity costs of taking land or resources out of use, or it may be necessary to introduce fines, penalties, user fees or payments for ecosystem services to regulate people's activities or transfer payments between different groups.

Valuation offers a tool with which to highlight needs, niches and opportunities for these additional enabling instruments. While it will not identify which instruments will be the most useful or successful, valuation will suggest where there are substantial imbalances in the distribution of adaptation costs and benefits which may need to be addressed, or which may afford an opportunity to better capture or reallocate values between groups. In particular, analysis of the distribution of EbA benefits, costs and impacts identifies where (and for whom) there may be uncompensated costs, unrewarded benefits, unpenalized damages or uncaptured ecosystem opportunities (TEEB 2008, 2010). It shows where there may be a need for additional actions to enable, encourage and sustain the EbA interventions that have been set in place. For example, if sustainable land management interventions are being proposed as a means of securing water supply benefits, valuation can show what kinds of costs upland farmers are incurring, what kinds of damages avoided or value-added are being received by downstream water users, and thus what levels of transfer payments could (or would need to) be captured from water users in order to finance and incentivise watershed protection measures.

3.6 Monitoring and evaluating EbA implementation

Valuation is a key tool for monitoring and evaluating the results or outcomes of EbA interventions. It provides a consistent way of tracking how (and to whom) benefits, costs and impacts have actually accrued in reality, in relation to the baseline or without-project situation. As laid out further in Chapter 4, a wide range of valuation methods and indicators, potentially reflecting diverse perspectives, are available which can be used to describe the baseline situation and then to track changes over time.

Summary of Chapter 4

Key points to bear in mind when designing and delivering EbA valuation studies

The following chapter lays out the different approaches and techniques that can be used to value EbA benefits, and presents case studies of how they have been applied. It deals with five main categories of valuation methods: biophysical effects, risk exposure and vulnerability, economic costs and benefits, livelihoods and wellbeing impacts, social and institutional outcomes. Guidance is also provided on dealing with risk and uncertainty, and identifying the appropriate mix of methods. To these ends, it emphasises the following points:

- The toolbox of valuation methods that can potentially be applied to EbA is a fairly standard one, and differs little from that which is routinely used to assess other types of adaptation infrastructure actions.
- At the same time, ecosystem-based approaches have a number of special characteristics. These add a level of complexity to EbA valuation which may not be present in more conventional appraisals and analyses.
- EbA valuation methods can be clustered into five broad categories, based on their thematic and technical focus. These comprise:
  - Biophysical effects – changes in the levels or types of services that are available and used to assist human and natural systems to adapt to climate change.
  - Risk exposure and vulnerability – changes in the extent to which people are affected by climate change and are resilient and able to adapt to it.
  - Economic costs and benefits – changes in the constraints and opportunities that influence people's ability to produce, consume, trade and invest.
  - Livelihood and wellbeing impacts – changes in the constraints and opportunities for people achieve an adequate quality or standard of living.
  - Social and institutional outcomes – changes in people's rules, relations, conduct and circumstances.
- In addition, integrated analysis methods combine information from a number of different sources, and it is also often necessary to overlay valuation with the use of tools to deal with risk and uncertainty.
- There is no such thing as the 'best' method with which to value EbA benefits, costs or impacts. The purpose of the EbA valuation and the specific questions that it seeks to address or answer should drive the selection of methods.

4 Selecting the methods:

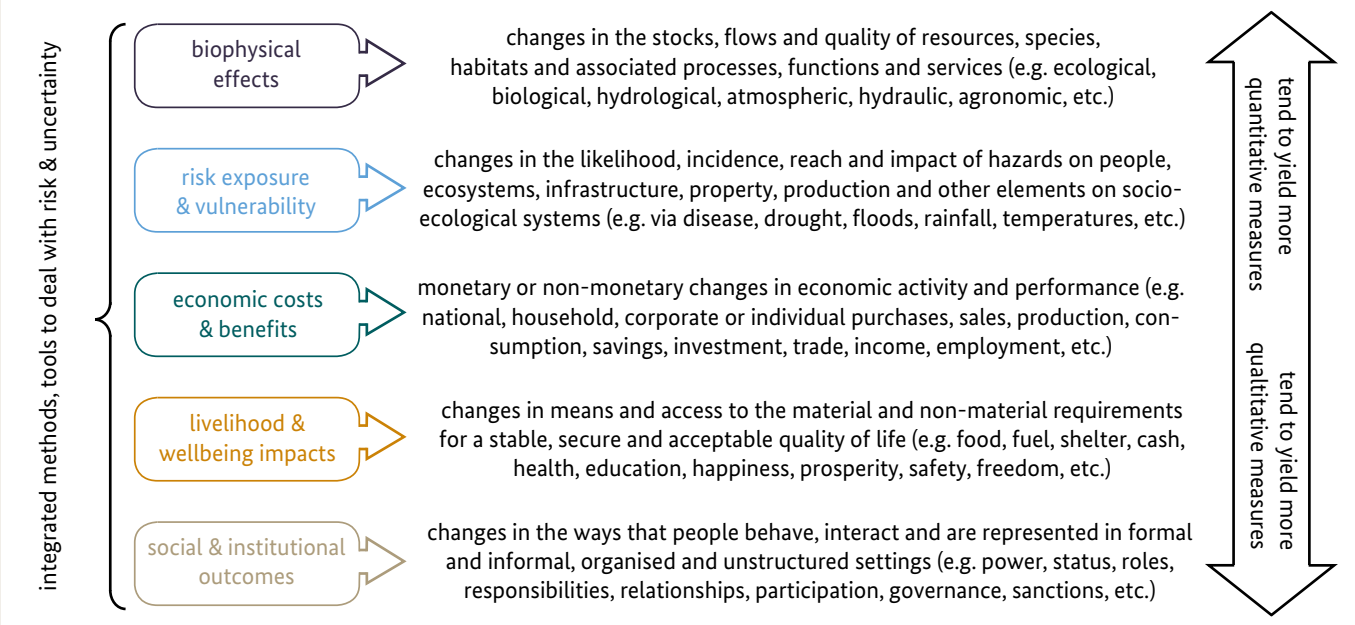
how to value EbA benefits

A wide array of methods are available with which to value EbA. These deal with different types of benefits, costs and impacts, have varying data needs, and express their results according to an assortment of metrics. On the one hand, ***the toolbox of valuation methods that can potentially be applied to EbA is a fairly standard one, and differs little from that which is routinely used to assess other types of adaptation infrastructure*** (or, indeed, public investments and development projects more generally). ***However, at the same time, ecosystem-based approaches have a number of special characteristics. These add a level of complexity to EbA valuation which may not be present in more conventional appraisals and analyses.***

One of the key features of EbA is the non-market nature of many of the benefits and co-benefits it generates. Ecosystem services often cannot be measured easily, accrue indirectly, or are produced as externalities to other sites, groups and sectors. It can also be difficult to attribute a particular quality or quantity of services to a given ecosystem, to establish how these services will increase or decrease as a result of changes in ecosystem area or status, or to deal with the issue of thresholds and non-linearities in ecosystem functioning. For example, many factors and relationships affect the generation of adaptation-related (and other) ecosystem services. In common with other types of adaptation measures, EbA also addresses climate effects and responses about which there is a high degree of uncertainty, are widely distributed across space and time, display high degrees of functional and spatial interdependence and involve vast and sometimes irreconcilable knowledge gaps and ambiguities.

EbA valuation methods can be clustered into five broad categories, based on their thematic and technical focus (Figure 5). These comprise methods to value biophysical effects, risk exposure and vulnerability, economic costs and benefits, livelihood and wellbeing impacts, social and institutional outcomes. In addition, integrated analysis methods combine information from a number of different sources, and it is also often also necessary to overlay valuation with the use of tools to deal with risk and uncertainty.

Figure 5: Categories of EbA valuation methods and examples



4.1 Biophysical effects

Valuing biophysical effects basically involves looking at changes in the levels or types of services that are available and used to assist human and natural systems to adapt to climate change. It requires identifying physical linkages and impacts, and measuring how the EbA measures under consideration will affect the stocks, flows and quality of resources, species, habitats and associated processes, functions and services (e.g. ecological, biological, hydrological, atmospheric, hydraulic, agronomic, etc.).

A recent review of EbA-relevant valuation methods carried out by GIZ pointed to the critical lack of 'hard' evidence of the physical effectiveness of ecosystem-based measures in addressing key climate hazards and adaptation goals (ECO Consult 2017). There was also found to be very little information available about the processes by which EbA approaches generate ecosystem service co-benefits. Most studies just look very generally at conserving or restoring a particular natural habitat, and assume that certain benefits will be secured. Since the logic and argument for investing in ecosystem-based measures rests on the assertion that they can generate particular benefits, this potentially undermines the credibility of efforts to demonstrate the advantages of EbA, and to make the business case for it.

Box 3: Commonly-used biophysical valuation methods

Just as adaptation goals and related ecosystem services vary (e.g. flood mitigation, storm protection, erosion control, crop production under stress, etc.), so a wide range of methods may be required to assess the biophysical effects of EbA, for example:

- Ecological (e.g. study of forest habitat composition, dynamics and human pressures over time)
- Biological (e.g. survey of aquatic flora and fauna)
- Hydrological (e.g. modelling of catchment runoff, infiltration, groundwater recharge, surface water flow and quality)
- Hydraulic (e.g. assessment of river depth, velocity and flood dynamics)
- Morphodynamic (e.g. assessment of the effects of river erosion and sedimentation interacting with seafloor topography, waves, tides, currents on shoreline profile and beach extent)
- Meteorological (e.g. assessment of the effects of river erosion and sedimentation interacting with seafloor topography, waves, tides, currents on shoreline profile and beach extent)
- Epidemiological (e.g. study of the incidence, spread and impact of water-borne disease)
- Nutrition (e.g. surveys of dietary habits, food intake and vitamin deficiencies among rural villages)
- Agronomic (e.g. study of cropping patterns, productivity and yield gaps)

While biophysical methods are not the main focus of this sourcebook, it is important to note that it is almost always necessary to have an idea of the quantity and quality of adaptation outcomes and ecosystem services generated by EbA in order to value its socio-economic benefits (Box 4). ***Some level of biophysical assessment and evidence of ecosystem functioning and chains of causality will almost always be required in EbA valuation.*** This is because the basic rationale for undertaking EbA rests on the claim that maintaining (or restoring) natural ecosystems will generate particular adaptation-related services and, usually, other social and economic co-benefits. Ecosystem services originate from spatially-structured ecosystems and land/seascapes, and depend on how their status is maintained over time (Lavorel et al. 2017). In general terms, the capacity of an ecosystem to provide adaptation-related ecosystem services depends on the area covered (its extent) and condition (its quality), and so the flow of services produced will vary depending on the condition and extent of the ecosystem (Hein 2014). It is necessary to be able to provide evidence that these biophysical linkages and causality actually exist, and the benefits being claimed for EbA really can be attributed to a given area, quality or type of ecosystem.

A variety of methods need to be used to assess and measure these linkages, as well as to model and project the changes in ecosystem services that will arise as a result of undertaking EbA measures (Box 3, also see Carpenter et al. 2009, Haines-Young and Potschin 2009, Hooper et al. 2005, Maes et al. 2014, Walpole et al. 2011). These may, depending on the adaptation context and goals under consideration, include ecological, biological, hydrological, hydraulic, morphodynamic, meteorological, epidemiological, nutritional, agronomic or many other methods. It is important to emphasise that specialised technical expertise is almost always necessary to undertake a biophysical assessment of EbA or ecosystem services (Box 5). With few exceptions, these types of studies lie well beyond the scope and capacity of socio-economic valuation experts.

Box 4:

Substantiating the links between grassland and wetland restoration and the generation of eco-hydrological services in Peru

See case study 25:
Physical impact assessment and cost-effectiveness analysis of green water interventions in Peru

All too often, the delivery of given adaptation and ecosystem service co-benefits is assumed rather than demonstrated when EbA measures are appraised and evaluated. This can act to undermine the credibility of the resulting findings and recommendations, especially where efforts have been made to model and quantify the biophysical impacts arising from alternative, grey adaptation measures.

The challenge: water shortages

A study was carried out to demonstrate the desirability of various ecosystem-based infrastructure options to ameliorate and overcome Lima's dry-season water shortages. The interventions centred around improving land and resource management in the upper watershed. The study was prompted by the need to generate evidence on the effectiveness of ecosystem-based approaches. While substantial built or 'grey' infrastructure projects had been planned and implemented to address the water crisis in Lima, green interventions were still not yet routinely considered as a part of the solution. The study therefore aimed to make the case for investing in ecosystem-based water infrastructure solutions, and provide the information that would be required to integrate them into project planning and selection frameworks.

Baseflow as core criterion

Baseflow was selected as the criterion against which performance would be assessed (the lowest rate of surface water flow in the year, expressed in cubic metres per second). The potential hydrological performance of different interventions was based on causal relationships recorded for agricultural programmes and credited watershed services markets in the United States, as well as local projects where possible. A variety of watershed mass equations and simple mass balance equations were applied to estimate improved baseflow for specific site-level sub-projects. The potential impact of each intervention was then estimated by projecting site-level baseflow benefits across the entire area of the watershed that each intervention would cover. Cost calculations were then undertaken, looking at expenditures made on materials, labour and project management (including community engagement and quality assurance). The cost-effectiveness analysis brought these two measures together. In order to calculate the marginal cost of each intervention, the annualised cost of the project was divided by the baseflow benefit, and presented as USD cost per cubic metre of waterflow.

Green interventions turned out effective and competitive

These indicators of cost-effectiveness were compared with 11 projects that are underway or planned for increasing water supply to Lima. The main finding of the study was that green interventions could substantially contribute to addressing Lima's dry season waterflow deficits, at costs that are competitive with the grey infrastructure options considered.

In addition, although not quantified in the study, it was pointed out that implementing these types of ecosystem-based interventions in Lima's upper watershed can result in additional social, cultural, and environmental benefits. These are particularly important in remote, underprivileged areas such as the upper watersheds, where local communities face limited and insecure livelihood op-portunities. Ecosystem-based options (unlike grey measures) also offer possibilities to increase local income, environmental conditions and water security, to engage upstream communities in supporting management efforts and even to investigate new markets and payments for ecosystem services.

Box 5:

Integrated analysis of physical effectiveness, cost-effectiveness and economic efficiency of flood risk management measures in Germany

See case study 13:
Physical effectiveness, cost-effectiveness and cost-benefit analysis of flood risk management measures in Germany

Subjecting adaptation measures to only one type of appraisal or evaluation technique, according to just one set of metrics, presents an incomplete (and sometimes incorrect) picture of their relative worth. Different measures perform more or less well, depending on the criteria they are measured against. For this reason it is best to combine a range of valuation techniques and metrics, to build up a more complete picture of the relative costs and benefits of alternative adaptation options.

For example, three different approaches were applied to evaluate flood risk management measures on the Mulde River, Germany. These were physical effectiveness, cost-effectiveness and economic efficiency. The aim was to demonstrate a methodology that could capture more fully the value of non-structural measures that are better in terms of effectiveness related to hydrological protection standards, and better make the case for these 'soft' techniques. The aim was to provide information which could help to overcome the barriers to implementation of non-structural techniques, and guide decision makers on the most appropriate methods to use when evaluating different measures in a consistent, comparative and comprehensive way.

'Do-nothing' option was taken as baseline for the evaluation

The physical effectiveness analysis measured the degree to which the measures achieved the specified adaptation target of no damages up to a 1:100 event. Average annual damages for different land use categories and inundation depths were computed compared to a baseline 'do-nothing' option, using a meso-scale damage evaluation approach to construct relative depth/damage curves. Monetary valuation then showed reductions in the monetary costs of average annual damages that would be achieved by each of the different adaptation measures.

The cost-effectiveness analysis compared the relative physical expenditures made on establishing and maintaining each option (costs) and outcomes (effects) of actions in terms of achieving flood-protection targets. These were expressed as absolute amounts as well as the costs per percentage of achieving the target (in other words the expenditures required to avoid 1% of the damages caused by a flood event each year). The cost-benefit analysis then drew these data together, and considered both cost and benefits in monetary terms as a measure of efficiency. It yielded measures of benefit:cost ratios and net present values.

Results may depend on criteria

Overall, the case study results showed that, when weighing up different flood control options, the choice of evaluation criteria can have a major impact on assessment results. In this regard, efficiency as an evaluation criterion was shown to be superior to cost-effectiveness and effectiveness. This is because cost-effectiveness and effectiveness are unable to consider all benefits in terms of damage reduction and might therefore favour structural over non-structural measures.

4.2 Risk exposure and vulnerability

Valuing risk exposure and vulnerability basically involves looking at changes in the extent to which people are affected by climate change and are resilient and able to adapt to it. It requires identifying when, how and to what extent certain physical or socio-economic impacts may occur and be felt by different people and places, and measuring how the EbA measures under consideration will affect changes in the likelihood, incidence, reach and impact of hazards on people, ecosystems, infrastructure, property, production and other elements in socio-ecological systems (e.g. via disease, drought, floods, rainfall, temperatures, etc.).

Although vulnerability assessment usually comes at an earlier stage of the EbA mainstreaming cycle, prior to valuing and comparing effectiveness and impacts of adaptation alternatives (see Chapter 3, Figure 3), one of the main goals of EbA is almost always to reduce the vulnerability of human and natural systems to the effects of climate change. This means that it is necessary to measure the changes in risk exposure and vulnerability that have occurred as a result of EbA.

A wide range of guidance is available on measuring climate risk exposure and vulnerability, at various levels of scale and for different sectors and stakeholder groups (see, for example IFRC 2006, GIZ 2014, ULI 2015, UNFCCC 2005). While there are significant challenges in integrating ecosystem services and capturing the complexity of social-ecological systems and their vulnerabilities, efforts have been made to develop approaches which specifically seek to address these factors in relation to EbA (see, for example, Munroe et al. 2015).

4.3 Economic costs and benefits

Valuing economic costs and benefits basically involves looking at changes in the constraints and opportunities that influence people's ability to produce, consume, trade and invest. It requires identifying economic linkages and impacts, and measuring how the EbA measures under consideration will result in monetary or non-monetary changes in economic activity and performance (e.g. national, household, corporate or individual purchases, sales, production, consumption, savings, investment, trade, income, employment, etc.).

Economic analysis typically forms a core component of adaptation valuation, and is often a required component of project appraisal and investment planning processes (see Chapter 5). There is now a relatively large number of studies which attempt to value the economic costs and benefits of EbA, especially ecosystem service values. These mainly seek to make the case for EbA or justify public investments in ecosystem-based approaches.

A wide variety of economic tools and techniques can be used to evaluate, rank or prioritise EbA measures in monetary terms, or compare them with other adaptation options (see Box 6). Most are concerned with measuring financial or economic profitability, via a range of (usually monetary) indicators such as net present value (NPV), internal rate of return (IRR), benefit-cost ratio (BCR), return on investment (ROI) or cost-effectiveness ratio (CER).

The most commonly used approaches (which have long been used in public and private decision-making processes to assess project alternatives or appraise investment options) are cost-benefit, cost-effectiveness and least cost analysis. Cost-benefit analysis weighs up the monetary costs and benefits over time

Box 6:

Commonly-used economic valuation methods

A variety of methods are commonly used to measure, value and analyse the economic costs and benefits of EbA, in monetary and non-monetary terms, for example:

- Cost-benefit analysis
- Cost-effectiveness analysis
- Least cost analysis
- Value for money approaches
- Input-output analysis
- General/partial equilibrium models
- National income/ ecosystem accounting
- Ecosystem valuation
- etc.

of different courses of action, cost-effectiveness analysis compares the relative (monetary) costs and (non-monetary, but quantified) outcomes or effects, while least-cost analysis determines the lowest cost alternative for generating a specified level of benefits (see Box 7 and Box 8). Value for money approaches have become increasingly popular over recent years as a way of assessing the relative desirability and performance of public investment options, and combine analysis of "the 4Es" of economy, efficiency, effectiveness and equity (see ICAI 2011, Jackson 2012). A large number of reviews, guidelines and toolkits can be found which outline how to apply these methods to climate change and adaptation issues (see, for example, ADB 2015, Lunduka et al. 2013, Shreve and Kelman 2014, Tröltzsch et al. 2013, UNFCCC 2011, UNDP 2015, Wise and Capon 2016).

Box 7:

Least cost analysis and cost-benefit analysis of watershed adaptation options in Thailand

Both biophysical and economic evaluations were carried out of alternative climate adaptation measures at the watershed level in two of Thailand's key river basins. The proposed interventions aimed to minimise the effects of extreme weather events such as floods, low river flows and droughts. Various EbA options were considered, including the management of natural floodplains and wetlands as silt traps, living weirs, riparian zone conservation as well as erosion control and forest rehabilitation in upstream areas. These were compared with the grey measures specified in existing river basin and infrastructure plans, such as physical control structures and dredging.

Direct costs calculated first

The studies had three, iterative, components: biophysical vulnerability analysis, scoping of engineering design options and economic appraisal of costs and benefits. Economic evaluations took up the identified EbA measures as well as the 'business as usual' grey engineering options that were already being implemented in the pilot river basins. The analyses considered a time horizon of 25 years, and used a discount rate of 3 per cent. First the direct investment and recurrent costs of each implementing measure were calculated, using actual market prices. This enabled a least-cost analysis to be carried out at each site, showing which of the adaptation options would be the cheapest to implement.

Next, benefit data was computed, using a combination of market prices, effect on production and damages avoided valuation techniques. This looked at the benefits (or avoided damages) associated with each adaption option in terms of changes in water quality and supply, crop yields and income. Ecosystem service co-benefits were also estimated for the EbA options, using benefit transfer techniques expressed per hectare of wetlands or forest.

Combinations of EbA and grey measures as model scenarios

Various scenarios were developed representing different combinations of ecosystem-based and grey engineering measures. Cost-benefit analysis was carried out to indicate net present values and cost-benefit ratios, as well as to show annual and overall costs avoided, and cost advantage per cubic metre of water.

See case study 35:
Biophysical and economic evaluation of climate adaptation options in Thailand's watersheds

Box 8:

Cost-effectiveness analysis of water-saving irrigation technologies in China

See case study 9:
Cost-effectiveness analysis of water-saving irrigation technologies for climate adaptation in China

While adaptation interventions often seek to contribute towards non-monetary objectives, economic arguments still provide a strong justification both to decision makers and to the intended beneficiaries of adaptation measures. Being able to demonstrate value for money or cost-effectiveness can provide an effective and convincing set of indicators with which to make the case for investing in EbA options.

In China, the economic viability of water-saving irrigation technologies as climate adaptation measures was measured by looking at the cost-effectiveness of four commonly-used technologies, as compared to traditional irrigation, in reducing the adverse effects of climate change. The reason for the study was that, although a large body of research indicated

Effectiveness yet to be valued

that certain irrigation techniques can contribute to water saving, the cost and effectiveness of using water-saving irrigation to cope with climate change remained unknown. It was observed that there have been few comparisons with other adaptation measures in the agricultural water sector. A clear picture of the cost-effectiveness of water-saving techniques for adaptation was thus seen as a way of supporting the identification of balanced responses to climate change and sustainable economic development.

Four of the most widely-used water-saving irrigation techniques in China (sprin kler irrigation, micro-irrigation, low-pressure pipe irrigation and channel lining) were each compared with a baseline scenario in which traditional irrigation was employed. Adaptation effectiveness was measured

Assessing all types of cost

in two ways, based on the main effects of water-saving irrigation techniques on reducing the adverse effects of climate change: increased crop yield and reduced water consumption (and hence improved drought resilience). Costs included the initial investment in capital and equipment, annual operations and maintenance, water fees and energy fees.

By comparing water-saving irrigation techniques against the baseline, the analysis yielded estimates of the cost-effectiveness ratios of annual average increase in grain yield and average volume of reduced water use per unit area of farmland irrigated. These were expressed as the additional cost of increasing each ton of grain yield (USD per tonne) and of reducing each cubic meter of water (USD per cubic metre).

Ecosystem valuation is often a core component of the economic analysis of EbA (see Box 9). While the question of how to place a monetary value on ecosystem services has long posed something of a challenge to economists, a suite of methods has been developed over recent years with which to value ecosystem services (see, for example Barbier et al. 1997, CBD 2007, Defra 2007, ELD Initiative 2015, Emerton and Bos 2004, Kumar et al. 2010, OECD 2002, TEEB 2008, 2010, UNEP-WCMC 2011). These are now relatively well-known and commonly-used, and are accepted by both conservation and development planners.

Box 9:

Factoring the value of ecosystem service co-benefits into coastal adaptation planning in Belize

Traditional economic appraisal techniques are not well equipped to deal with indirect and non-market values, or to trace the broader effects of adaptation actions beyond the immediate project site or adaptation goal. This means that it is often difficult to demonstrate the advantages of EbA as compared to other adaptation options.

Defence against sea level rise

The use of techniques to value and account for the economic effects of ecosystem services is becoming more common, in adaptation planning and elsewhere. In Belize, ecosystem valuation was incorporated into efforts to assess and compare the relative costs and benefits of alternative adaptation options to defend the coastline around Placencia against sea level rise and coastal storms. The study compared various packages of ecosystem-based options (including conservation and restoration of coral reefs and mangroves, forest restoration and rehabilitation) and grey infrastructure (such as sea walls).

Three co-benefits identified

The study included ecosystem services assessment, scenario development and cost-benefit aspects. Three ecosystem service co-benefits were considered in addition to the main adaptation goal (coastal protection): lobster fisheries, tourism and recreation, carbon storage and sequestration.

First, ecosystem service locations and levels of provision were modelled using InvEST (integrated valuation of ecosystem services and trade-offs). This is a spatially-explicit, software-based tool for modelling ecosystem service values and trade-offs that uses maps as information sources and produces maps as outputs. Three adaptation scenarios were compared: integrated adaptation (EbA and some grey infrastructure in developed areas without high-value beachfront property), reactive adaptation (grey infrastructure is the primary emphasis and sea walls are built to protect investments in tourism and private property), and no action.

The cost-benefit analysis then looked at the monetary impacts of the different adaptation measures in terms of their physical establishment and maintenance costs as well as the value of the ecosystem services they would generate. The value of lobster fisheries was calculated by looking at catch values, coastal protection values were estimated through avoided damages to property and infrastructure, tourism and recreation values were based on revenues and earnings, and carbon storage and sequestration was valued at the social cost of carbon.

Spill-over effect: potential negative impact on tourism

Benefit calculations also factored in spill-over effects (such as the potential negative impacts on tourism from seawall construction). The cost-benefit model also accounted for the expected costs that would arise from sea level rise and increasing temperatures in the future, including changes in lobster catch and expected property damage from erosion and storms. For each of the three adaptation scenarios under consideration, future cost and benefit streams were calculated, and discounted in order to yield a single measure of net present value.

See case study 5:
Use of InVEST to weigh up coastal adaptation options and trade-offs in Placencia, Belize

Numerous other quantitative (but not necessarily monetary) indicators can be used to measure the economic impacts and effects of EbA (see Box 10). These involve tracking changes in economic activity and performance in related markets (for example via purchases, sales, production, consumption, savings, investment, trade, income, employment and so on), or by looking at broader measures and statistics such as inflation, unemployment and interest rates, incidence of poverty, per capita GDP or Gini coefficients. Sometimes they are based on formal economic modelling approaches (such as national income accounting, ecosystem accounting, input-output analysis, general or partial equilibrium models), but more commonly just involve a simpler analysis of trends in the activity or indicator under question. These types of economic analysis can potentially be carried out at many different levels of scale, from the microeconomic (at the level of the individual person, household, farm, company, etc.), through sectors, to the macroeconomic (at the aggregated level of the overall village, province, country, region, etc.) analysis.

Box 10:

Assessing non-monetary economic indicators of adaptation impact in South Africa

Looking at changes in monetary values is not the only way of tracing the economic impact of adaptation measures, and may not always be the best one. For example, employment effects are a particular priority in South Africa's development and economic policy, and are considered to be a particularly critical vulnerability that could be severely worsened by climate change. One of the key goals of the National Climate Change Response is to reduce the impact of job losses and promote job creation, for example through using adaptation actions to create new jobs to which workers can migrate from affected sectors. Job creation and loss is also one of the core indicators in the national climate change monitoring and evaluation system.

A study was recently carried out to measure how climate change will affect employment in key sectors of the South African economy, and to identify how adaptation measures contribute to generating job-related benefits. This represents an innovative approach which attempts to move beyond the conventional emphasis on monetary measures of costs and benefits, and instead to look at broader indicators of economic impact and performance which both have a significance influence on people's social and economic wellbeing, and will resonate with development decision makers.

Farmers' jobs under threat?

A national employment vulnerability assessment was carried out. This looked at the likely impact of climate change on jobs in key sectors of the economy and at the national level. It considered both direct and indirect, positive and negative effects – for example how projected contractions in farming possibilities or declines in coal mining and steel production might lead to job losses, as

See case study 31:
Assessment of the employment benefits of climate adaptation in South Africa

EbA valuation

well as how adaptation actions could result in new employment creation. The main output was estimates of the numbers and types of jobs lost and created in different sectors and at the national level as a result of climate change (and climate adaptation measures), as well as analysis of linkages within the economy. The study generated indices of vulnerability which measured the severity of these different effects, and showed which kinds of jobs would be affected and for whom.

4.4

Livelihood and wellbeing impacts

Valuing livelihood and wellbeing impacts basically involves looking at changes in the constraints and opportunities for people achieve an adequate quality or standard of living. It requires identifying linkages and impacts on people's means of livelihood and perceptions of wellbeing, and measuring how the EbA measures under consideration will result in changes in means and access to the material and non-material requirements for a stable, secure and acceptable quality of life or standard of living (e.g. food, fuel, shelter, cash, health, education, happiness, prosperity, safety, freedom, etc.).

The GIZ review of EbA valuation methods discovered very few studies or commonly-applied methods which seek to value the non-monetary livelihood and wellbeing outcomes of adaptation measures (ECO Consult 2017). On the one hand, this means that the full impacts and benefits of EbA are often under-estimated. At the same time, it leads to the danger of livelihood and wellbeing goals being marginalised in favour of easily-measurable or monetizable 'hard' impacts. The relative neglect of livelihood and wellbeing in EbA valuation also has implications for distribution, equity and representation of the interests of particular groups. The review found a general failure to consider the perspectives and preferences of different groups. Most commonly the metrics and indicators used to measure (and judge) EbA benefits are determined by government policy-makers, technical 'experts' or development donors. Very few studies explicitly incorporate a diversity of alternative definitions of 'benefits', or articulate values in these broader terms.

Box 11:

Commonly-used livelihood and wellbeing assessment methods

A key concern in valuing EbA impacts on livelihoods and wellbeing is to find methods that can allow EbA benefits to be measured in terms of stakeholders' own ***perceptions***, ***preferences*** and ***priorities***, and expressed through locally meaningful metrics and indicators, for example:

- Sustainable livelihood analysis
- Household livelihood security assessment
- Participatory risk and vulnerability assessment
- Participatory ecosystem valuation
- Stakeholder-focused or locally-driven cost-benefit analysis
- Participatory rural appraisal — PRA (informant interviews, focus groups, ranking, weighting, mapping, seasonal calendars, etc.)

The key concern in assessing or valuing the local livelihood and wellbeing impacts of EbA (or other types of adaptation approaches) is to be able to identify, and then measure, changes in people's means and access to the material and non-material requirements for a stable, secure and acceptable quality of life. Conventional economic techniques (as described above) are often not well-equipped to do this, because they are heavily dependent on monetary metrics, and are usually based on external views of what are the most 'important' costs and benefits.

The way in which affected parties value and experience livelihood and wellbeing impacts is however not fixed or universal, and is closely linked to cultural considerations (Adger et al. 2012). In response, participatory assessment techniques which are based on communities' own definition of climate risks and effects, as well as the values and impacts of different adaptation options on local livelihoods and economic opportunities, are starting to emerge and be applied to EbA valuation (see Box 11, Box 12). These commonly take the sustainable livelihoods framework as their basic entry point (see, for example, CARE 2002, FAO and ILO 2009, Lax and Krug 2013).

Box 12:

Using extended social cost-benefit analysis to evaluate the livelihood impacts of community-based adaptation measures in Niger

The need to find valuation techniques which can satisfactorily reflect a range of livelihood impacts is particularly important when assessing the effectiveness, efficiency and desirability of community-level adaptation options.

To these ends, extended social cost-benefit techniques were used to compare and contrasts the benefits and costs of a package a variety of 'hard' solutions (including small-scale infrastructure and physical measures) and 'soft' approaches (such as livelihood interventions, environmental measures, capacity-building and empowerment) to community-based adaptation interventions in Niger. These did not only take account of physical expenditures and income (where a more conventional cost-benefit analysis would stop), but also measured the broader evolution of community economic, social and environmental capital.

Analyse principles that underpin social return on investment

The methodology merged traditional cost-benefit analysis with the principles that underpin social return on investment. This followed a three pronged approach: building theories of change; measuring quantitative social and economic capital outcomes; and assessing quantitative environmental capital evolutions and climate variability. It had a strong focus on community engagement and participation, reflecting the principles of the community-based adaptation measures that it was evaluating.

Social capital: quality of life

The economic capital outcomes measured included crop and livestock cash income and subsistence consumption, as well as the value of savings (both monetary and in-kind). Various indicators were used to quantify social capital outcomes. These include quality-adjusted life years (for health), school attendance and length of schooling (education) and number of persons in household solidarity networks (social capital), as well as ranked scales of women's influence and participation in decision-making (gender) and perceptions of capacity and knowledge to establish resilience strategies (community empowerment and adaptive capacity).

Environmental capital outcomes were evaluated according to two variables relating to desertification: sustainable land management and restoration of degraded lands, and avoided deforestation and reforestation. These were measured in terms of trees planted or maintained, and hectares of land restored. The extended social cost-benefit analysis yielded a range of non-monetary indicators, as well as three main monetary measures: net present value, benefit:cost ratio and value for money (benefits generated per unit of spending).

High returns from community-based measures

The results of the study suggested that the community-based climate adaptation interventions had yielded high returns. They had managed to increase the economic capital of communities in terms of revenue and savings, as well as 'soft' social and environmental capital measured in terms of health, education, empowerment, reforestation and avoided land degradation. Many of these effects would have been excluded had conventional, monetary evaluation techniques been used.

See case study 24:
Extended social cost-benefit analysis to evaluate 'hard' and 'soft' community-based adaptation measures in Niger

Many of the tools that are used to foster participatory or community-based climate adaptation planning have equal application to identifying and tracking EbA costs, benefits and values (Nay et al. 2014). These include methods designed to explicitly consider stakeholder perceptions and preferences of climate risks and vulnerabilities in relation to their own livelihoods and wellbeing (see, for example, Aalst et al. 2008, ActionAid 2005, CARE 2009, Oxfam Australia 2012, Reed et al. 2013, Rizvi et al. 2016). A number of approaches have also been developed which shift the focus of economic appraisal towards locally-defined livelihood and socio-economic wellbeing outcomes (Chambwera et al. 2012, Chadburn et al. 2013, LFP 2010, Vardakoulias 2014, WorldFish 2013b), including participatory ecosystem valuation (see ValuES 2014). In addition, a range of other participatory methods which have long been in usage in development planning are starting to be applied to both identify and measure changes in climate adaptation costs, benefits and impacts in terms of local livelihood and socio-economic wellbeing outcomes (see, for example, IIED 2009, Macchi 2011, WorldFish 2013a).

4.5

Social and institutional outcomes

Valuing social and institutional outcomes basically involves looking at changes in people's rules, relations, conduct and circumstances. It requires identifying linkages and impacts on individual and group behaviour and relationships, and measuring how the EbA measures under consideration will result in changes in the ways that people behave, interact and are represented in formal and informal, organized and unstructured settings (e.g. power, status, roles, responsibilities, relationships, participation, governance, sanctions, etc.).

The EbA valuation method review also found very few examples of studies to assess the social and institutional costs, benefits and impacts of EbA. This is a notable gap, given that many adaptation efforts are concerned with 'soft' measures and outcomes as either a primary goal or enabling condition (for example building capacity and awareness, enhancing governance, equity and participation, or seeking to effect changes in people's behaviour and practices).

Many of the participatory assessment methods mentioned above can also be applied to assess social and institutional impacts (Box 13). These are particularly relevant in situations where it is necessary to uncover more personal or sensitive information about people's behaviour changes, or to address the unintended or indirect consequences of EbA. Agent-based models, too, are increasingly being used to assess people's behavioural responses, interactions and capacities as regards climate adaptation measures (see, for example, Balbi and Giupponi 2010, Patt and Siebenhüner 2005).

Box 13:

Commonly-used social and institutional assessment methods

Various different methods can be used to measure the social and institutional outcomes of EbA, many of which are based on participatory techniques and direct consultation with stakeholders, for example:

- Participatory techniques
- Agent-based models
- Stakeholder mapping and assessment
- Social network analysis
- Institutional and context analysis
- Knowledge-attitude-practices surveys

In addition, several tools are available which are geared specifically towards understanding and tracing changes in social and institutional processes in relation to different adaptation outcomes. For example social network analysis (WorldFish 2013c, Bharwani et al. 2013) generates an understanding of social and institutional structures, actors and linkages, while mapping and measuring relationships and flows of information between people, groups and organisations. Institutional and context analysis also provides a way of tracing political and institutional factors, as well as changes in power, interests and decision-making structures (UNDP 2012). Stakeholder mapping and assessment is a tool that has long been used in development and conservation planning to examine and display the relative influence that different individuals and groups have over decision-making and how influence and cooperation change over time. It also has wide application to tracking the impact of EbA and other adaptation measures (see Mayers and Vermeulen 2005, Sova et al. 2013). Knowledge, attitudes and practices surveys offer a very direct way of investigating the changes in people's perceptions and behaviour that may have resulted from EbA (Box 14, also see Fontenard 2016, Hope 2016, Ojomo et al. 2015).

Box 14:

Measuring changes in climate change-related knowledge, attitudes and practices in Guyana

A study was recently carried out in Guyana, to assess and measure people's knowledge, attitude and behavioural practices relating to climate change, including adaptation, mitigation and disaster risk reduction factors. This had five main aims: to explore knowledge and perceptions of climate change, identify how the causes of changing weather patterns are explained, investigate barriers to responding to climate change, assess media consumption patterns and preferences, and inform recommendations on the best methods of communicating on climate change. It also provides a baseline from which future changes in knowledge, attitude and behaviour can be measured.

Household and student survey

The study used both quantitative and qualitative methods. A questionnaire-based national household survey and a student survey were conducted to examine people's levels of knowledge, attitudes and practices towards climate change. This commenced with demographic questions, followed by questions pertaining to knowledge of climate change, attitudes toward climate change and practices related to climate change. The survey ended with questions about media usage.

Study enabled understanding of attitudes and practises

The qualitative research was conducted to introduce contextual information to the study to enable a deeper understanding of 'how' and 'why' certain attitudes and practices exist. Qualitative information was collected via focus groups and key stakeholder/informant interviews with local community members, the media, national government, local leaders and non-governmental organisations, as well as national-level government and international donor agencies.

See case study 15:
Measuring changes in climate change-related knowledge, attitudes and practices in Guyana

4.6

Cross cutting considerations: risk, uncertainty and the selection of methods

Dealing with risk and uncertainty

As mentioned at the beginning of the chapter, there is often a great deal of uncertainty about possible future climate outcomes, as well as substantial gaps in information and data about adaptation costs, benefits and impacts. For this reason, EbA valuation and assessment studies usually incorporate tools to deal with risk and uncertainty, and apply these as an additional layer of analysis to further interpret and test the valuation estimates that have been generated (Box 15). Most of these methods actually deal with risk, in the sense that they generate probabilistic data which combines likelihood and consequence components of both current and anticipated impacts (see Tröltzsch et al. 2013). Uncertainty cannot be assigned a quantitative probability.

At the most basic level, a weight or index can be assigned which enables risk-adjust-

ed costs and benefits to be calculated and compared. This is usually computed by looking at the statistical likelihood of a certain set of circumstances or events occurring. Various more sophisticated techniques can also be used which build on this simple principle. Most focus on modifying the results of monetary value estimates. For example, Monte Carlo simulation involves replacing single figures

Box 15:

Commonly-used methods for dealing with risk and uncertainty

A variety of methods can be used to deal with risk and uncertainty, of varying detail and complexity. Commonly-used methods include:

- Allocation of weights
- Probability analysis
- Monte Carlo simulation
- Risk-benefit analysis
- Decision analysis
- Real option analysis
- Acceptable risks
- Robust decision-making
- Delphi method
- Sensitivity analysis
- Scenario analysis

with probability distributions of possible values for key inputs (see Mainelli and Palmer 2007). Risk-benefit analysis can in a way be considered the inversion of normal cost-benefit analysis, because it starts by presuming no action and then assesses the costs of inaction as the likelihood of the specified risk occurring. Decision analysis weights the expected values of a given course of action (in other words, the sum of possible values weighted by their probability of occurring) by attitudes to risk, to give expected utilities. It draws up and assesses decision makers' preferences, judgements and trade-offs in order to obtain weights that are attached to outcomes carrying different levels of risk. Real option analysis and acceptable risks analysis are economic decision support tools that quantifies the investment risk associated with uncertain future outcomes (see Tröltzsch et al. 2013).

Uncertainty, which refers to situations where little is known about future impacts and no probability can be assigned to certain outcomes, is much more difficult to deal with. Analysis usually involves showing how value estimates would change under different hypothetical circumstances or conditions. For example, robust decision making is used in situations of deep uncertainty (where no probabilistic data are available) to model 'good enough' or 'no regret' outcomes (Werners et al. 2013).

The Delphi method is another tool that can be applied to deal with a scenario where insufficient information is available on the costs and benefits of adaptation alternatives. It involves conducting a structured iterative group communication to collect opinions and feedback from selected stakeholders or experts on costs and benefits (see UNFCCC 2011). Scenario and sensitivity analysis are perhaps the most commonly-applied tools to deal with uncertainty, and provide an additional overlay to other valuation methods to enable analysis to incorporate a variety of different assumptions, or to express a variety of alternative courses of action and possible outcomes (see Box 16).

Box 16:

Using sensitivity analysis to deal with uncertainty when assessing adaptation options for Albania's power sector

See case study 1:
Cost-benefit analysis of adaptation options for Albania's power sector

An extended cost-benefit analysis was carried out to examine alternative adaptation options in Albania's power generation sector. This analysis looked at their economic desirability to groups across the economy, and included, as well as direct costs and revenues, the cost of carbon dioxide emissions, ecosystem service values, disturbance to people and property and vulnerability to natural disasters.

The intention was to examine options to manage the risks and vulnerabilities to energy security in the face of climate change, and to provide information that could be used to inform and support energy sector investment planning and decision-making.

Electricity may be affected

Once the cost-benefit analysis had been run, a sensitivity analysis was carried out, because of the high levels of uncertainty surrounding future climate and economic parameters. The sensitivity of the results of the cost-benefit analysis was assessed relative to changes in the cost of carbon and air pollution, the value of water, ecosystem service values, disturbances to society, electricity revenues, fuel cost and the social discount rate. Another set of parameters was designed to explore

Identifying the appropriate mix of methods

Not all methods are suited to examine all types of EbA values, or can be used to address every valuation purpose or decision question. However, ***there is no such thing as the 'best' method with which to value EbA benefits, costs or impacts***. Methods generate varying results because they represent different perspectives or focus on different factors (Berghöfer et al. 2015). Choosing between methods based on technical considerations alone is unlikely to be sufficient to identify the most appropriate study design.

As we have already noted in Chapter 3, ***the purpose of the EbA valuation and the specific questions that it seeks to address or answer should drive the selection of methods***. In practical terms, it will of course also be necessary to bear in mind the budget, time and other resources that are able to be allocated to the study, the technical capacities that can be drawn on, as well as other considerations that may shape which are the most appropriate valuation methods to use (for example data availability, the feasibility of field surveys, or the need to ensure the participation of particular stakeholder groups). These topics are dealt with further in Chapter 5.

An important guiding principle in EbA valuation is that one method is rarely enough: focusing on only a single aspect of values (for example biophysical, economic or social) is unlikely to provide an accurate or useful picture. ***In almost all cases, EbA valuation requires taking a multidimensional, multidisciplinary approach which combines different methods, perspectives and types of expertise.*** This involves assessing and evaluating benefits, costs and impacts from several technical viewpoints, and in terms of a number of different metrics and indicators of effectiveness, efficiency and impact. The review of EbA-relevant valuation methods identifies a commonly-applied minimum requirement for most adaptation assessments or valuation studies is physical effectiveness, cost effectiveness and economic efficiency. Best practice would also suggest that non-monetary economic and social benefits are included in the valuation exercise wherever possible (see Box 17).

the effect that increasing frequency of extreme events may have on the availability of electricity from various sources. The primary source of risk is the vulnerability of power transmission assets to wind and lightning strikes. To set up this scenario, a penalty was placed on long-distance transmission assets, which are more vulnerable to these risks.

Box 17:

Integrated biophysical, social and economic assessment of ecosystem-based disaster risk reduction approaches to road construction in Nepal

See case study 23:
Integrated biophysical, social and economic assessment of ecosystem-based disaster risk reduction approaches to road construction in Nepal

Ecosystem-based approaches typically deliver a wide range of benefits to different groups. Different valuation methods and metrics are required, to ensure that this diversity of costs and benefits (and the interactions between them) is captured. These principles were applied in an integrated valuation of different road engineering options in three districts of Nepal's Western Development Region. The study had a particular focus on the use of bio-engineering techniques to deliver ecosystem-based disaster risk reduction outcomes. This is because roads are one of the major causes of shallow landslides in rural Nepal. The study compared 'grey' engineering options (earthen or unmanaged roads) with 'green' roads (eco-safe infrastructure which involves soil bio-engineering along the roadsides and makes use of natural vegetation to stabilise soils and slopes).

Modelling soil loss before and after the monsoon

The study aimed to show how bio-engineering techniques could be adapted to the local environment and serve to reduce landslide instabilities. It followed an integrated methodology that brought together biophysical measurements, assessment of social impacts and economic valuation.

The biophysical component involved assessing the erosion occurring around different types of road. LIDAR was used to measure rates of soil loss both before and after the monsoon. Surveys were also carried out to assess plant survival and root structure. The social component used a combination of methods.

A social vulnerability assessment was carried out by means of a household survey, and a variety of participatory techniques were used to elicit community opinions and knowledge on road-related costs and benefits. These included focus group discussions, participatory mapping, problem and solution analysis.

Erosion control and protection against landslides are valued

The economic component looked at the direct costs and benefits of road construction and maintenance, as well as valuing ecosystem services such as erosion control and protection against landslides. Unlike the other two components of the study, it was based mainly on secondary data gathered through a desk study, supplemented by focus group discussions. The economic analysis compared grey and green roads over a 40 year time frame, modelling five scenarios based on different patterns of rainfall, labour costs, benefit generation and discount rates. The main components in the cost-benefit analysis were road establishment and maintenance, income from the sale of products derived from soil-stabilising plants and enhanced access to markets, other facilities and services.

One reason why there is a need to combine methods is that effective, equitable and sustainable climate adaptation must typically meet various goals and demonstrate progress towards a number of different targets, both biophysical and socio-economic, qualitative and quantitative. This is especially the case for EbA, which usually seeks to generate multiple adaptation benefits and ecosystem service co-benefits. It is therefore almost always necessary to value a range of different impacts, and to investigate how they interact and trade-off with each other. In contrast, failing to adequately account for the full range of EbA values runs the risk of presenting an incomplete (and at the worst incorrect) picture, which underestimates its worth and advantages from development and adaptation viewpoints.

The importance of adopting the concept of multiple values in EbA valuation has already been emphasised in Chapter 2. This pluralism of benefits and beneficiaries, costs and cost-bearers also demands that a range of valuation methods are used. A third important reason for combining valuation methods is the fact that different approaches are often additive or complementary. For example, in order to value EbA measures or ecosystem services in economic or monetary terms, clear evidence of (and quantitative data on) their biophysical effects is also required (Box 5). By the same token, as EbA interventions seek to help people to adapt to the adverse effects of climate change, merely describing biophysical impacts is unlikely to be sufficient to assess, evaluate or justify a particular measure. It is also usually necessary to demonstrate how these effects link to changes in vulnerability and risk exposure, or result in shifts in the social and economic status of affected groups.

In some instances, a multidimensional or pluralistic approach to EbA valuation can be achieved by synthesising and comparing the results of different study components. In other cases, integrated analysis methods can be applied which have the capacity to deal simultaneously with a number of different metrics and measures, so as to present combined or composite pictures of relative values and performance. A variety of frameworks have been developed that attempt to combine the assessment of both biophysical and economic impacts of different adaptation options (see, for example, AECOM 2012, Sharp et al. 2016). Multi-criteria analysis is often recommended in situations where the environmental or social impacts of adaptation cannot be assigned a monetary value, to reflect multiple value concepts or incorporate the perspectives of different groups, or to provide a framework for considering the synergies and trade-offs between a variety of EbA factors or values (Box 18).

Box 18:

Combining cost-benefit analysis and multi-criteria analysis to assess mangrove management options and trade-offs in the Philippines

Source:
Janssen and Padilla (1999)

In the Philippines, as in many other countries, mangrove degradation has resulted in the loss of important environmental and economic products and services including forest products, flood mitigation and nursery grounds for fish. A valuation study was carried out in Pagbilao municipality, Luzon, prompted by pressures to overturn a ban that had been enacted on mangrove clearance and conversion for aquaculture. The study used a combination of cost-benefit analysis and multi-criteria analysis to evaluate mangrove management alternatives.

Use scenarios of single versus combined management

Eight management alternatives were defined. These described a variety of scenarios, including the use of the entire mangrove forest by one interest group (for example environmental agency, community or fishpond operators) as well combined uses by competing users (for example subsistence and commercial forestry, aqua-silviculture, semi-intensive and intensive aquaculture, strict preservation).

Field surveys were undertaken to assess production and prices of forest products, capture fisheries and aquaculture. Based on the monetary value of goods produced and management costs, a cost-benefit analysis was carried out. This suggested that semi-intensive aquaculture was the most preferred alternative followed by intensive aquaculture. Preservation and forestry alternatives were found to generate substantially less value in terms of goods.

Decision problem: competing objectives

The cost-benefit analysis could not however fully capture distributional effects, which is a central political issue. Also, environmental effects (such as carbon emissions, soil accretion, shore protection, ecotourism and biodiversity) could not be valued in monetary terms. Because decision makers also consider equity and environmental objectives in their decisions, the valuation was redefined into a multi-objective decision problem with the following three objectives: maximise efficiency (i.e. maximise monetary benefits over costs), maximise equity (i.e. maximise income to local population) and maximise environmental quality (i.e. maximise the balance of positive and negative effects to the environment). Whereas the first two objectives could be expressed in monetary metrics, expert judgement was used to create an index of relative environmental performance.

This multi-criteria ranking of alternatives yielded interesting

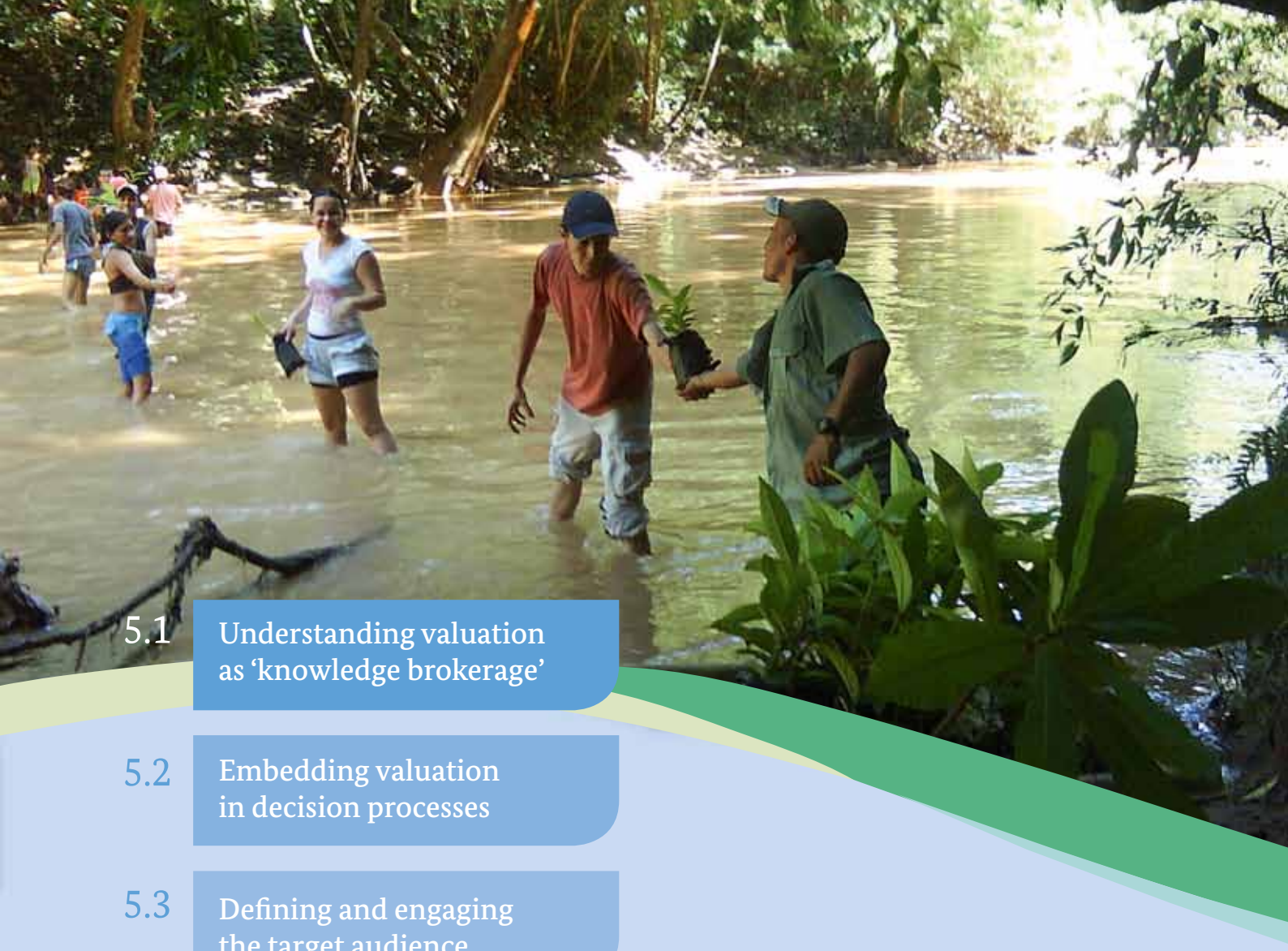
conclusions, which were different from those of the cost-benefit analysis. No alternative performed best on all three objectives. Also clear was the conflict between the equity and environment objectives and the efficiency objective. Alternatives performing well on efficiency performed badly on equity and environment and *vice versa*. Different types of decision makers are involved in the management of the mangrove forest. Because each type of decision maker has his/her own objectives, each decision maker will use the information on the alternatives in a different way.

Summary of Chapter 5

Key points to bear in mind when designing and delivering EbA valuation studies

The following chapter elaborates the four most important considerations in managing the valuation process so as to enhance its strategic impact: embedding the valuation study in real decision processes, defining and engaging the target audience, communicating interesting, appropriate and useful information, and building long-term capacity. To these ends, it emphasises the following points:

- EbA valuation should be understood as a 'knowledge brokerage' process between science and policy domains.
- If EbA valuation is to succeed in meeting its policy purpose and have strategic impact, active steps should be taken to foster relevance, credibility and legitimacy. There are four particularly important considerations to bear in mind:
  - embedding the valuation study in real decision processes,
  - defining and engaging the target audience,
  - communicating interesting, appropriate and useful information, and
  - building long-term capacity
- Fitting EbA valuation into the appraisal and evaluation procedures that are already required to be applied to inform decision-making, rather than carrying it out as a separate exercise, is always desirable.



5 Enhancing the strategic impact:

leveraging decision change and influence

5.1 Understanding valuation as 'knowledge brokerage'

As described in Chapters 1 and 2, an overarching reason for undertaking EbA valuation is the need to overcome the gaps in knowledge and awareness which serve as barriers to the uptake and mainstreaming of ecosystem-based approaches. The ultimate goal is to inform and influence decision-making, so as to encourage more effective, sustainable and equitable climate adaptation. In this sense, ***valuation should be understood as a 'knowledge brokerage' process between science and policy domains*** (see Reinecke et al. 2013a, Reinecke 2015). In other words, it is a way of bridging the boundary between scientists and decision makers, by transforming data on benefits, costs and impacts into information that can be used to support adaptation policy, planning and management in the real world.

The principle of knowledge brokerage implies that some kind of handover takes place whereby both the information on EbA values and the methods that have been used to generate it will become accepted, absorbed and institutionalised within adaptation decision-making. Yet this kind of mainstreaming is usually not straightforward in practice. Decision makers are not always ready to accept or act on the results of valuation. However good the study has been in technical terms, and however convincing the case it makes for ecosystem-based approaches, this does not necessarily mean that it will be effective.

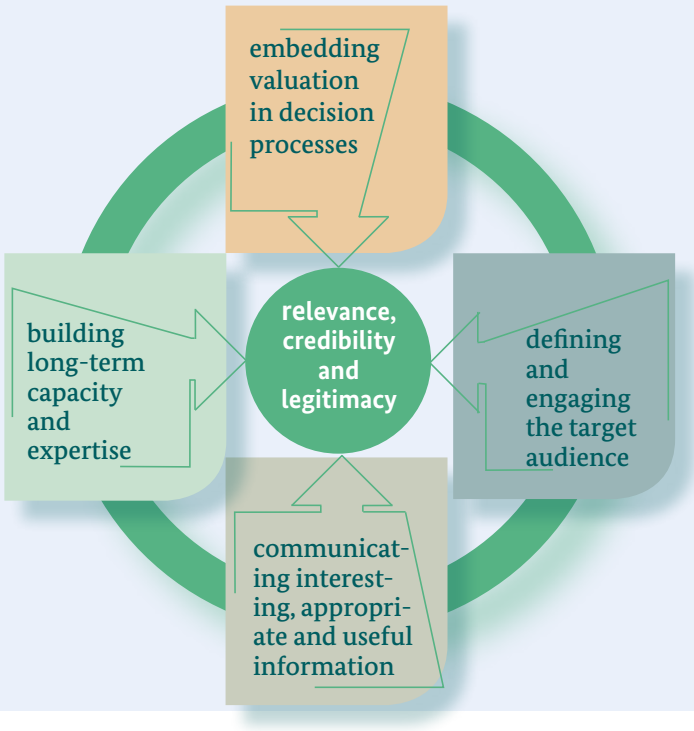
The GIZ review of EbA valuation methods found that, all too often, EbA valuation has no discernible impact on on-the-ground adaptation policy, planning and practice (ECO Consult 2017). The fact that scientific information is rarely integrated into mainstream development efforts and that knowledge is not used as it 'should' be to consistently inform policy and practice has also been noted to be a longstanding issue as regards information on biodiversity and ecosystem services more generally (see Rodela et al. 2015), including assessment and valuation (see Berghöfer et al. 2016, Cash and Clark 2001).

It is now widely accepted that efforts to close the knowledge-policy-practice loop in relation to biodiversity and ecosystem services are more likely to be successful when they manage information generation and dissemination in ways that simultaneously enhance its relevance, credibility, and legitimacy to decision makers (Cash et al. 2003). These three characteristics seem to be the most important in distinguishing effective assessments and valuations (Carmen et al. 2015, Cash and Clark 2001).

In the context of EbA, relevance refers to the applicability of valuation findings to the needs of adaptation planners, managers and policy-makers. Credibility deals with the technical adequacy and believability of the evidence and arguments presented on the effectiveness of ecosystem-based approaches. Legitimacy reflects the perceived validity and trustworthiness of both the EbA valuation process and its results as being fair, unbiased, and respectful of stakeholders' divergent values and beliefs.

If EbA valuation is to succeed in meeting its policy purpose and have strategic impact, active steps should be taken to foster relevance, credibility and legitimacy. There are four particularly important considerations to bear in mind: embedding the valuation study in real decision processes, defining and engaging the target audience, communicating interesting, appropriate and useful information, and building long-term capacity (Figure 6). It is worth noting that these aspects are not just strategic in terms of increasing the likelihood of decision makers' buy-in and on-the-ground impact, but also typically serve to strengthen the technical quality, practical usefulness and policy relevance of EbA valuation. This is because they allow for a continuous dialogue and feedback loop to be established between the study team and decision makers. At the same time, they reflect best research practice and good conduct in the sense that of helping to ensure that valuation is carried out in as inclusive, transparent and participatory a way as possible.

FIGURE 6: Key tools and considerations for enhancing the strategic impact of valuation



5.2 Embedding valuation in decision processes

As long as EbA valuation remains external to the decision-making process that it seeks to guide or inform, then it is unlikely to exert much influence. For example, an assessment of the economic value of mangroves for shoreline protection that is carried out as an occasional technical study by a conservation NGO will probably not do much to encourage decision makers to invest in green, rather than grey, coastal adaptation options as compared to one that is conducted as part of the economic appraisal of a public sector investment programme. Unfortunately, this is all too often the case. One of the key findings of the GIZ review of EbA valuation was that most studies are carried out on a rather ad-hoc basis, outside the more systematized and structured appraisal and evaluation procedures used by the governments or companies that they seek to influence (ECO Consult 2017). In addition, it was found that EbA valuation is often conducted only after adaptation options have been selected, with the aim of modifying a decision that had already been made, rather than trying to influence how the project, programme or policy options were selected and designed in the first place.

In nearly all cases, adaptation investments (whether being carried out at the policy, programme or project level) are routinely subjected to scrutiny before funds can be committed, and then reviewed to check whether the funds were well-spent. Intervention at each stage of the project cycle are typically required to pass fairly standardised appraisal and evaluation procedures (TABLE 1) – although the exact approaches and requirements will of course depend on the country, sector, agency or organisation and specific decision-making context in which the action is being implemented. Public investments and donor-funded development projects, for example, almost always undergo a cost-benefit analysis or similar economic appraisal process in order to be approved, so as to demonstrate that they generate a particular rate of return or value for money (see BOX 19). Likewise some form of environmental impact assessment and other screening exercise (such as social, health, risk safety impact assessments) are usually required for all major infrastructure investments.

Table 1: Comparison of appraisal and evaluation procedures

	Appraisal	Evaluation
Aim of assessment	Whether an EbA proposal or a particular option is worthwhile, and whether to proceed with it	What the actual performance and impact of the EbA option was, and whether it was worthwhile
Use of output	Justify and make the case for EbA, select adaptation options, design and plan adaptation actions, assess feasibility of measures	Justify and make the case for EbA, judge the performance of adaptation measures, share actual evidence, feedback lessons learned
Timing	*Ex ante* prior to implementation	*Ex post* during or after implementation
Method	Comparison of options against each other, or 'do nothing' option Estimated assessment of future risk	Comparison of results against each other, 'do nothing' option, baseline and target outcomes Assessment of risks and impacts that did or did not materialise
Scope	Predict the benefits, costs and impacts that will arise if the EbA measures are implemented	Review actual outcomes that have occurred as a result of the EbA measures

Adapted from HM Treasury (2013)

Box 19:

Cost-benefit analysis of flood mitigation interventions in Canada as part of the appraisal process for public sector investment projects

The Government of Alberta in Canada has certain regulatory requirements regarding the appraisal of public sector investment projects, in order to determine whether they are technically, financially and economically viable. Cost-benefit analyses are routinely used by the Canadian Government as part of the business case for projects at Federal, Provincial and Municipal levels. In line with these requirements, the Resilience and Mitigation Branch of the Government of Alberta's Environment and Sustainable Resources Department must often commission valuation studies in order to justify and choose between different public infrastructure investment options, including those relating to adaptation.

Aim: ameliorate flood damages

The Springbank Off-Stream Flood Storage Mitigation Project was intended to ameliorate flood damages in the city of Calgary. In order to fulfil appraisal requirements, different intervention options were subjected to a cost-benefit analysis. This provided a comparison of project benefits (in terms of damages averted) to project costs (including capital and operating costs), to verify that the project was economically viable and could be considered to be a justifiable use of public funds.

In line with government guidance and appraisal procedures, the analysis followed a relatively simple process, as it looked only at direct costs and benefits and did not take broader social environmental impacts into account.

Comparison with other options

On the benefit side, the analysis considered avoided flood-related damages, while the costs incorporated the capital and recurrent expenditures associated with establishing and maintaining the physical structures and associated engineering measures. Benefits were restricted to economic benefits accruing in the flood risk area within the City of Calgary boundaries.

The Springbank Off-Stream Flood Storage Mitigation Project was compared with two other flood control options: McLean Creek Flood Storage Project and Glenmore Reservoir Diversion. The benefit:cost ratios of each were compared for each of 1:100 and 1:200 year protection, under high and low damage scenarios.

See case study 8:
Cost-benefit analysis of flood mitigation interventions in Canada

Fitting EbA valuation into the appraisal and evaluation procedures that are already required to be applied to inform decision-making, rather than carrying it out as a separate exercise, is always desirable. This is the case even when it means that some level of modification in their methodology and approach is required (such as incorporating ecosystem services into cost-benefit analysis or environmental impact assessments). It permits EbA to be considered on the same footing as other adaptation alternatives and public investment options, according to the standardised measures and procedures that are routinely applied to inform decision choices, rather than always leaving it as a special case or an exception to the rule. This is an important step towards mainstreaming.

Obviously, EbA valuation will not always be tied clearly to a particular step in the project cycle, or be able to be carried out alongside formal appraisal and evaluation procedures. For example, valuation is often used by conservation organisations to make the case for ecosystem-based

approaches or for general advocacy and awareness purposes. In such instances, a key concern will be to ensure that the study is carried out in a way that responds to, and is closely connected with, the broader decision-making processes and decision makers that it seeks to influence.

5.3 Defining and engaging the target audience

It is perhaps self-evident that unless the target audience is clearly defined, and actively engaged in the valuation process from start to finish, then it is unlikely that decision makers will buy into its findings or be interested in taking them up (see Box 21). Participation is a crucial factor in making the results of the valuation relevant, credible and legitimate. There are also many other benefits to be gained from stakeholder engagement, which extend beyond merely motivating support and buy-in (Box 20). Often the process of experiencing or being involved in valuation is as important in leveraging decision change and influence as the results of the study are. Decision makers themselves are usually far better positioned to influence the policy processes which they contribute towards and form a part of than are external organisations or 'experts'. Yet, although the need for stakeholder engagement may seem obvious, many EbA valuation exercises are carried out by teams of experts as pure academic research exercises, with little or no recourse to the audience that they seek to influence.

Box 20: Benefits from engaging the target audience in the valuation exercise

A well-managed collaboration between the potential users and providers of EbA valuation can have spin-off effects at several levels:

- ***Improving the quality*** of the information collected: regular interaction and dialogue allows for additional data and expert opinion to be contributed, and for the quality of data and its interpretation to be validated.
- ***Enhancing awareness and support*** for ecosystem-based approaches: regular exchange permits a shared specification of the problem or questions to be tackled, contributes towards enhanced awareness and knowledge, helps decision makers to become familiar with the concept and advantages of EbA, and engenders a feeling that decision makers' needs and priorities are being adequately reflected and addressed.
- ***Strengthening buy-in and influence*** over decision-making: participation helps decision makers to take ownership over the valuation process and product, and increases the likelihood that it will be managed within (or perceived as being part of) their own mandates, ways of working and management structures.

Adapted from Berghöfer et al. (2015)

Box 21:

The importance of stakeholder engagement in evaluating the effectiveness and impact of hybrid "building with nature" coastal adaptation measures in Indonesia

An innovative 'Building with Nature' (BwN) model has been used to undertake coastal restoration and adaptation measures along the severely eroded coastline of Demak Regency, Central Java. This uses a hybrid, grey-green approach which combines the construction of permeable brushwood dams and mud nourishments with mangrove rehabilitation, sustainable aquaculture and other livelihood diversification measures.

Evaluate pilot and scale it up

The project has so far passed through two stages, both of which have involved studies to measure biophysical and socioeconomic impacts. The first focused on evaluating the effects of a small-scale pilot activity, aiming to demonstrate that the novel BwN approach could indeed work, and to make the case for scaling it up more widely. The second involves developing a monitoring protocol for a larger follow-on initiative. Stakeholder engagement and participation in evaluating effectiveness and impact (as well as in the actual implementation of the measures) has played a key role in the acceptance, uptake and subsequent upscaling of these BwN approaches.

For example, local-level interviews and focus group discussions provide a major source of data about changes in local livelihood status and ecological conditions. This is supplemented by sampling surveys and direct observations made by community members themselves about mangrove rehabilitation and the recovery of pond fisheries. Communities are actively engaged in collecting and recording monitoring information (for example through taking part in regular dialogues, helping with the collection of field measurements, keeping logbooks and other records).

A strong principle of stakeholder engagement has also been adopted for sharing monitoring and evaluation results. A regular cycle has been established which brings together the various different agencies and groups that are involved in the project. Every six months, information is presented, analysed and discussed, and the design and delivery of interventions are updated as necessary.

Approach became influential in other parts of Indonesia

The evidence of intervention impact has generally been well-received by the target audience (coastal planners and managers, including local community members). The participatory, 'learning by doing' approach that was employed, as well as the strong emphasis on stakeholder participation and communication, was instrumental in securing the buy-in and support that is required to sustain and scale-up the eco-engineering models that have been developed in Demak.

The BwN approach has proved to be influential in shaping how coastal adaptation and disaster risk reduction policy and planning is carried out in other parts of Java, and Indonesia more widely.

See case study 17:
Evaluating the biophysical and socioeconomic effectiveness of hybrid "building with nature" coastal adaptation measures in Indonesia

Even when the valuation purpose has been clearly identified (see Chapter 3) and the study has been closely embedded or aligned with the project cycle or decision-making process (see Section 5.2 above) it may not be immediately obvious who the target audience or end-users of information should be, or at which level (and to what extent) they should be engaged. These issues need to be tackled early on in the valuation process. At a minimum this involves thinking through the political and policy context to the valuation, the needs for evidence, and the stakeholder interests, influences and linkages as regards adaptation decision-making (Start and Hovland 2004). For example, if valuation is being used to compare the relative merits of reforestation and reservoir construction as a means of improving dry season water flows to strengthen climate resilience, then a thorough analysis will probably need to be made of different land uses and land users, tenure and resource management regimes in the upper watershed as well as competing and possibly conflicting water demands and access rights on the part of downstream water consumers. In this case, the main target audience, and ultimate users, of the valuation information may lie well outside the climate adaptation sector. A wide variety of tools can be used to assist in defining the target audience for EbA valuation.

These overlap closely with the methods that used to assess the social and institutional outcomes of EbA (see Chapter 4) – such as stakeholder and social network assessments, institutional and context analysis, and agent-based modelling.

A particularly key concern is to understand, early on, the relative power and interest of different groups as well as the other factors that shape how (and by whom) adaptation decisions are actually made and how the valuation results might be used and taken up. Power interest grids, for example, provide a simple tool that can help to identify and prioritise levels of stakeholder engagement and strategies for fostering participation during the valuation process (see GTZ 2007).

Then, the most appropriate and effective means of engaging with the target audience will vary, depending on the study context, but will likely need to incorporate a variety of tools, including both formal and informal meetings, sharing of updates and other communications (see below). Making the target audience a part of the technical study team, engaging key stakeholders as advisors, steering committee members or peer reviewers, or providing them with another role in the valuation exercise itself is often one of the most successful forms of engagement.

5.4

Communicating interesting, appropriate and useful information

Communicating an EbA valuation study involves far more than just disseminating its findings. It is about fostering awareness and dialogue, and shifting the paradigms that drive adaptation planning. As such, it is rarely possible to export the written results of a technical valuation study directly to decision makers, and expect them to be accepted, understood, sanctioned and acted on. Rather, the process of building decision-support information and policy advice is more of a social process which reveals itself through repeated exchanges and joint actions between scientists, decision makers, various interest groups and the media (Reinecke et al. 2013a) – and thus involves a continuous renegotiation and shifting of the boundaries of the 'knowledge brokerage' domain mentioned at the beginning of this chapter.

The key need is to focus on managing these social processes and stakeholder interactions so as to convey information on EbA values in forms and ways that make it interesting, appropriate and useful to those concerned (Box 22). If this is not the case, decision makers are unlikely to be convinced by EbA valuation, or to act on its findings. For example, the key factor in whether reforestation is deemed to be the most appropriate investment option for strengthening adaptation in the water sector may not be the ability to demonstrate that it will offer the lowest-cost investment option for securing a given dry season base flow, but rather whether it can help to avoid a given level of hydropower generation outages or maintain year-round irrigated food crop production.

EbA valuation methods

Box 22:

Targeting valuation metrics and messages by using a saved health, saved wealth approach to communicate the benefits of coastal adaptation options in Viet Nam

See case study 40:
Saved health, saved wealth approach to compare the benefits of coastal adaptation options in Viet Nam

Different audiences have varying mandates, interests and levels of understanding – and therefore respond to diverse triggers, messages and indicators about the value of EbA, in itself or as compared to other adaptation alternatives. A targeted approach is often required when designing a valuation study, so as to ensure that the data presented and metrics used will succeed in communicating interesting, appropriate and useful information to the intended users of the study.

Move beyond mere monetary-based measures

In Viet Nam a 'saved health, saved wealth' approach was used to communicate the benefits and impacts of EbA as compared to grey coastal adaptation options in Soc Trang Province of the Mekong Delta. The choice of a saved health, saved wealth approach deliberately intended to move beyond the reliance on monetary-based measures that characterises conventional economic approaches to investment appraisal and project analysis. The aim is to measure the benefits and impacts of adaptation activities in terms that are both standardised and universally comparable, and reflect issues that are of primary concern to decision makers.

Target audience were coastal planners and decision makers

This standardisation and comparability, as well as the use of wealth and health indicators, resonated with coastal planners and decision makers in Viet Nam (the target audience for the valuation study). It also helped to ensure that they considered the study findings to be interesting, useful and credible. The methodology compared economic assets and life expectancy under a baseline business-as-usual scenario with the economic damages, illnesses and mortality that would be avoided through undertaking adaptation measures. Both monetary and non-monetary metrics were used to measure these

It is also apparent that the causal links between the communication of information and policy change are not always straightforward. Theories of knowledge utilisation suggest that the 'use' of research findings does not happen through a direct and instrumental transfer of information to decision makers, but rather as a more diffuse process of 'knowledge creep' (Reinecke et al. 2013b). This reinforces the importance of treating communication as a continuous process, not one that just comes in at the end of the valuation study. It is not only important to share the final results of the valuation study, but also to continuously communicate what it is about, how it is progressing and how it is being conducted. This is intimately tied to the processes of stakeholder engagement and participation that have been set up for the valuation study: meetings, dialogues, lobbying and other interactions are all a critical component of communication.

There is no 'one size fits all' solution to communicating interesting, appropriate and useful information on EbA values.

impacts. Saved health looked at avoided disease, disability and life loss, measured through DALYs or disability-adjusted life years. Saved wealth was measured in terms of economic benefits and (avoided) expenditures, incorporating damages to private property, public infrastructure, agri-

What costs of salinisation?

cultural and fisheries income, as well as the costs of erosion and land salinisation. Environmental co-benefits were described (but not quantified) via a checklist of indicators such as air quality, water quality, soil conditions, biodiversity, quality of employment, livelihoods of the poor and cultural heritage.

Various tools are required to plan, package, target and monitor information (Table 2). Just as the target audience and stakeholders in EbA are not homogenous and may have contrasting (and even conflicting) needs, interests, mandates and power to influence adaptation decision-making, so the information that is required to influence their decisions varies. Good communication does not occur automatically, and will not happen just because a valuation study has been well-designed and targeted, or has generated practical, policy-relevant and technically-robust findings. It is important to tailor both the messages that are shared and the means of communication to the target audience and the cultural, social, institutional and decision-making milieu in which they are embedded, through following a careful process of planning, packaging, targeting and monitoring (Hovland 2005).

TABLE 2: Key elements and tools in the communication process

Elements	Area of focus	Examples of tools
Planning	Why, how and to whom communication takes place	Communications strategy, stakeholder analysis, social network analysis, problem tree analysis, force field analysis, etc.
Packaging	How and in what terms messages are formulated and positioned	Visioning future scenarios, telling a story, providing a solution, using surprise, being persuasive, appealing to emotions, tying into news story, etc.
Targeting	How communications will be delivered to the intended target audience	Writing technical reports and policy papers, building a community of practice, lobbying, websites, blogging, social media, print, TV and radio and visual media engagement, etc.
Monitoring	Whether valuation made any difference to adaptation or other outcomes	Interviews, observations, surveys, checklists, active learning, most significant change, outcome mapping, etc.

Adapted from Hovland (2005)

5.5 Building long-term capacity and expertise

A final, and yet crucial, condition for fostering relevance, credibility and legitimacy and enhancing the strategic impact of EbA valuation is the development of long-term capacity. Biophysical, economic and social assessment techniques all require specialist technical training and expertise, and their application to climate adaptation – and especially ecosystem-based approaches – is a relatively new field. One response to these capacity limitations is not to be overambitious, and to select methods which can be easily implemented using existing skillsets. More commonly, low valuation capacity means that expertise is sought outside the agencies that are responsible for adaptation planning and implementation – or even externally to the country in which valuation is being carried out. This is rarely a sustainable solution. It also makes it much more difficult to embed valuation in on-the-ground decision-making processes, or to mainstream it as a tool that is routinely used to inform adaptation planning.

Capacity needs do not relate only to the technical knowhow and training required to undertake valuation. They also involve building an understanding among adaptation planners and managers of the need and usefulness of commissioning EbA valuation in the first place, and creating the expertise that is required to commission, design and coordinate the studies, and to interpret and apply their results. Although formal training needs assessments offer a useful tool with which to plan for creating appropriate expertise, and investigate where skills development efforts will have the most impact, efforts should always be made to build capacity development into EbA valuation exercises as they take place (see BOX 23). The very process of carrying out EbA valuation provides an opportunity to learn through doing, and to integrate expertise from partner institutions and local stakeholders.

Box 23:

Using the valuation process to build capacity among protected area managers in Mexico

Economic valuation was used to communicate the high value of three protected areas (PAs) in Mexico: Cabo Pulmo National Park, Cozumel Reefs National Park / Cozumel Island Flora & Fauna Protection Area and Iztaccíhuatl-Popocatépetl National Park. This aimed to demonstrate the contribution of PAs to local, national and sectoral development processes, as well as generating information that could be used to address key conservation threats and management issues. The valuation exercise formed a step in applying an "Integrating Ecosystem Services into Development Planning" (IES) approach, which works through a series of participatory steps to define and address ecosystem service-related threats, opportunities and trade-offs.

How do development goals impact on ecosystem services?

A variety of participatory tools were used to identify the key management issues and challenges that valuation might help to address, and to assess the ways in which development goals depend and impact on PA ecosystem services. This served to bring conservation managers and other local stakeholders directly into the process of identifying the main purposes and targets of the valuation studies. Based on these priorities and purposes, on-the-ground valuation studies were designed and carried out. Staff from Mexico's National Commission of Protected Natural Areas (CONANP) were then closely involved in carrying out the valuation, and in presenting the results to others.

While the valuation studies generated important information for PA conservation and local development planning, their main impact was to raise awareness and capacity on the use of economic valuation to make the case for integrating PA ecosystem services into development planning. The studies provided new skillsets and tools to assist CONANP to better represent their interests as regards the mainstreaming of ecosystem values into sectoral policy and planning.

Not just a training exercise

Yet, while capacity-building was a key goal and output of the valuation process, it is important to note that the intention was not to create a body of staff that were technically trained to conduct ecosystem valuation. Rather, it was to provide conservation managers and decision makers with the knowledge and understanding that would enable them to identify, commission and supervise valuation studies to assist them in their work in the future. Establishing long-term valuation capacity and awareness at the institutional level also helped to secure the sustainability of the study results, and ensure that they were accepted, taken up, and will likely have a lasting impact.

See case study 20:
Integrating Ecosystem Services into Development Planning valuation of the economic contribution of protected area ecosystem services in Mexico

Summary of Chapter 6

Key points to bear in mind when designing and delivering EbA valuation studies

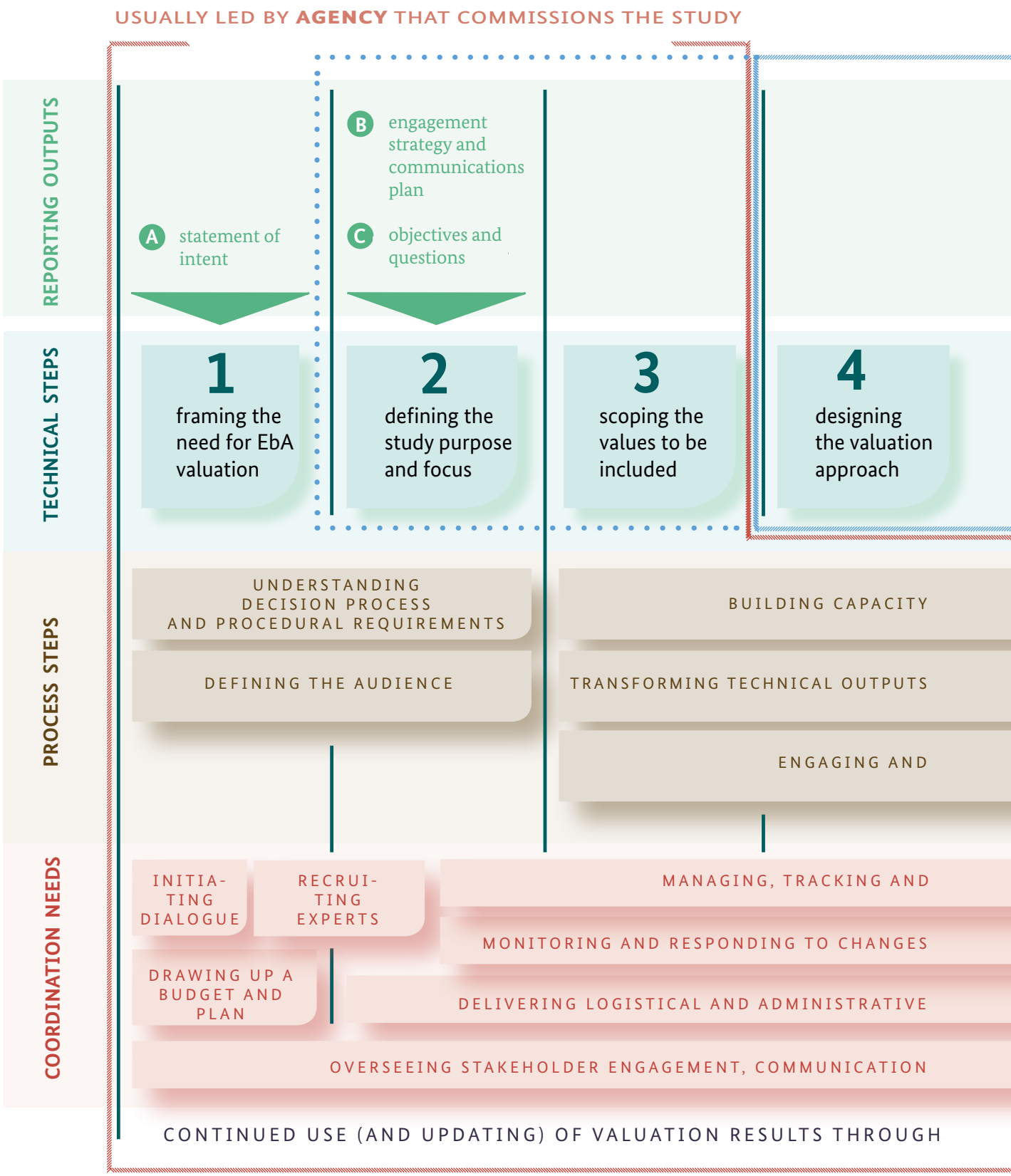
The following chapter combines the insights of the previous sections of the sourcebook into a series of checklists to assist in planning and carrying out EbA valuation. It explains the most important 'things to think about' and 'things to do' when commissioning, designing and implementing valuation studies. To these ends, it emphasises the following points:

- EbA valuation almost always requires engaging external technical experts, and closely interacting and communicating with key stakeholders.
- Most valuation studies follow a logical progression through seven main stages: (1) framing the need for EbA valuation, (2) defining the study purpose and focus, (3) scoping the values to be assessed, (4) designing the valuation approach, (5) collecting the data, (6) analysing the information and (7) documenting the findings.
- However, the process of EbA valuation rarely comes to a complete end once the findings are documented. The results will typically continue to be applied, used and updated through dissemination, communication, dialogue and policy advice. This also requires continuing engagement with adaptation stakeholders and decision-makers.
- It is crucial to ensure that the valuation process is managed well, in the sense of applying best-practice research principles such as inclusivity, transparency and accountability, as well as setting in place the broader enabling conditions that are required to ensure relevance, credibility and legitimacy.
- The success of EbA valuation does not just rest on selecting the 'best' purpose, methods and data or with carrying out the 'right' technical and process steps. It also depends on effective coordination. It is necessary to be mindful of the logistical, administrative and other management requirements for ensuring that the valuation study runs smoothly and according to plan.

6 Delivering the assessment:

commissioning, designing and implementing valuation

Drawing on the insights, experiences and best practices described up to here, it is possible to identify a number of practical steps and elements that should be incorporated into EbA valuation. The exact nature, scope and length of the study process will of course vary, depending on its purpose, the context in which it is being carried out, and the resources available to it. Most valuation exercises will however involve four types of 'things to think about' and 'things to do' (see FIGURE 7):



- ***Technical steps:*** the main stages in undertaking valuation;
- ***Reporting outputs:*** the documentation or other materials that will be produced;
- ***Process steps:*** the areas of support that are required to foster good conduct and quality control in carrying out the study; and
- ***Coordination needs:*** the logistical, administrative and other management inputs that are required to ensure that the study runs smoothly and according to plan.

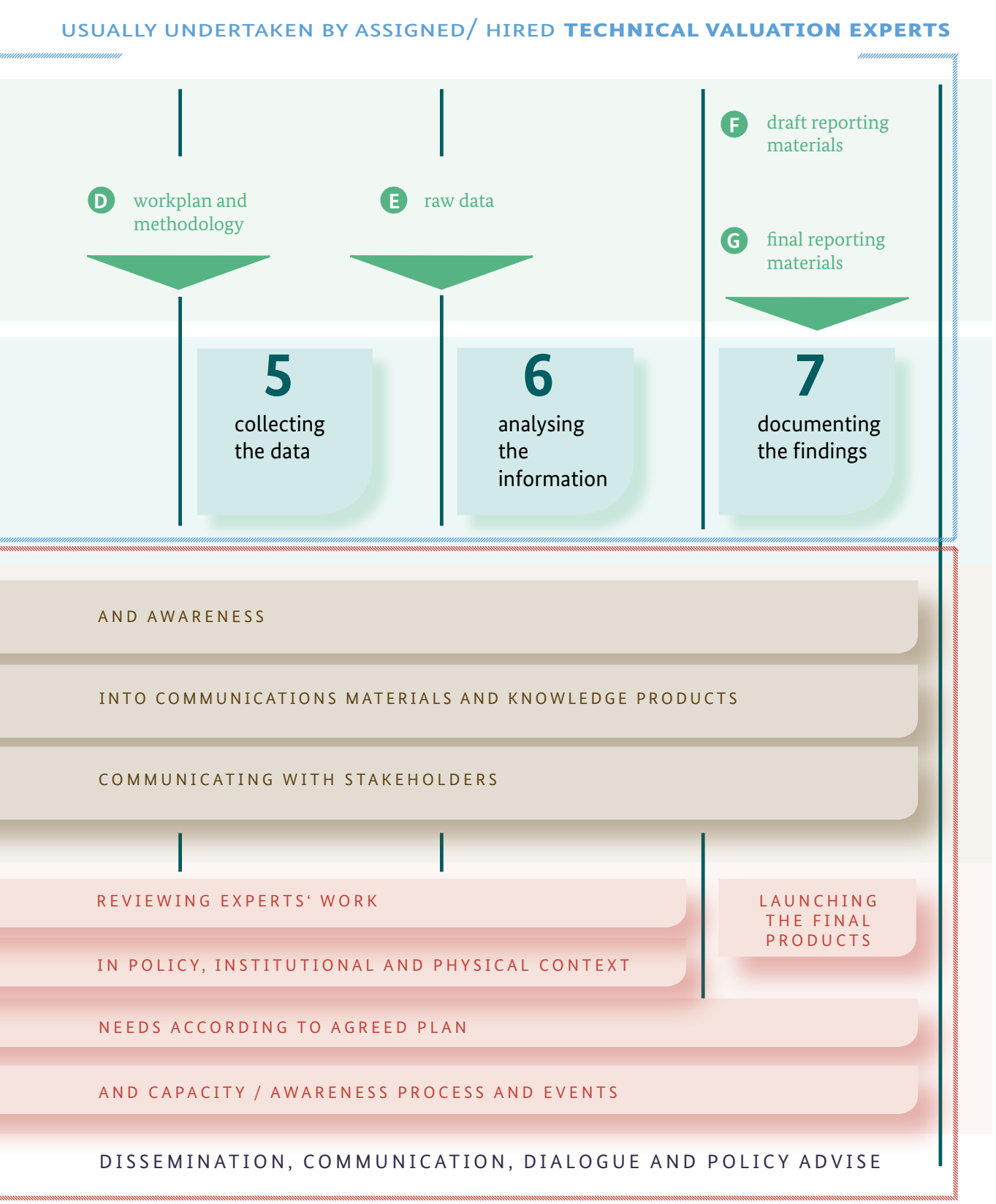


FIGURE 7: Practical steps in putting together an EbA valuation study: things to think about and do

6.1

Technical steps and reporting outputs

Most valuation studies follow a logical progression through seven main stages, and usually produce a similar array of reporting outputs. These ensure that the information and analysis required to value EbA benefits, costs and impacts are produced in a credible and relevant way, and include:

1 framing the need for EbA valuation → **2** defining the study purpose and focus → **3** scoping the values to be included →

Step 1. Framing the need for EbA valuation involves thinking through the rationale for valuation. A key point to remember is that, although valuation can be a powerful tool for promoting more effective adaptation decision-making – and, conversely, under-valuation often poses a major challenge to EbA (see Sections 1.1 and 2.3) – better 'evidence' of values is not always the main factor hindering EbA uptake or mainstreaming. A very important initial step is therefore to establish with certainty that there is, indeed, a need for valuation. This would usually result in a statement of intent which summarises why the valuation study has been deemed necessary in the first place (reporting output A). This often also provides the basic justification or concept that is used to secure funding or management approval for carrying out the study, and informing partners about it.

Step 2. Defining the study purpose and focus involves clearly identifying the practical purpose and envisaged outcome of the study. It also requires specifying the questions that it aims to answer, the stakeholders it seeks to engage with and the target audience that it intends to communicate with (see Chapters 3 and 5). This important step is to do with articulating exactly how (and through whom) the study intends to support, inform or influence a particular aspect of adaptation decision-making. The decision objective and questions to be addressed should be clearly documented (reporting output B), and an engagement strategy and communications plan should be developed (reporting output C).

Step 3. Scoping the values to be included involves clarifying what is to be assessed or valued in terms of EbA benefits, costs and impacts as well as the beneficiaries and cost-bearers (see Chapter 2). Valuation studies rarely need to be totally comprehensive in their coverage: they focus on the key values that are most importance (and relevant) to the study purpose, questions, decision process and target audience being addressed.

Step 4. Designing the valuation approach involves elaborating the specific methods and metrics that will be applied to measure EbA values (see Chapter 4). This includes data needs and sources, information collection procedures and analytical approaches, as well as logistical aspects and process elements such as planning for field surveys, stakeholder participation and communications. It should result in a workplan and methodology (reporting output D), detailing both the technical approach and the milestones for delivering the valuation study, and linking in to the stakeholder engagement strategy and communications plan that have been produced earlier.

Step 5. Collecting the data involves obtaining the information that is needed to value the selected EbA benefit, costs and impacts. The length and complexity of this step can vary greatly, depending largely on the complexity of the valuation methods being used and whether, and to what extent, they require primary data collection, surveys and field visits. It should result in the delivery of the raw data (reporting output E) required to compute EbA values.

Step 6. Analysing the information involves combining and interpreting the raw data to answer the decision questions specified for the valuation study. Again, the timing and level of detail will depend largely on the study scope, coverage and methodology.

Step 7. Documenting the findings involves compiling draft and final reporting materials (reporting outputs F and G). It should be noted that these may or may not be limited to a written report – they often also include policy briefs, graphics or *PowerPoint* presentations. In turn, these outputs are usually transformed into other materials which are then shared via various means, in line with the communications plan that has been developed for the study (see Section 5.4).

In addition, it is worth emphasising that the process of EbA valuation rarely comes to a complete end once the final results or reporting outputs have been delivered. Most EbA valuation studies will usually have broader and longer-lasting relevance and applications. These may be in relation to the original topic or issue being addressed as it evolves over time, or for other decision-making processes and needs that might arise in the future in other sites and sectors, for other groups or adaptation goals. The valuation results will typically continue to be applied, used and updated through dissemination, communication, dialogue and policy advice.

Steps 1 and 2 and reporting outputs A, B and C are typically led by the agency or organisation that commissions the exercise, or delegated to an expert in political economy, decision analysis or stakeholder assessment. The actual valuation is however usually undertaken by technical experts that are assigned or hired to do so, who may also be engaged to participate in or observe steps 1 and 2. Sometimes, although less commonly, the team of technical valuation experts could also provide the skills and capacities that are required to lead on framing and defining the exercise. Thus, steps 3-7 and reporting outputs D - G typically comprise the core elements of the terms of reference that would be developed for the technical experts that will be undertaking the study.

6.2 Process steps

It is crucial to ensure that the valuation process is managed well, in the sense of applying best-practice research principles such as inclusivity, transparency and accountability, as well as setting in place the broader enabling conditions that are required to ensure relevance, credibility and legitimacy. These steps are closely linked to the perspectives and tools outlined in Chapter 5, and include:

Understanding decision process and procedural requirements

Understanding the decision process and procedural requirements is critical in ensuring that the valuation study is properly embedded in the decision-making structure that it seeks to guide or inform, and increases the likelihood that its findings having influence and impact (see Section 5.2). It is also a key step in defining the study purpose (see Section 3.1).

Engaging and communicating with stakeholders

Engaging and communicating with stakeholders should be a continuous process, throughout the course of the valuation study. As well as contributing value information, this is a way of enhancing awareness about EbA, and strengthening buy-in and influence (see Section 5.3).

Building capacity and awareness

Building capacity and awareness is also an ongoing concern from the start to the end of the valuation study. Not only does the study process offer ample opportunities to build general understanding and knowhow on EbA valuation among decision makers and other partners, but can also be used as a mechanism for delivering more formal training and skills-enhancement (see Section 5.5).

Defining the audience

Defining the audience should help to make the study purpose and questions well-targeted, and is also central to developing effective strategies for engaging and communicating with key stakeholders (see Section 5.3).

Transforming technical outputs into communications materials and knowledge products

Transforming technical outputs into communications materials and knowledge products is an important step in communicating the findings of the valuation study, and should take place at every stage and for every reporting output (see Section 5.4). The aim is to ensure that the information that is shared from the EbA valuation is interesting, appropriate and useful to the target audience.

These process steps are usually undertaken by the agency or organisation that commissions the valuation exercise, although certain tasks and functions sometimes need to be delegated to partners or external specialists. As described above, experts in political economy, decision analysis or stakeholder assessment may be sought to assist in identifying or dealing with stakeholder assessment aspects. Partnerships may also be formed to deliver stakeholder engagement and communications activities – for example with professional communications agencies, non-governmental organisations, or local civil society groups. Capacity-building and awareness, too, may require engaging external partners or experts.

6.3 Coordination needs

The success of EbA valuation does not just rest on selecting the 'best' purpose, methods and data or with carrying out the 'right' technical and process steps. It also depends on effective coordination. It is necessary to be mindful of the logistical, administrative and other management requirements for ensuring that the valuation study runs smoothly and according to plan, including:

INITIATING DIALOGUE

Initiating dialogue with decision makers involves getting the ball rolling, and preparing the ground for the valuation study that is to follow (and the process of stakeholder engagement that will ensue). Depending on the decision process that is being targeted and the context in which the exercise is taking place, this may require introducing the valuation study to local stakeholders, establishing a platform to interact with industry and business, seeking high-level endorsement, or even following some kind of a formal application and approval process.

DELIVERING LOGISTICAL AND ADMINISTRATIVE NEEDS

Delivering logistical and administrative needs must obviously take place on a timely basis throughout the study process, according to the agreed budget and plan.

DRAWING UP A BUDGET AND PLAN

Drawing up a budget and plan is a very practical and necessary task. It is always important, early on, to have a clear idea of the funding, timing, staffing and other material needs of the study, and to be sure that they can actually be met. It is also crucial to chart out the timeline, activities, milestones and responsibilities for delivering the study.

RECRUITING EXPERTS

Recruiting experts may involve hiring external consultants, forming a partnership with another organisation or group, or assigning tasks to staff within the agency that has commissioned the valuation study. Depending on the staffing arrangements, this may necessitate preparing terms of reference, initiating an advertisement and tender process, evaluating bids or applications, and negotiating contracts.

MANAGING, TRACKING AND REVIEWING EXPERTS' WORK

Managing, tracking and reviewing experts' work should be seen as a continuous process. It is rarely feasible to withdraw from the valuation study as soon as the technical tasks are assigned or a consultancy contract has been issued. Periodic discussions, reviews and tracking are almost always required, to establish that the intended study focus and purpose is being maintained, that tasks are proceeding according to plan, and that quality and other standards are being upheld. If capacity is very limited, it may be prudent to consider engaging an external expert, mentor or review panel to assist.

MONITORING AND RESPONDING TO CHANGES IN POLICY, INSTITUTIONAL AND PHYSICAL CONTEXT

Monitoring and responding to changes in policy, institutional and physical context involves periodically checking and rechecking that the study purpose, questions and focus remain relevant. Conditions and circumstances may change over the course of the valuation study, which require a shift in its focus, or demand that new issues, concerns or even stakeholders are taken on board.

With few exceptions, coordination is almost always the responsibility of the agency or organisation that commissions the valuation exercise.

OVERSEEING STAKEHOLDER ENGAGEMENT, COMMUNICATION AND CAPACITY/ AWARENESS PROCESS AND EVENTS

Overseeing stakeholder engagement, communications and capacity/awareness process and events typically requires frequent attention. It involves checking on process (that engagement, communications, capacity and awareness concerns are continuing to be addressed) as well as on products (that workshops, meetings, reports and other materials are being delivered as required).

LAUNCHING THE FINAL PRODUCTS

Launching the final products is an important activity – valuation studies usually yield at least one major document, message or outreach event that reports on their overall findings. It should however be emphasised that the delivery of certain findings or conclusions about EbA costs, benefits and impacts rarely spells the end of processes to use valuation to leverage decision-making change. Often, a valuation study serves as the first stage in creating awareness and capacity, or in shifting adaptation paradigms and decision-making procedures.

7 Learning from experience:

case studies of EbA-relevant valuations

The literature contains a wealth of examples of the use of valuation to assess, measure and compare adaptation measures. Some of the most interesting examples of valuation have been compiled as ***case studies***, as a supplement to this sourcebook. These 4-6 page case studies are directly accessible through links.

They reflect a mixture of grey, green and hybrid adaption measures, apply a wide range of valuation methods, illustrate various areas of technical focus, and report on studies carried out for many different purposes, across a diverse array of biomes, sectors and decision-making contexts.

Figure 8: Map of EbA-relevant valuation case studies

Table 3: List of EbA-relevant valuation case studies

1. Albania	Cost-benefit analysis of adaptation options for the power sector This case study involved an extended cost-benefit analysis of adaptation options in Albania's power generation sector. The aim was to provide information that could be used to inform and support energy sector investment planning by identifying the optimal power generation asset to supply the shortfall in electricity that would directly be caused by climate change. Although the options being considered were all grey, engineered solutions, the analysis considered a wide range of social and environmental indicators, alongside more conventional financial costs and benefits.

2. Argentina	Physical effectiveness and cost efficiency analysis of water sector adaption measures	This case study describes an integrated assessment to consider the physical effectiveness and cost efficiency impacts of adaptation measured designed to address seasonal water shortages in a river basin in north-west Argentina. This measured reductions in unmet water demand against the cost of achieving these savings. The analysis sought to help decision makers make informed choices among alternative water infrastructure designs that would be robust and sustainable in the face of climate change.
3. Australia	Cost-benefit analysis to make the case for flood mitigation investments	This case study evaluates the economic impacts of flood mitigation interventions in Australia. It uses biophysical models and cost-benefit analysis to assess climate risk, assets at risk and the protective capacity of mitigation measures. The aim was to establish the business case for flood mitigation investments, as well as to showcase methods that can be used to inform the allocation of limited regional government funding to infrastructure projects.
4. Bangladesh	Cost-benefit analysis of national-level grey and green adaptation options	This case study describes a cost-benefit analysis of various options for climate adaptation in Bangladesh. It considers both grey and green interventions, as well as longer-term measures to increase labour productivity and relocate vulnerable coastal populations. The aim was to generate information that could be used to prioritise strategic options for adaptation, and guide investment planning.
5. Belize	Use of InVEST to weigh up coastal adaptation options and trade-offs	This case study describes a study to compare the biophysical impacts and economic value of alternative packages of grey and green coastal adaptation options in Belize. The aim was to influence coastal zone planning processes. The InVEST tool was used to model and map the provision of ecosystem services (including coastal protection, fisheries, tourism and carbon). Cost benefit analysis was then applied to weigh up the physical costs of different adaptation options as well as the value of the ecosystem service benefits and damages avoided they would generate.
6. Burkina Faso and Ghana	Income statements and cost-benefit analysis of 'soft' and ecosystem-based adaptation activities	This case study measured the economic performance of a variety of 'soft' and ecosystem-based adaptation measures that had been implemented in the Volta Basin of Burkina Faso and Ghana. It was based on qualitative techniques as well as monetary income statements and cost-benefit analysis. The aim was to demonstrate a methodology and generate information that could be used to better design, implement and evaluate adaptation measures to meet local community needs and constraints.
7. Canada	Cost-benefit analysis of engineered and non-structural coastal adaptation options	This case study assessed the economic value of coastal adaptation options in Canada. Cost-benefit analysis techniques were used to measure the erosion and flood-related financial, economic and (in some cases) social and environmental damages avoided, and to compare them with the direct cost of adaption interventions. This yielded a prioritised list of adaptation needs and measures, showing where interventions were most justified in economic terms.

8.	Canada	Cost-benefit analysis of flood mitigation interventions This case study describes a cost-benefit analysis carried out to assess the desirability of a flood mitigation project in Canada. It came up with measures of profitability in terms of damage costs avoided relative to the project investment, and also compared the project with two other flood control options in order to ascertain which returns the highest benefit:cost ratio. The study was carried out to fulfil the regulatory requirements of the Government of Alberta, to determine if the project was economically viable.
9.	China	Cost-effectiveness analysis of water-saving irrigation technologies for climate adaptation This case study looks at the economic viability of water-saving irrigation technologies as climate adaptation measures in China. This is measured by looking at the cost-effectiveness of four commonly-used technologies, as compared to traditional irrigation, in reducing the adverse effects of climate change, via increased crop yield and reduced water consumption. The aim was to generate new information that could support the identification of balanced responses to climate change and sustainable economic development.
10.	Czech Republic	Cost-benefit analysis of flood adaptation measures This case study assesses the costs and benefits of ongoing and planned flood protection adaptation measures in the Czech Republic. Following a hazard and impact assessment which simulated the spatial patterns of damages and losses in different locations and generated damage estimates, a cost-benefit analysis was carried out to generate recommendations to decision makers about whether the proposed investments will promote economic efficiency.
11.	Fiji	Least-cost, damage cost and cost-benefit analysis of urban coastal adaptation options This case study describes an economic analysis of coastal adaptation options in Fiji. It compares the costs, benefits and overall profitability of different combinations of grey and green measures. The intention was to inform and guide the development of a full adaptation plan. The study involved a least-cost analysis, a damage cost assessment, and a cost-benefit analysis which also incorporated the ecosystem service co-benefits generated by green adaptation options.
12.	Georgia	Cost-benefit analysis of sustainable farmland management practices This case study describes a cost-benefit analysis of farm management alternatives in Georgia, which aimed to guide and inform actions to avert land degradation and facilitate climate adaptation. The focus was on measures to reduce the incidence crop residue burning. A variety of valuation methods were used (including choice experiments, market prices and damage costs avoided) to value costs and benefits, and come up with indicators of the private and public returns to different land management options.
13.	Germany	Physical effectiveness, cost-effectiveness and cost-benefit analysis of flood risk management measures This case study evaluates the physical and economic impacts of flood risk management measures at two sites on the Mulde River, Germany. Three different approaches were applied to evaluate the flood control measures: physical effectiveness, cost-effectiveness and cost-benefit (efficiency) analysis. The aim was to demonstrate a methodology that could capture more fully the value of non-structural measures that are better in terms of effectiveness related to hydrological protection standards, and better make the case for these 'soft' techniques.

14. Greece	**Choice experiments to value the public benefits of adaptation for river basin ecosystem services** This case study describes the application of choice experiment techniques to value local residents' preferences for undertaking climate adaptation measures which would maintain key ecosystem services in a river basin in Greece. The intention was to provide decision-support information that could assist in adaptation planning, and would highlight the need to invest in measures to secure the river basin in the face of climate change.
15. Guyana	**Measuring changes in climate change-related knowledge, attitudes and practices in Guyana** This case study describes a knowledge, attitudes and practices survey on climate change awareness and education in Guyana. The aim was to investigate current perceptions, identify gaps, and generate recommendations to help in addressing sustainable climate change adaptation, mitigation and disaster risk programming. The study was conducted using both qualitative and quantitative methodologies, involving structured questionnaires and interviews with key stakeholders.
16. India	**Extended cost-benefit analysis of drought and flood-related disaster risk-reduction and response interventions** This case study assesses the costs and benefits of flood disaster risk-reduction and response interventions in India. To do this, it considered a variety of economic, social, human and physical values that would not be included in conventional cost-benefit analyses. The aims was to provide evidence that investments in disaster mitigation and preparedness measures are well-spent, and to demonstrate a tool that can be used to choose between different intervention options.
17. Indonesia	**Evaluating the biophysical and socioeconomic effectiveness of hybrid "building with nature" coastal adaptation measures** This case study describes how the benefits of a hybrid "Building with Nature" approach to coastal restoration and adaptation were evaluated. A variety of methods were used to measure biophysical and socioeconomic effects such as coastal risk reduction, land and water quality improvements, mangrove re-establishment and livelihood gains. These included field observations and measurements, satellite and drone technologies, household surveys and community consultations.
18. Malawi	**Bayesian Belief network to quantify the biophysical adaptation benefits of climate-smart agriculture** This case study describes a study carried out to quantify the biophysical adaptation benefits of climate-smart agriculture in Malawi. It used a multiple-indicator Bayesian Belief Network based on assigning subjective probabilities to express a degree of belief in particular events or outcomes. This was used to compare the impacts of different farm interventions on climate change vulnerability. The aim was to demonstrate a simple methodology that could be used to generate evidence to justify and encourage higher investments in climate adaptation.
19. Malawi and Tanzania	**Participatory mapping and valuation of farmers' land management costs, benefits and preferences** This case study describes the use of participatory methods to assess local perceptions and preferences for different land use management choices and agroecosystem services in Malawi and Tanzania. The study was prompted by the top-down nature of many of the assessment methods that are conventionally used to guide the design of agricultural projects, especially their failure to adequately consider farmers' own needs and priorities. It aimed to inform the selection, design and evaluation of sustainable land management (SLM) and climate-smart agriculture (CSA) interventions.

20. Mexico	"Integrating Ecosystem Services into Development Planning" valuation of economic contribution of protected area ecosystem services	This case study describes an exercise to value protected area ecosystem services, as part of a broader exercise to understand and act on ecosystem service dependencies, impacts and opportunities. The aim was to demonstrate their economic contribution to local, national and sectoral development processes, as well as generating information that could be used to address key conservation threats and management issues. Capacity-building formed a cross-cutting objective, and continuous area of focus in the valuation study.
21. Morocco	Multi-stakeholder cost-benefit analysis and contingent ranking of climate adaptation in the irrigation sector	This case study evaluates economic aspects of adaptation interventions in the irrigation sector in Morocco. It employs a cost-benefit analysis focused, multi-stakeholder approach which takes account of the wider effects of adaptation measures on different sectors and groups, as well as the potential synergies and trade-offs between them. The intention was to provide a fuller picture of adaptation impacts as well as to generate information that could be used to make the case for adaptation and encourage uptake.
22. Myanmar	Using InVEST to conduct a natural capital assessment of ecosystem service values and trade-offs	This case study describes work carried out in Myanmar to map and value natural capital at the national level and in Tanintharyi Region. A broad range of ecosystem services were considered, including sediment retention, waterflow regulation, flood attenuation and coastal protection. Future climate impacts were incorporated into the valuation scenarios that were modelled. The information was intended to feed into various land use planning applications, including understanding trade-offs and identifying options for protected areas, infrastructure development and climate adaptation
23. Nepal	Integrated biophysical, social and economic assessment of ecosystem-based disaster risk reduction approaches to road construction in Nepal	This case study describes a cost-benefit analysis to compare green and grey options for road development in Nepal. This integrated biophysical, social and economic methods in order to cover a wide range of different effects and values. The main aim was to generate evidence to make the case for bio-engineering and ecosystem-based disaster risk reduction to planners, budget holders and policy makers at both district and national levels.
24. Niger	Extended social cost-benefit analysis to evaluate 'hard' and 'soft' community-based adaptation measures	This case study evaluates community-based adaptation measures in Niger. Unlike more conventional cost-benefit analysis techniques, it incorporated a wide variety of quantified indicators to measure changes in communities' economic, social and environmental capital. The study sought to demonstrating the effectiveness of community-based adaptation approaches for building resilience and adaptive capacity across a broad range of outcomes.
25. Peru	Physical impact assessment and cost-effectiveness analysis of green water interventions	This case study valued both the physical and economic impacts of ecosystem-based water supply interventions in Peru. This yielded indicators of potential effects on baseflow and cost-effectiveness. The aim was to make the case for integrating and prioritising green options into water planning and investments, at the same time as developing and demonstrating a practical assessment methodology that could be applied more generally to infrastructure in other sectors.

26. Philippines	Cost-benefit analysis and total economic valuation to make the case for ecosystem-based coastal adaptation	This case study describes two climate adaptation-related ecosystem valuation exercises carried out in the Philippines. One compared the relative costs and benefits of grey and green coastal adaptation options, while the other was a broader exercise that looked at both adaptation and non-adaptation related benefits of ecosystem restoration and conservation at the river-basin level. It makes the point that both targeted and general information on ecosystem values can help to make the case for green adaptation measures.
27. Philippines	Integrated ecosystem accounting	This case study describes how ecosystem accounts were developed for two sites in the Philippines. The aim was to demonstrate to local decision makers the environmental and economic consequences of various land use trade-offs for different groups and sectors, so as to help to inform the development of strategies for managing competing claims on natural resources. The study adopted the UN System of Environmental-Economic Accounting, combining spatial, biophysical and economic data and integrating various ecosystem valuation tools.
28. Portugal	Cost-benefit analysis of coastal protection interventions to safeguard ecosystem services	This case study adopts a spatially-explicit approach that allows for both the physical and financial-economic assessment of coastal protection investments options at the local scale in Central Portugal. This uses a shoreline evolution model is used in combination with a benefits transfer approach for the valuation of coastal ecosystems to assess the costs and benefits of a wide range of types, locations and combinations of coastal protection investment options. The aim was to make the case that it is worthwhile to undertake investments to protect natural, as well as settled, coastal areas.
29. Saint Lucia	Cost-benefit analysis of the adaptation benefits of climate-proofing community infrastructure	This case study describes efforts to value the adaptation benefits arising from climate-proofing a community centre in Saint Lucia. A cost-benefit analysis was carried out which looked both at the direct costs of retrofitting and the foregone damage costs and various other social and environmental benefits. The aim was to show how economic analysis can be used to guide decision-making, as well as to convince policy makers that investments in adaptation can be worthwhile.
30. Samoa	Cost-benefit analysis of community-level coastal protection measures	This case study carried out an economic assessment of a seawall and associated 'green' and 'soft' adaptation measures to protect a coastal village in Samoa against erosion and storm surges. Cost-benefit analysis techniques were used, looking at direct expenditures on constructing and maintaining the measures, and on avoided damages to land and infrastructure. The aim was to determine whether the adaptation intervention represented a worthwhile use of funds and should be scaled up elsewhere.
31. South Africa	Assessment of the employment benefits of climate adaptation	This case study describes studies carried out to measure how climate change affects employment prospects in South Africa (and, conversely, how adaptation measures will generate added benefits to the labour force). It used a methodology based on modelling the employment-creation potential of climate adaptation and mitigation measures, and on the climate-related job losses to value these effects in major sectors of the economy, and at the national level.

32. South Africa

Cost-effectiveness analysis to value rangeland rehabilitation measures in Namaqualand

This case study describes work carried out to measure how climate change affects employment prospects in South Africa. This involved modelling both climate-related job losses and the employment-creation potential of climate adaptation and mitigation measures. The effects were modelled for major sectors of the economy, and at the national level. The intention was to better understand the labour impacts of climate change and climate-change responses, so as to guide the development of policy responses to sustain and enhance jobs.

33. Sudan

Simplified cost-benefit analysis techniques to evaluate drought-related disaster risk reduction measures

This case study measured the costs, benefits and impacts of drought-related disaster risk reduction measures in Sudan. Simplified, rapid cost-benefit techniques were used to weigh up the physical costs and outputs from interventions, and show their relative return on investment. Quantitative and qualitative community-based indicators of resilience were also developed. The aim was to evaluate the site-specific effects as well as to contribute towards global efforts to improve disaster risk reduction performance measurement and impact analysis.

34. Tanzania and Indonesia

Technical suitability and physical impact assessment of community-level flood adaptation measures

This case study describes a study carried out to measure the technical suitability and physical effectiveness of community-initiated flood adaptation interventions in informal urban settlements in Indonesia and Tanzania. The methodology combined qualitative and quantitative techniques to investigate and measure the extent to which adaptation measures conformed to engineering standards, and were effective in protecting against flood impacts.

35. Thailand

Biophysical and economic evaluation of watershed adaptation options

This case study describes biophysical-economic evaluations of climate adaptation options at the watershed level in two of Thailand's key river basins. The focus was on assessing the potential of ecosystem-based approaches to protect against extreme weather events, as compared to conventional 'grey' options. The aim was to support local water planners and national decision makers to design and implement effective measures for the prevention of flooding and drought in the face of climate change.

36. Uganda

Cost-benefit analysis of farm-level adaptation measures

This case study involved an economic assessment of different project options for farm-level adaption measures addressing crop production, livestock production and water management. It used standard cost-benefit analysis techniques. The aim was to assist in prioritising the interventions according to their relative economic viability and profitability under different climate futures.

37. United Kingdom

Bayesian Belief network to assess the water quality and flood mitigation benefits of riparian buffer strips

This case study describes the application of a Bayesian Belief Network approach to assess the effectiveness of different riparian buffer strip management options in delivering water quality and flood risk mitigation services in the UK. The aim was to develop and demonstrate the ecosystem approach via a joint model which integrated biophysical and socioeconomic aspects, and was geared towards generating results that are of use to decision-making.

38. USA	Contingent valuation to measure the public benefits of wetland restoration
	This case study measures public perceptions of the benefits of wetland restoration in the USA, and analyses these values by assessing their willingness to pay to mitigate the negative consequences of wetland loss. The aim was to overcome current methodological and knowledge gaps about the general public's perceptions of wetland values, including storm protection, ecosystem services and recreational benefits. The study demonstrates the importance of including public opinion, as well as scientific 'expert' data, in coastal decision-making.
39. USA	Integrated biophysical and economic valuation to weigh up coastal adaptation options
	This case study investigates the effectiveness of different adaptation options in addressing coastal erosion, flooding hazards and sea level-rise in the USA. An integrated valuation methodology was applied which combined hazard projections with biophysical modelling and economic analysis. The aim was to provide decision makers in the region with the tools they need to compare a suite of possible adaptation strategies to combat accelerating coastal erosion in their jurisdictions.
40. Viet Nam	Saved health, saved wealth approach to compare the benefits of coastal adaptation options
	This case study describes how a "saved health, saved wealth" approach was used to weigh up the benefits and impacts of grey and green coastal adaptation options in southern Viet Nam. Two alternative interventions were considered: a concrete dyke and mangrove rehabilitation. The methodology compared economic assets and life expectancy under a baseline business-as-usual scenario with the economic damages, illnesses and mortality that would be avoided through undertaking adaptation measures.

EbA valuation methods

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key sources on EbA valuation techniques and applications

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Albania

Case study 1

Cost-benefit analysis of adaptation options for Albania's power sector

This case study involved an extended cost-benefit analysis of adaptation options in Albania's power generation sector. The aim was to provide information that could be used to inform and support energy sector investment planning by identifying the optimal power generation asset to supply the shortfall in electricity that would directly be caused by climate change. Although the options being considered were all grey, engineered solutions, the analysis considered a wide range of social and environmental indicators, alongside more conventional financial costs and benefits.

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What was being measured, and why?

This study was carried out to examine alternative adaptation options in Albania's power generation sector. The intention was to examine options to manage the risks and vulnerabilities to energy security in the face of climate change, and to provide information that could be used to inform and support energy sector investment planning and decision-making. As the diversification of power generation assets was identified as a key adaptation option, a cost-benefit analysis was conducted with a view to identifying the optimal power generation asset to supply the shortfall in electricity that would directly be caused by climate change.

The extended cost-benefit analysis looked at the desirability of alternative adaptation options in economic, not purely financial, terms: it was concerned with measuring impacts and values to groups across the economy, not just to power operators and consumers. Thus, even though it was concerned only with engineered (not ecosystem-based) options, the a relatively wide variety of economic, environmental and social indicators were incorporated into the calculations. These included, as well as direct costs and revenues, the cost of carbon dioxide emissions, ecosystem service values, disturbance to people and property and vulnerability to natural disasters.

Which methods were used?

First of all, to assess the range of energy generation technologies that could be used, the shortfall in power that would result from climate change was identified. This was based on the projections provided in the National Energy Strategy, which took into account two scenarios: passive (no energy demand control or energy efficient measures) and active (including implementation of energy efficiency measures such as residential property insulation standards and installation of domestic solar water heating). Expert opinion was engaged to extend and modify these projections based on the climate change risks that had been identified, potential energy supply curves were generated that would meet demand, and shortfalls in power generation were calculated.

Next, adaptation options to meet the projected power shortfall due to climate change impacts were identified, and a cost-benefit analysis was carried out to compare them. Eight reasonable and practicable technology-based options (asset types) for filling the electricity shortfall were identified during stakeholder workshops: import, combined cycle gas turbine, improvement and updating of existing large hydropower plants, improvement and updating of existing small hydropower plants, install new small hydropower plants, wind power, concentrated solar power, install new large hydropower plant. To compare the costs and benefits of all the different assets on a like-for-like basis, a quantity of power was chosen, 350 GWh, which could meet the estimated climate change-induced shortage for 20 years. All of the generation capacity is not required at once, but rather the need increases over the assessment period. Each of the assets under study have different expected periods of service.

Workhops identify eight technology-based options

Both public and private benefits and costs were included in the calculations, and a qualitative analysis of non-monetizable benefits and costs was also carried out. The eight power technology options were evaluated on the basis of eight parameters that were determined based on the outcome of workshops and discussions with stakeholders. Parameters were chosen that reflect financial, social, and environmental aspects of the different options: capital expenditure, operating expenditure, electricity revenue, value of water, carbon dioxide emissions, ecosystem service values, disturbance to people and property and discount rate. Vulnerability to natural disasters and increased climatic vulnerabilities is another parameter that was

Case study 1

Albania

identified as being important at the workshops, but was only able to be incorporated into the cost-benefit analysis through sensitivity testing.

The cost-benefit analysis was run over a period of 40 years (2010-2050), so as tie in with climate modelling timeframes and a notable threshold date. It yielded net present value estimates for each of the identified adaptation options. The options were sorted and presented, and any which returned a net present value less than zero was not considered economic or sustainable. Finally, a sensitivity analysis was carried out. This is because cost-benefit analyses of this type are inherently subject to uncertainty. By varying key input parameters over a wide but reasonable range, the implications of a range of possible futures can be examined. The sensitivity of the results to variation in the value of key parameters was therefore assessed, looking at the cost of carbon and air pollution, the value of water, ecosystem service values, disturbances to society, electricity revenues, fuel cost and the social discount rate. Another set of parameters was designed to explore the effect that increasing frequency of extreme events may have on the availability of electricity from various sources. The primary source of risk is the vulnerability of power transmission assets to wind and lightning strikes. To set up this scenario, a penalty was placed on long-distance transmission assets, which are more vulnerable to these risks.

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What were the findings?

The three most economic and sustainable adaptation options were identified as being enhancements to existing large hydropower assets, enhancements to existing small hydropower assets and the building of new small hydropower plants.

While two other options appeared unsustainable in the light of the specified goal (namely: filling the future shortfall in electricity supply due to the impacts of climate change) — building new large hydropower plants, and importing power — they were not excluded. This is because, in the context of the study, the relative ranking of the options is more important than the specific net present value of any particular option. Both of these options may, in fact, be sustainable in certain contexts.

Case study 1

Albania

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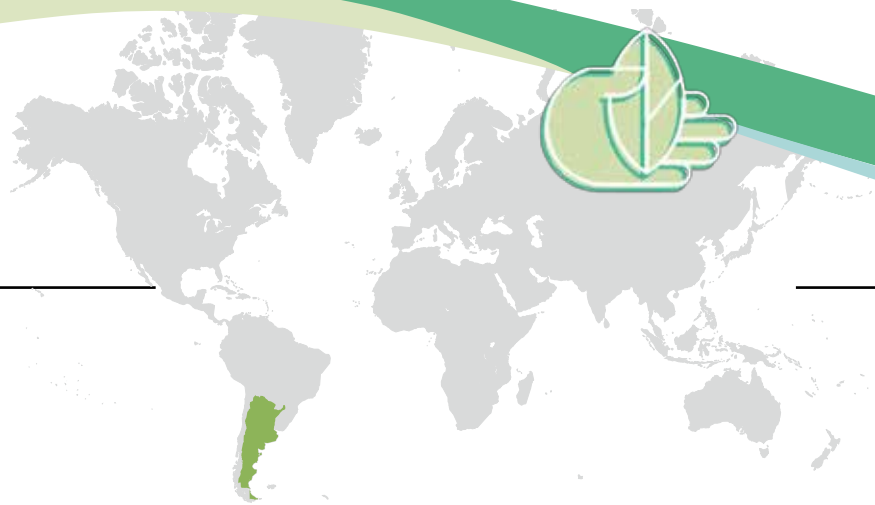
Argentina

Case study 2



Physical effectiveness and cost efficiency analysis of water sector adaption measures in Argentina

This case study describes an integrated assessment to consider the physical effectiveness and cost efficiency impacts of adaptation measures designed to address seasonal water shortages in a river basin in north-west Argentina. This measured reductions in unmet water demand against the cost of achieving these savings. The analysis sought to help decision makers make informed choices among alternative water infrastructure designs that would be robust and sustainable in the face of climate change.

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What was being measured, and why?

This study was carried out to evaluate possible water sector adaptation interventions in a region already suffering from water scarcity in north-western Argentina. It measured options for addressing seasonal water shortages through enhancing the effectiveness and efficiency of agricultural and urban water use by means of improvements in water supply and distribution infrastructure. The study assessed three adaptation options terms of their physical effectiveness in reducing unmet water demand, and their cost-efficiency measured as cost per unit reduction in unmet demand.

The study was carried out for the Inter-American Development Bank (IDB). It was stimulated by the IDB's recognition that many of the infrastructure projects carried out in water and irrigation (as well as in other sectors such as sanitation, flood control, transport, and energy) may be affected negatively by climate change. Assessing both the possible future changes that might occur in water availability and the means to address them is an important step toward ensuring that infrastructure projects meet their operational, financial, and economic goals. The aim was therefore to develop and demonstrate economic analysis and decision support tools to estimate the costs and benefits of climate adaptation measures, and to help decision makers make informed choices among different infrastructure designs and alternative policies for water resources management.

Which methods were used?

Evaluation of the effectiveness of adaptation measures in addressing seasonal water shortages was informed by the outputs of hydrological and climate modelling in the study area (the Upper Bermejo River of the Rio Grande Basin). This commenced with data collection and an assessment of the natural conditions, focusing on streamflow, current and future climate, soils, and land use. Existing water infrastructure, water management practices and water demand was also estimated. A hydrology and climate model for Latin America and the Caribbean, Hydro-BID, allowed for the modelling of current and future streamflows. Using these data outputs, a comparison of water supply and demand was made using a Water Evaluation and Planning (WEAP) model, so as to calculate unmet water demand for several climate projections and several adaptation scenarios.

The assessment of adaptation options examined unmet water demand from 2011-2060 for three selected climate projections and three packages of adaptation measures. These comprised option 1 – improved water efficiency (improvements to urban water supply and distribution infrastructure), option 2 – improved irrigation efficiency (improvements to irrigation application technologies, moving from furrow to drip systems) and option 3 – improved urban and irrigation efficiency (a combination of the previous two options) These were measured against the reference scenario 0 – current efficiency (where no efficiency improvements are implemented, leakages in urban systems remain high, irrigation efficiency remains lows, and both cropping patterns and rates of increase in water demand remain as is).

The adaptation options were assessed in terms of their physical effectiveness (measured in terms of reduction of unmet water demand) and cost efficiency (evaluated by comparing net cost per cubic meter of water saved). Physical effectiveness was calculated by conducting water balance analyses, employing a WEAP model to show the unmet demand under each adaptation option and climate scenario. Reductions in unmet water demand were expressed in terms of millions of cubic metres saved relative to the reference base case. Cost-efficiency was derived from the present value of all capital and operating costs associated with that option, divided by the total reduction in unmet demand. This was expressed in terms of USD per m^3/day saved, discounted over the study period.

Case study 2

Argentina

What were the findings?

The evaluation showed that major reductions in future unmet water demand could be achieved by improving the effectiveness of urban water distribution infrastructure and improving irrigation application efficiency. Improving the efficiency of urban water use was projected to reduce unmet demand only modestly, limiting its rise to approximately 141-183 million m^3/year. In contrast, improving the application efficiency of water use in irrigation had a substantial impact, limiting the increase in unmet demand to about 16-44 million m^3/year. Cost efficiencies were calculated to be in the order of USD 0.02 for urban and industrial water efficiency improvements and USD 0.04 - USD 0.07 for improvements in irrigation application efficiency for sugar cane and tobacco respectively.

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Australia

Case study 3

Cost-benefit analysis to make the case for flood mitigation investments in Australia

This case study evaluates the economic impacts of flood mitigation interventions in Australia. It uses biophysical models and cost-benefit analysis to assess climate risk, assets at risk and the protective capacity of mitigation measures. The aim was to establish the business case for flood mitigation investments, as well as to showcase methods that can be used to inform the allocation of limited regional government funding to infrastructure projects.

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What was being measured, and why?

This study was carried out to highlight the economic gains that can be achieved from investments in flood mitigation infrastructure in three towns of New South Wales and Queensland, Australia. It applied a cost-benefit analysis based on the assessment and monetary valuation of climate risks, risks to assets and production, and the protective capacity of mitigation measures. This enabled the overall gains from flood mitigation interventions to be modelled, as well as the costs and benefits of individual measures or packages of measures to be compared.

The study was carried out in response to the recognition that, given the demands on government budgets and in ensuring taxpayers' money is well spent, establishing a robust business case is a vital pre-condition for advancing flood mitigation investments. One of the key aims of the study was to provide evidence that measures such as levees are a cost-effective and proven means of reducing long-term community exposure to the risk of floods. t also sought to showcase methods that can be used to inform the allocation of limited regional government funding to infrastructure projects. The overall goal was to provides decision-makers with a systematic and forward-looking way of developing a business case for flood mitigation investments.

Which methods were used?

The study assessed flood protection investments in Grafton (New South Wales), Roma and St. George (Queensland). It focused on large-scale public flood mitigation investments to reduce the economic cost of natural disasters. Because of these community-wide protection and public financing aspects (and thus of the business case that is required to support them), the study was aimed to evaluate a broad range of benefits and the costs of respective mitigation options. It used a cost-benefit approach based around three core modules: climate risk, elements at risk and protective capacity of mitigation. Various flood mitigation measures were assessed, including levees, floodway channel diversions, drains, dams, storm water drainage systems. A period of 50 years was selected as the time frame, reflecting the long-term nature of the investments. The analysis adopted a conservative financial-based approach, and did not consider the additional social and environmental costs associated with flooding.

Time frame of 50 years reflected long-term nature of investments

The climate risk module examined total flood risk, encompassing weather patterns at the three towns and surrounding areas. It utilised past records of weather patterns, and projected these trends into the future based on technical assessments of flood risks which projected expected damages for different scale flood events. The analysis was made over the long term, allowing for future changes in the frequency and severity of heavy rainfall events. This scenario was based onto technical assessments of flood risks for which projected expected damages for different scale flood events.

The elements at risk module investigated the impacts of floods on people, assets and productive activities. This involved evaluating the towns' current economic composition, industry, residential housing and public infrastructure profiles. These were obtained from local and national government records, and were compared with statistics showing property damages from past flood events. This established, for each site, 'value at risk' across different asset classes such as residential houses, commercial buildings and public infrastructure, and its economic structure.

The protective capacity of mitigation module looked at the extent to which different measures protect a community and how much

Case study 3

Australia

it costs to build and maintain them. This essentially involved measuring the long-term capital and operating expenditures against total economic benefit, measured as avoided losses from expected disaster events. Damages avoided included both direct and indirect costs resulting from flooding, such as damage to private and public assets, regional production and productivity losses. It also looked at potential improvements in insurance coverage. Reductions in insurance premiums were included on the basis that construction of a flood levee reduces uncertainty and therefore provides greater ability by insurers to adequately and appropriately price premiums based on risk. Discounts to risk premiums were calculated from the average premiums paid at the time of the study.

Bringing these figures together, the cost-benefit analysis yielded a range of indicators of the estimated benefits of flood mitigation interventions. These included a statement of capital and maintenance costs, a breakdown of benefits (avoided) costs to households, businesses, public infrastructure, productivity and insurance coverage. Net present values and benefit-cost ratios provided overall measures of project profitability over different time frames.

EbA valuation case studies

What were the findings?

The study showed that significant economic value is at risk from floods in the study sites and that, accordingly, there are strong protective benefits from flood mitigation interventions. Based on their protective capacities and underlying weather risks, the flood mitigation investments in Roma and St. George showed net benefits of AUD 64.7 million and AUD 25.7 million respectively over the next 50 years, while the legacy flood mitigation structures in Grafton show a long-term net economic gain of AUD 59.2 million.

It also demonstrated that effective flood mitigation can be delivered at low cost. Benefit-cost ratios for the three levee systems were in the order of 2.2-5.4, indicating a robust economic return on investment for the community. Importantly, this compared well with other infrastructure projects which were candidates for limited allocations of regional development funding from governments.

Case study 3

Australia

EbA valuation

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Bangladesh

Case study 4

Cost-benefit analysis of national-level grey and green adaptation options in Bangladesh

This case study describes a cost-benefit analysis of various options for climate adaptation in Bangladesh. It considers both grey and green interventions, as well as longer-term measures to increase labour productivity and relocate vulnerable coastal populations. The aim was to generate information that could be used to prioritise strategic options for adaptation, and guide investment planning.

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What was being measured, and why?

This study was carried out to assess the costs and benefits of climate adaptation in Bangladesh. Bangladesh is one of the most vulnerable countries in the world to climate change, with tropical cyclones, floods, droughts and other extreme weather events creating an immediate threat to the economy.

The study sought to demonstrate that adaptation should be deeply embedded into the national development strategy. Bearing resource constraints in mind, it aimed to present information about the relative costs, benefits and returns to different adaptation options that could be used to support development and investment planning.

Which methods were used?

The study looked at both interim measures or "reactive adaptation interventions" which focus specifically on storm surges and inland flooding, and a long-term strategy of resilient economic growth, assets diversification and human capital formation. The interim-reactive measures included foreshore afforestation and mangrove protection, construction of cyclone-resistant shelters/ housing and early warning systems, polders reconstruction and setback. Two long-term strategies were considered: measures to increase agricultural productivity and population relocation.

The cost-benefit analysis of interim-reactive measures focused on the protection of population, property and agricultural land within cyclone risk zones and inundation zones with depths of more than 1 m. A first step was to calculate the size and distribution of this population. Then, the impacts, costs and benefits of each of the three specified adaptation options were calculated. For all of the adaptation options, the costs were based on the physical costs of establishing and maintaining the specified adaptation measures. Benefit calculations however varied for each option. The analysis yielded present values and benefit:cost ratios for each adaptation option, calculated at 3, 5 and 10 per cent discount rates over the period 2015-50. Monte-Carlo simulations were also run for each sub-analysis, in order to account for uncertainties.

For mangrove afforestation and protection option, this required constructing biophysical models to estimate the protective functions of mangroves and polders, and the likely future patterns of extreme weather events, their incidence, severity and impact. Damage cost techniques were used to estimate the resulting losses. In addition, the broader value of ecosystem provisioning, recreational, biodiversity and carbon sequestration services were estimated using benefit transfer techniques.

Assessment of the construction of cyclone-resistant shelters/ housing and early warning systems looked at reduced injuries and loss of life for both humans and livestock, as well as avoided damages to housing and personal property. These were calculated based on data from previous natural disasters, translated into individual risk estimates. Per capita gross domestic product (GDP) was used as a proxy for the value of life year lost, and injuries were estimated at USD 100 per case.

Case study 4

Bangladesh

Which Methods were used?

The polder reconstruction and setback option was combined with the establishment of a mangroves greenbelt and a fund to encourage cyclone-resistant private housing. As with the other adaptation options, a variety of avoided damages to agriculture housing and infrastructure were modelled.

The long-term strategies relating to agricultural productivity and population relocation were modelled at a macro-level, assuming certain percentage growth rates in domestic agricultural production per capita (20 per cent between 2015-2050) and labour participation (0.5 per cent per year), as well as residual damages from climate change (estimated as percentage of output). In order to calculate the benefits and costs of transformations in agricultural productivity, a production function incorporating land per unit of labour, people employed in agriculture, capital and total factor productivity was calibrated with USDA data for South Asia. Assumptions were made about the changes in these component variables, as well as the required investment costs.

The relocation of population inland was considered in combination with job creation in the manufacturing and service sectors. Estimates were made of avoided damage costs (from coastal storms and disasters as well as from progressive land and water degradation), increased participation in productive employment, as well as the physical costs of relocation.

EbA valuation case studies

What were the findings?

The overall conclusion of the study was that almost all of the adaptation options considered had a benefit:cost ratio of greater than one. Only polder reconstruction and setback a less than 3 metre inundation area was demonstrated to be unprofitable. The two long-term strategies, aiming to increase agricultural productivity and relocation vulnerable populations, showed the highest returns, followed by mangrove restoration protection (all with benefit:cost ratios greater than two). In contrast to the other options, mangrove-based adaptation generates a sizeable share of external benefits, as well as offering opportunities to leverage additional financial flows and income (for example through the carbon market and tourism).

Case study 4

Bangladesh

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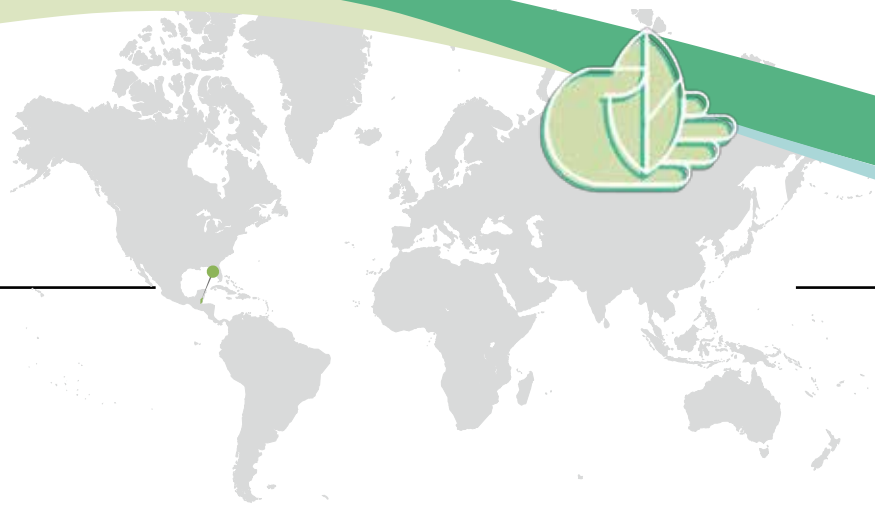
Belize

Case study 5



Use of InVEST to weigh up coastal adaptation options and trade-offs in Placencia, Belize

This case study describes a study to compare the biophysical impacts and economic value of alternative packages of grey and green coastal adaptation options in Belize. The aim was to influence coastal zone planning processes. The InVEST tool was used to model and map the provision of ecosystem services (including coastal protection, fisheries, tourism and carbon). Cost-benefit analysis was then applied to weigh up the physical costs of different adaptation options as well as the value of the ecosystem service benefits and damages avoided they would generate.

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What was being measured, and why?

This study was carried out to assess and compare the relative costs and benefits of alternative adaptation options to defend the coastline around Placencia, Belize against level rise and coastal storms. The study compared various packages of ecosystem-based options (including conservation and restoration of coral reefs and mangroves, forest restoration and rehabilitation) and grey infrastructure (such as sea walls).

The study sought to generate information to feed into and influence coastal zone planning processes led by the Belize Coastal Zone Management Authority and Institute (CZMAI), including the development of a nationally binding Integrated Coastal Zone Management Plan (ICZMP) with region-specific spatial planning and guidance. It also aimed to address some of the key constraints faced by cost-benefit analyses of adaptation options so far, and in so doing, strengthen the methodology for climate change adaptation planning.

The study was carried out by the Natural Capital Project, WWF as a consultancy to the Inter-American Development Bank entitled "Identification and Valuation of Adaptation Options in Coastal-Marine Ecosystems". The work was carried out in collaboration with the Belize Coastal Zone, Management Authority and Institute (CZMAI).

Which methods were used?

The study included ecosystem services assessment, scenario development and cost-benefit aspects. The ecosystem services assessment was based on InvEST (integrated valuation of ecosystem services and tradeoffs). This is a spatially-explicit, software-based tool for modelling ecosystem service values and trade-offs that uses maps as information sources and produces maps as outputs. InVEST has various modules dealing with different biomes and ecosystem services. These models are based on production functions that define how changes in an ecosystem's structure and function are likely to affect the flows and values of ecosystem services across the landscape, expressing the results in either biophysical or monetary terms.

Four ecosystem services were modelled: lobster fisheries, coastal protection, tourism and recreation, carbon storage and sequestration. This yielded estimates of the locations and levels of ecosystem service provision. Three adaptation scenarios were compared: integrated adaptation (EbA and some grey infrastructure in developed areas without high-value beachfront property), reactive adaptation (grey infrastructure is the primary emphasis and sea walls are built to protect investments in tourism and private property), and no action.

Four ecosystem services were modelled

The cost-benefit analysis then looked at the monetary impacts of the different adaptation measures in terms of their physical establishment and maintenance costs as well as the value of the ecosystem services they would generate. The value of lobster fisheries was calculated by looking
at catch values, coastal protection values were estimated through damages to property and infrastructure, tourism and recreation values were based on revenues and earnings, and carbon storage and sequestration was valued at the social cost of carbon. Benefit calculations also took account of spillover effects (such as the potential negative impacts on tourism from seawall construction). The cost-benefit model also accounted for the expected costs that would arise from sea level rise and increasing temperatures in the future, including changes in lobster catch and expected property damage

Case study 5

Belize

Which methods were used?

from erosion and storms. For each of the three adaptation scenarios under consideration, future cost and benefit streams were calculated, and discounted in order to yield a single measure of net present value (NPV).

Data was obtained from a number of sources. Ecosystem services data were collected as part of a three-year coastal zone planning process led by CZMAI. Information was also provided by a variety of government agencies in Belize, WWF offices, local non-governmental organisations and private entities, and peer-reviewed literature. Many of the cost and benefit figures that were used came from desk reviews and benefit transfer techniques, supplemented by extensive stakeholder dialogues and consultations with policy-makers.

What were the findings?

The main findings of the study was that adaptation measures based primarily on grey engineering (the reactive adaptation scenario) would pose the highest risk to sea grass, coral reefs, and mangroves. The greatest benefits overall and highest levels of efficiency are achieved with a package of adaptation measures which combine grey and green approaches (the integrated adaptation scenario). Even though this option does not provide the highest returns for coastal protection, its costs are far lower, and it generates a substantially higher level of co-benefits for fisheries, tourism and climate mitigation.

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Case study 5

Belize

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Burkina Faso, Ghana

Case study 6

Income statements and cost-benefit analysis of 'soft' and ecosystem-based adaptation activities in Burkina Faso and Ghana

This case study measured the economic performance of a variety of 'soft' and ecosystem-based adaptation measures that had been implemented in the Volta Basin of Burkina Faso and Ghana. It was based on qualitative techniques as well as monetary income statements and cost-benefit analysis. The aim was to demonstrate a methodology and generate information that could be used to better design, implement and evaluate adaptation measures to meet local community needs and constraints.

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What was being measured, and why?

This study was carried out to measure the costs, benefits and performance of various 'soft' and ecosystem-based adaptation activities that had been carried out in the Volta Basin in east-central Burkina Faso and north-west Ghana. It used qualitative techniques to describe the economic and technical effects of interventions, as well as income statement and cost-benefit analysis methods to generate monetary data on their financial and economic performance.

The study was prompted by the general lack of information about the costs and benefits of different adaptation options. In the absence of such knowledge, it is almost impossible to identify implementation needs or gaps in relation to local communities, and, especially, to adjust the content of interventions to best deliver on adaptation goals in an effective, equitable and sustainable manner.

The overall objective of the study was therefore to contribute participatory learning about the economic benefits of climate change adaptation initiatives in Burkina Faso and Ghana. It also aims to identify and analyse the content, scope and relevance of the adaptation activities and evaluate the costs and benefits generated by promoted adaptation activities through analysing technical, environmental and economic performance.

Which methods were used?

The study looked at four 'soft' and ecosystem-based adaptation interventions: multi-purpose reforestation/tree planting, gardening, rearing of small ruminants and crop warranty/storage credit system based on loans guaranteed by already-harvested stocks. Two additional adaptation interventions, organic manure/stabilised compost pits and sustainable non-timber forest product harvesting, were not valued due to a lack of data.

The methodology had a strong emphasis on participatory techniques, aiming to involve the main adaptation stakeholders in the process of collecting and analysing information. Data collection was conducted through focus group interviews and individual surveys which discussed environmental variables and climate hazards, as well as the adaptation activities themselves, the income and other benefits that had been generated, and their strengths and weaknesses. The focus group interviews involved the participants in collective actions such as seedling production, reforestation and exploitation of non-timber forest products. Individual interviews were also conducted with technical and non-governmental organisations that played an active role in implementing the adaptation interventions, and used a semi-structured questionnaire.

Focus group interviews and individual surveys

A questionnaire survey was also administered to a sample of just under 200 of beneficiaries of the adaptation activities (selected from a total beneficiary population of 500 people). This covered the impacts of the adaptation measures, their implementation costs and cash income generated.

Based on these data, descriptive statistics were calculated to characterise and describe the participants in the adaptation activities, and the context in which they operate. Income statement techniques were then used to estimate the costs and income of the adaptation measures, so as to evaluate their financial and technical performance. A cost-benefit analysis was undertaken to assess the internal rate of return and the net present value of adaptation investments. Finally, a frequency analysis was conducted to investigate the responses to questions asked during the group interviews.

Case study 6

Burkina Faso, Ghana

What were the findings?

The study showed that all of the adaptation interventions were cost-effective, with benefit-cost ratios that were greater than one. These findings confirmed that it is legitimate to invest public (or donor) resources in climate change adaptation measures.

From a private point of view, adaptation activities have been financially beneficial to the participants. Every West African CFA Franc (CFAF) invested in adaptation generates CFAF 169 for gardening, CFAF 22 for rearing small ruminants, CFAF 20 for secured warranting and 127 CFAF for reforestation/planting fruit trees. From a social point of view, the investments made by the project and beneficiaries generated an internal rate of return of 30 per cent, much higher than the interest rate for bank savings in Burkina Faso.

However, constraints were identified as regards beneficiaries' capacity to successfully engage in adaptation activities. This exerts a significant influence on the level of the economic and technical performance obtained, and can undermine the effectiveness and profitability of adaptations. Importantly, it implies that the promotion of adaptation activities in rural communities must also include capacity-building measures.

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Case study 6

Burkina Faso, Ghana

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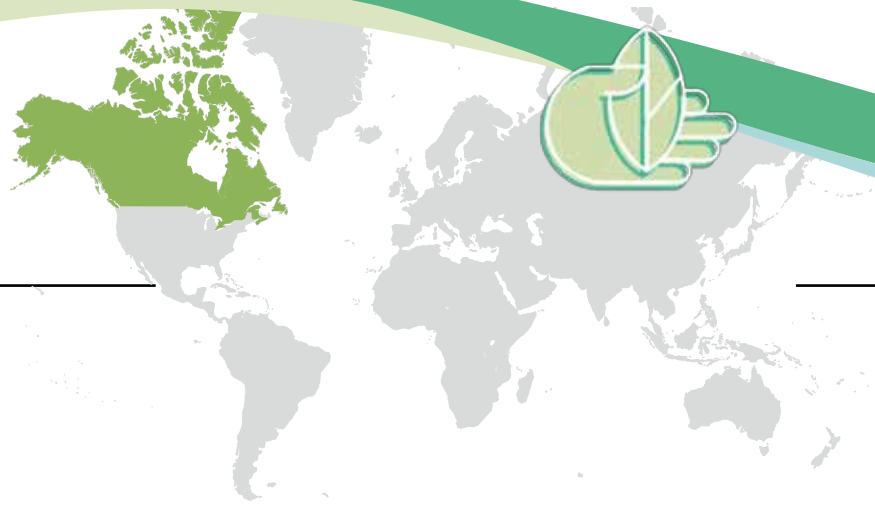
Canada

Case study 7



Cost-benefit analysis of engineered and non-structural coastal adaptation options in Canada

This case study assessed the economic value of coastal adaptation options in Canada. Cost-benefit analysis techniques were used to measure the erosion and flood-related financial, economic and (in some cases) social and environmental damages avoided, and to compare them with the direct cost of adaption interventions. This yielded a prioritised list of adaptation needs and measures, showing where interventions were most justified in economic terms.

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What was being measured, and why?

This study was carried out to assess adaptation options for the east coast of Canada. It uses cost-benefit analysis to compare the cost of implementing an adaptation strategy and its impacts against the benefits of the losses mitigated. The main objective was to determine the economic viability of various interventions for protecting the coastline. This involved adding an economic layer of analysis to existing climate change impact and adaptation data relating to sea-level rise, coastal flooding, coastal erosion and infrastructure and property vulnerability, as well as evaluating the economic costs and benefits of appropriate adaptation options.

The study was commissioned by the Economics Working Group of Canada's Climate Change Adaptation Platform. It was prompted by the general lack of information about either the economic benefits and costs of climate adaptation or the methods by which they could be quantified, meaning that that planners and decision-makers had no tested protocol to follow when prioritising the adaptation options available to them. The study therefore sought to create economic knowledge and tools to help decision-makers in Canada's private and public sectors make better adaptation investment choices and policy decisions.

Which methods were used?

The study considered 11 case study sites were selected across Quebec and the Atlantic Provinces covering various infrastructures and economic sectors, including transportation, trade, fisheries, tourism, residential areas and agriculture. Each case study analysis provided an inventory of infrastructure, properties and assets jeopardized by the impacts of coastal flooding and/or coastal erosion within the next 50 years, a portfolio of potential adaptation options to address these projected risks, and an assessment of these options based on their costs and benefits. Both hard and soft engineering structures were considered, as well as non-structural adaptation options.

Key assumptions related to climate change and hazards projections concern sea-level rise, flooding and erosion assessment. For sea-level rise, the RCP 8.5 scenario from the Fifth Assessment Report by the Intergovernmental Panel on Climate Change (IPCC) was selected, assuming a constant increase in greenhouse gases until 2100. For erosion hazard, the historical rates derived from aerial and terrestrial measurements of coastline retreat were linearly projected in the future. For the flooding hazard, water level return periods were used to project the extent of flooding.

A slightly different range of costs and benefits were valued in the two different regions. In addition to the construction and maintenance costs adaptation options, all of the study sites considered erosion-related and flood-induced losses and damages to land, commercial buildings and public infrastructure as well as the general economic impacts of reduced land values, loss of goods and commercial revenues and decline in trade and tourism revenues. In the Quebec case studies, the costs of emergency evacuation, traffic disruptions and debris clean up were also valued, and a series of environmental and social costs were factored into the analysis. These included loss of natural habitats and fish spawning grounds, as well as loss of sea access, decline in recreational use, reduced quality of lie, deterioration in the landscape and loss of historical and cultural heritage. The benefits originating from the positive impacts of adaptation were only included in cost-benefit analyses for the Quebec sites, and included gains in tourism revenues, enhancements in fish spawning grounds and improvements in the coast's recreational use, quality of life and landscape.

Two different valuation sets according to region

Case study 7

Canada

Which methods were used?

The economic approaches applied in both sets of case studies were based on stakeholder consultation. These helped to identify the potential impacts of erosion and flooding hazards, select the adaptation options to be assessed, estimate the costs and benefits of adaptation options, and quantify potential impacts. Importantly, the support of stakeholders increased the robustness of the results and led them to appropriate the results. In Quebec, field consultations were also carried out by surveying residents and tourists in order to quantify and estimate the use values. In addition, a provincial survey of 2,000 Quebec residents was conducted over the Internet to determine the potential impacts of specific adaptation options on their tourism behaviour.

The economic cost-benefit analysis was then carried out. This was based on a time horizon of 50 years (from 2015-2064), applied a discount rate of 4 per cent, and valued costs and benefits at economic (rather than) financial prices. First the net present value of the non-intervention, business as usual, scenario was calculated, overall and per linear metre. This offered a baseline scenario for comparing adaptation options, as it represented the costs associated with damages from erosion and/or flooding when intervention is minimal. Similar calculations were carried out for the different adaptation measures, showing the net present value and benefit:cost ratio of each.

Business as usual: baseline scenario for comparing options

The most advantageous adaptation options were then compared with the non-intervention option. On the basis of the incremental costs and benefits associated with undertaking adaptation measures (or, conversely, failing to act), the study sites were divided into five groups. Each group represented a different level of investment priority, and provided a means of indicating to decision-makers where (and to what level) it would be economically justified to implement adaptation interventions, as well as which adaptation options would generate the highest level of benefits and costs avoided to society.

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Case study 7

Canada

What were the findings?

The study found that the non-intervention option triggers net costs that range from CAD 0-705 million. Expressed by linear meter of coastline for a better appreciation of site importance, non-intervention costs range from CAD 0-777,848, centred on a median of CAD 1,221. Based on a comparison of their net present values with the non-intervention baseline, the results indicated that implementing an adaptation option would generate a net value-added for 29 of the 46 sites studied.

Adaptation brings benefits beyond the site itself

The categorisation of sites and adaptation options into five groups, depending on their economic profitability and in comparison to a do-nothing scenario, generated extremely useful information for decision-makers. The first group, not intervening is not an option, was of the highest priority and represented sites where failing to intervene would represent a considerable loss for society. In most cases, there were strategic regional and provincial assets at stake, meaning that adaptation would bring benefits that spread beyond the site itself. The analysis showed that investments of ranging from CAD 1.5 million to CAD 77.1 million were warranted and would return a net benefit. Sites in the second group, net advantage to intervene, registered high levels of damages and associated loss of coastal assets or uses. Investments in the range of CAD 100,000 to CAD 13 million could be justified economically. Most of the sites in the third group, small advantage to intervene, consisted of a single major asset which needs to be protected. Only relatively low-cost investments were justified. For the fourth group, within a margin of CAD 25,000, the added-value of adaptation was minimal. Because the potential damages were minimal, the discounted cost of the adaptation option needed also to be relatively low to justify any intervention. The fifth and last group, no economic advantage to intervene, included sites where the cost of the non-intervention option is zero or almost negligible as well as where adaptation options were more costly than the averted damages.

One of the most important lessons learned from the study concerned the collaborative approach that had been adopted. The cost-benefit analysis process was supported by strong ties with communities and decision-makers. Key public and private asset managers, local and regional authorities and representatives from various sectors (civil security, transportation, agriculture, environment, etc.)

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Canada

were invited to contribute to the case studies. Over the project's two-year period, dialogue was established and maintained. Not only did this serve to increase access to data and information and make the studies more robust in technical terms, but it also made a significant difference in how the results were perceived. These processes of engagement increased stakeholder understanding, acceptance and buy-in, and, as a result, enhanced consensus on adaptation options. Furthermore, stakeholders appeared more likely to defend and use the figures generated when they were actively involved in validating the assumptions and results.

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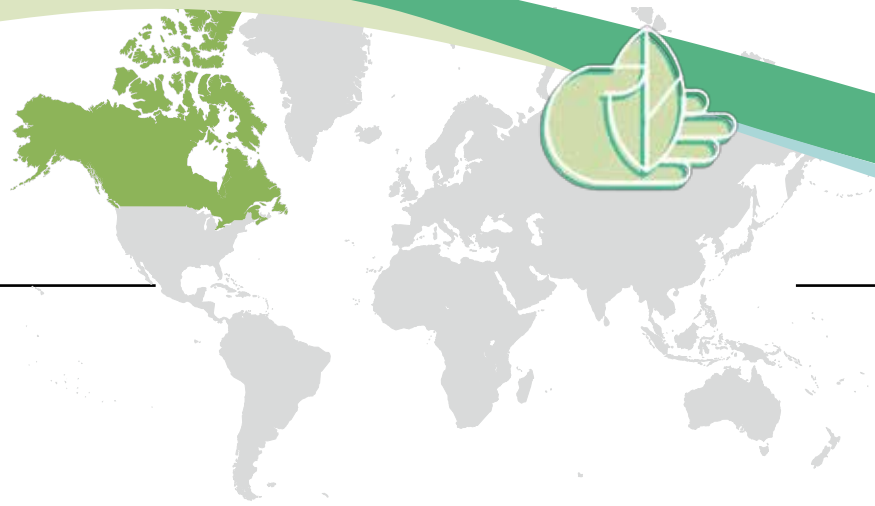
Canada

Case study 8



Cost-benefit analysis of flood mitigation interventions in Canada

This case study describes a cost-benefit analysis carried out to assess the desirability of a flood mitigation project in Canada. It came up with measures of profitability in terms of damage costs avoided relative to the project investment, and also compared the project with two other flood control options in order to ascertain which returns the highest benefit: cost ratio. The study was carried out to fulfil the regulatory requirements of the Government of Alberta, to determine if the project was economically viable.

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What was being measured, and why?

This study was carried out to assess the desirability of a the Springbank Off-Stream Flood Storage Mitigation Project, intended to ameliorate flood damages in the City of Calgary, Canada. It compares the project with two other flood control options in order to ascertain which returns the highest benefit:cost ratio.

The study commissioned by the Resilience and Mitigation Branch of the Government of Alberta's Environment and Sustainable Resources Department as part of the normal appraisal process for public sector investment projects. Cost-benefit analyses are routinely used by the Canadian Government as part of the business case for projects at Federal, Provincial and Municipal levels. The purpose of the Springbank Off-Stream Flood Storage Mitigation Project analysis was to provide a comparison of project benefits (in terms of damages averted) to project costs (including capital and operating costs), to determine if the project was economically viable and could be considered to be a justifiable use of public funds.

Which methods were used?

The analysis looked at the three components of the project: a river diversion structure, a diversion channel and reservoir inlet structure and an off-steam storage dam and reservoir. It followed a relatively simple process, as it looked only at direct costs and benefits and did not take broader social environmental impacts into account. On the benefit side, the analysis considered only avoided flood-related damages, while the costs just incorporated the capital and recurrent expenditures associated with establishing and maintaining the physical structures and associated engineering measures. Benefits were restricted to economic benefits accruing in the flood risk area within the City of Calgary boundaries.

Preliminary engineering design already carried out

The cost inputs were based on a preliminary engineering design that had already been carried out for the project. These included construction costs, upstream mitigation measures and land acquisition, as well as annual operation and maintenance. Land acquisition costs were based on market values, using conservative (higher cost) estimates. The investment costs were modelled for both 1:100 and 1:200 year protection scenarios. As additional subsurface soils investigations and more detailed hydrological assessment and topographic data are required to better establish the project details and size, a 25 per cent contingency was also included as an attempt to account for additional costs that may be incurred as a result of further development of the engineering design.

Avoided damage costs (the project benefits) were calculated using a probabilistic approach. Flood damages were estimated with the application of depth-damage curves applied to the various return flood events (probability). The flood damage probability distribution was then plotted and the average annual damage estimated for project evaluation purposes. Damage assessments were generated for nine return frequencies including: 1:2 year, 1:5 year, 1:10 year, 1:20 year, 1:50 year, 1:100 year, 1:200 year, 1:500 year and 1:1000 year, which allowed for the computation of average annual damages. Damage estimates were also assessed under two cases: a higher or 'worst case' condition and a lower or 'anticipated case' condition.

Case study 8

Canada

Which methods were used?

With and without project scenarios were modelled to compare between the events predicted to occur if the project is implemented and those predicted to occur if it does not go ahead. With the updated average annual damages and cost estimates of the diversion alternative, an economic efficiency evaluation was performed, based on the net present value of benefits and costs. A discount rate of four per cent was applied, the same as is used for all flood mitigation projects across Alberta Province. Benefit:cost ratios, present values and average annual damages were then calculated for each of 1:100 and 1:200 year protection, under high and low damage scenarios.

The Springbank Off-Stream Flood Storage Mitigation Project was compared with two other flood control options: McLean Creek Flood Storage Project and Glenmore Reservoir Diversion. The benefit: cost ratios of each were compared for each of 1:100 and 1:200 year protection, under high and low damage scenarios.

What were the findings?

The analysis estimated that the cost of the Springbank Off-Stream Reservoir project designed to accommodate a 1:100 year flood event, excluding the price of land acquisition, would be some CAD 160 million. It would result in a reduction of average annual damages of between CAD 13.75 million and CAD 26.11 million, depending on the protection and damage scenario being considered. The project thus achieved a positive benefit:cost ratio under all four scenarios (ranging from 1.3 under a low damage scenario to around 2 for a high damage scenario), suggesting that it was an economically effective project. When compared with other flood mitigation options, the Springbank Off-Stream Reservoir project was also found to generate higher benefit: cost ratios than either of the other mitigation options considered (the McLean Creek Flood Storage Project and Glenmore Reservoir Diversion).

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Case study 8

Canada

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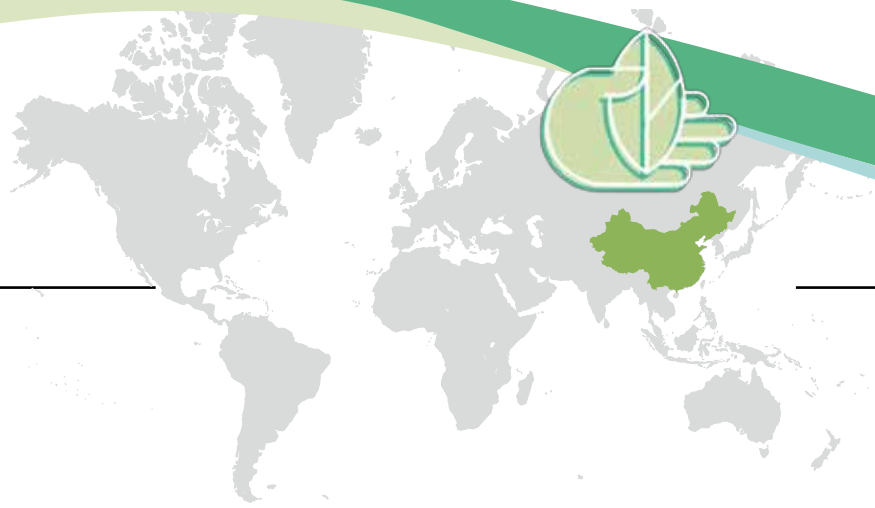
China

Case study 9



Cost-effectiveness analysis of water-saving irrigation technologies for climate adaptation in China

This case study looks at the economic viability of water-saving irrigation technologies as climate adaptation measures in China. This is measured by looking at the cost-effectiveness of four commonly-used technologies, as compared to traditional irrigation, in reducing the adverse effects of climate change, via increased crop yield and reduced water consumption. The aim was to generate new information that could support the identification of balanced responses to climate change and sustainable economic development.

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What was being measured, and why?

This study involved a cost-effectiveness analysis of four water-saving irrigation techniques that are widely implemented in China to address the impacts of climate change. The aim was to thoroughly understand the economic feasibility, effectiveness and efficiency of water-saving irrigation as a climate adaptation intervention.

The reason for the study was that, although a large body of research indicated that certain irrigation techniques can contribute to water saving, the cost and effectiveness of using water-saving irrigation to cope with climate change remained unknown. It was observed that there have been few comparisons with other adaptation measures in the agricultural water sector. A clear picture of the cost-effectiveness of water-saving techniques for adaptation was thus seen as a way of supporting the identification of balanced responses to climate change and sustainable economic development.

Which methods were used?

The study carried out a cost-effectiveness analysis, a decision-making tool that compares alternative means of achieving a given goal with regard to their resource utilization (cost) and outcomes (effectiveness). It can be used to find the least-cost means of reaching a particular goal, or to estimate the expected costs of achieving a particular outcome. Four of the most widely-used water-saving irrigation techniques in China were included in the study: sprinkler irrigation, micro-irrigation, low-pressure pipe irrigation and channel lining.

The four selected irrigation techniques were each compared with a baseline scenario in which traditional irrigation was employed. Each option was described in terms of the water consumption and grain yield per hectare of irrigated farmland, as well as the costs of undertaking irrigation. These costs included the initial investment in capital and equipment, annual operations and maintenance, water fees and energy fees. Data on capital and recurrent costs as well as crop yields were obtained from published studies, whereas energy and water prices came from government statistics. Estimates of the increases in grain yield and reductions in agricultural water consumption were taken from previous research which was based on field experiments comparing traditional irrigation methods with water-saving technologies.

Adaptation effectiveness was measured in two ways, based on the main effects of water-saving irrigation techniques on reducing the adverse effects of climate change: increased crop yield and reduced water consumption (and hence improved drought resilience). Both of these benefits reduce the vulnerability of farmers. By comparing water-saving irrigation techniques against the baseline, the analysis yielded estimates of the cost-effectiveness ratios of annual average increase in grain yield and average volume of reduced water use per unit area of farmland irrigated. These were expressed as the additional cost of increasing each ton of grain yield (USD per tonne) and the of reducing each cubic meter of water (USD per cubic metre).

Case study 9

China

What were the findings?

Based on the cost-effectiveness analysis, the study found that water-saving irrigation was a cost-effective means of coping with climate change, and generates significant adaptation benefits. Only one approach (channel lining) returns a negative cost-effectiveness ratio, but when considering the revenues from improved adaptation, all of the measures assessed were economically feasible. Even though micro-irrigation, in particular, has very high incremental costs for adaptation (it returns the highest cost per increased unit of grain yield and saved unit of water), it performs best of all four technologies considered. Micro-irrigation has the highest cost-effectiveness ratio for both of the adaptation effects assessed (crop yield and water use), followed by sprinkler irrigation, low-pressure pipe irrigation and channel lining.

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Czech Republic

Case study 10

Cost-benefit analysis of flood adaptation measures in the Czech Republic

This case study assesses the costs and benefits of ongoing and planned flood protection adaptation measures in the Czech Republic. Following a hazard and impact assessment which simulated the spatial patterns of damages and losses in different locations and generated damage estimates, a cost-benefit analysis was carried out to generate recommendations to decision-makers about whether the proposed investments will promote economic efficiency.

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What was being measured, and why?

This study was carried out to value existing and planned measures to address flood risks in the Vltava river basin, Prague, the Czech Republic. It assessed both the biophysical hazards and impacts resulting from flooding under different climate change pathways, and the economic return on investment.

The case study was one of two being carried out as part of a larger project which sought to support adaptation planning in Europe through building the knowledge base on the economics of adaptation to climate change and converting this into practical information for decision makers. The case study aimed to provide real-world economic appraisals of investments in climate change adaptation in the European context, in order to show how cost-benefit analysis can provide a viable tool for appraisal of adaptation investments. It also intended to generate information which could help inform decisions about which investments would promote economic efficiency, and help in mainstreaming adaptation in infrastructure development as a crucial component of building resilience to climate change impacts.

Which methods were used?

The study assessed a package of flood protection adaptation measures that were underway or planned to be implemented in the Vltava river basin. This included four main categories of interventions, including increasing the safety of water works against overflowing, involving the reconstruction and modification of existing water reservoirs; reconstruction and renewal of polders, reservoirs and dykes to increase the flow capacity of the channels of water courses; water retention and restoration measures such as increasing the water retention ability of the landscape, creation of new retention areas along water courses and protection of the landscape against erosion; and water management measures centred on changing water runoffs in time, especially in the case of multifunctional reservoirs (accumulation, hydro-energy, flood protection or recreation) that imply adjustment of manipulation regulations. The methodology included four components: a context analysis, hazard and impact assessment, followed by the economic assessment using cost-benefit analysis, and then the decision whether the investments promote economic efficiency.

Methodology included four components

First, background data on the institutional and planning context to the site was compiled, and then hazards and impacts were modelled. Hazard data was collected from a range of GIS maps and databases (on hydrological and water resources, flood danger and risks), as well as from the census of the Czech Statistical Office (affected populations and housing), national surveys and insurance companies (value of assets subject to flood risk), state enterprises (water use) and other sources. These were used to estimate future hazards by simulating the spatial patterns of damages and losses in different locations, considering 5-, 20-, 100-, 500-year return periods.

The impacts of climate change on floods, and the costs and benefits of flood protection adaptation measures in the Vltava river basin was simulated by means of the hydrological model Bilan. This used temperature and rainfall projections for two pathway scenarios to the year 2100, using a set of regional climate models. The outputs of the hydrological modelling were then translated into flooding extent and depths, assets under risk were identified, and expected

Case study 10

Czech Republic

Which methods were used?

annual damages were calculated from exceedance probability loss curve which represents a relationship between different levels of flood damage of a particular return period and the corresponding probabilities of flood events. This took account of damages to housing, businesses, public buildings and road infrastructure as well as loss of agricultural production.

The cost-benefit analysis then assessed economic aspects of the adaptation measures. The main project benefits were the damage costs avoided. The costs included both capital and recurrent expenditures, as well as 'lump sum costs': the additional costs that are incurred when a 50-year or higher flood occurs. Measures of net present value were generated to show the relative profitability of the adaptation interventions. The net benefits of the adaptation options were expressed as the difference between the situation without new adaptation investment (with a 10-year protection) and adaptation investment (with a 500-year protection), over the period 1999-2014. Lastly, a sensitivity analysis was performed measuring the influence of changes in key input parameters when other parameters are held constant.

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What were the findings?

Overall, the results supported the adaptation measures. The analysis showed a positive net present value for flood protection measures in all of the climate scenarios under consideration. The expected profitability was however found to vary greatly with the use of different discount rates and return periods while the choice of infrastructure cost variables and depth-damage functions are less significant.

Case study 10

Czech Republic

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Fiji

Case study 11

Least-cost, damage cost and cost-benefit analysis of urban coastal adaptation options in Fiji

This case study describes an economic analysis of coastal adaptation options in Fiji. It compares the costs, benefits and overall profitability of different combinations of grey and green measures. The intention was to inform and guide the development of a full adaptation plan. The study involved a least-cost analysis, an damage cost assessment, and a cost-benefit analysis which also incorporated the ecosystem service co-benefits generated by green adaptation options.

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What was being measured, and why?

This study was carried out to provide an economic analysis of climate adaptation options in coastal Lami Town, Fiji. It compared both the costs and the benefits of different combinations of ecosystem-based and engineering adaptation options to reduce vulnerability to storms and extreme weather events, The resulting information was intended to be used the basis for development of a full adaptation plan for Lami Town.

The study was carried out as an inter-agency collaboration between *United Nations Environment Programme (UNEP)*, the *Secretariat of the Pacific Regional Environment Programme (SPREP)*, *Conservation International*, *UN-Habitat*, Lami Town Council, and the *University of Maryland Center for Environmental Science*.

Which methods were used?

The study was preceded by a vulnerability and adaptation assessment, which provided information on key threats to natural resources, described the local socio-political context, and identified potential climate adaptation measures. The cost-benefit analysis analysed these options further.

Lami town is surrounded by various protective natural ecosystems, including mangroves, coral reef, seagrass and mudflats and, in upstream areas, forested areas. With threats from both coastal flooding and river flooding and erosion predicted to increase with climate change, preserving intact natural ecosystems is seen as a key strategy to assist in halting erosion and protecting Lami Town from current and future storms and extreme weather events. Several ecosystem-based adaptation options were identified, including the rehabilitation of mangroves and riparian buffers, and reducing upstream logging and coral extraction. In addition, a number of engineering-based solutions have conventionally been applied in the region and are slated as possibilities for further development, including physical measures to increase drainage and protect, dredge and realign rivers, the construction of infrastructure such as sea walls, storm surge barriers, sea dykes, the flood-proofing of buildings and roads, as well as activities to reclaim land and undertake beach nourishment.

Several engineering-based solutions had been applied before

A number of economic analyses were carried out, calculated over 10 and 20 year time frames, and brought to present values by using a 2 per cent discount rate. A least-cost analysis was carried out which looked at the total cost of implementing adaptation options, singly or in combination. This considered both capital and maintenance costs. The economic analysis also looked at the relative costs of damages under different adaptation scenarios. These were calculated relative to a 'do nothing' scenario, using data collected after flood events on losses to businesses and households, as well as health costs. The government structures and provision of flood relief supplies and services were however unavailable and not included. Obviously, different adaptation measures are more or less effective in different situations, so various levels of damages avoided were estimated for each option.

Finally, these data on physical costs and avoided damages were brought together in a cost-benefit analysis. This also incorporated

Case study 11

Fiji

Which methods were used?

the value of ecosystem service co-benefits that would be provided from ecosystem-based approaches involving the conservation or rehabilitation of mangroves, coral reefs, mudflats/seagrasses and upland forests. Unit values were calculated for different ecosystems and services, based on benefit transfer techniques which extrapolated figures from studies carried out in similar circumstances elsewhere. Cost-benefit analyses were carried out for four scenarios, each involving a different balance of ecosystem-based and engineering options and ranging from purely ecosystem-based through to purely engineering solutions. This yielded measures of net present value (NPV) and annualized net present value (ANPV), as well as benefit:cost ratios showing the benefits generated for every Fijian Dollar (FJD) spent on coastal adaptation.

What were the findings?

The study clearly showed that the benefits of taking action outweighed the costs, in all cases of both grey and green adaptation measures. Green options tend to be cheaper to implement. the costs per unit area (m^2) or per unit length (m) are vastly different (see table below). As a cost over 20-years, replanting mangroves or stream buffers costs less than FJD 5 per m^2, while building seawalls or reinforcing river banks costs more than FJD 2,000 per metre. Packages of ecosystem-based options also give higher benefit:cost ratios, even though assumed damage avoidance is higher for pure engineering options, with a benefit of FJD 19.50 for every dollar spent.

EbA valuation case studies

Case study 11

Fiji

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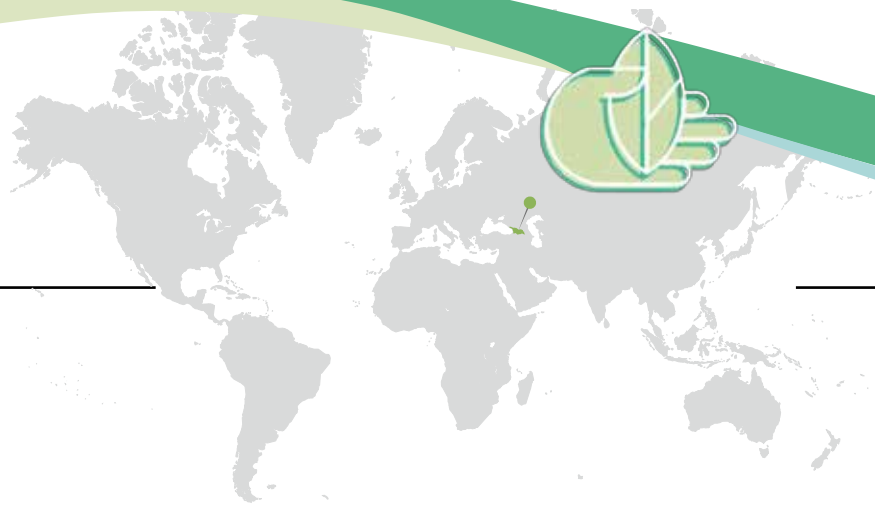
December 2017

Georgia

Case study 12



Cost-benefit analysis of sustainable farmland management practices in Georgia

This case study describes a cost-benefit analysis of farm management alternatives in Georgia, which aimed to guide and inform actions to avert land degradation and facilitate climate adaptation. The focus was on measures to reduce the incidence crop residue burning. A variety of valuation methods were used (including choice experiments, market prices and damage costs avoided) to value costs and benefits, and come up with indicators of the private and public returns to different land management options.

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What was being measured, and why?

This case study reports on a study to assess the benefits of undertaking measures to address land degradation. It looked at the issue of agricultural burning in Dedoplistskaro District, an important food-producing region of Georgia. After harvesting, farmers burn the crop residues remaining in their fields (rather than collecting them and incorporating them into the fields). This damages the land and destroys nutrients that would otherwise go into the soil. It also has a knock-on effect on other aspects of the farm landscape that generate beneficial services: for example on hedges which provide windbreaks and shelter. In the context of climate change (especially the increasing occurrence of dry spells and heat waves), frequent and larger fires are becoming more common. Measures to control burning therefore also form an important component of climate adaptation strategies.

The study was carried out to strengthen policy implementation. Although the Ministry of Environment had initiated legal changes to ban crop residue burning, this policy needed to be justified on economic and ecological grounds, if it was to be enforced. To these ends, the valuation study was undertaken to demonstrate the economic benefits and costs of implementing the burning ban.

...***contd. overleaf***

Which methods were used?

The valuation exercise was carried out as a case study under the Economics of Land Degradation Initiative (ELD), and adopted the ELD "6+1 step approach" to conducting cost-benefit analyses for sustainable land management options. This involves a process of scoping, ecosystem service identification, economic valuation, analysis of land degradation patterns and pressures, cost-benefit analysis and on-the-ground implementation.

The cost-benefit analysis compared three alternative scenarios, each involving different land management practices: continued burning of residues (business as usual), a voluntary no-burn scenario, and a legal ban on burning. Various different private and public costs and benefits were considered which would be influenced by the burning or incorporation of crop residues, and the continued presence or absence of hedgerow windbreaks. These included changes in farmer welfare, crop yields, farm income and avoided carbon emissions. The physical costs of establishing and maintaining the ban were also estimated.

A choice experiment valuation survey was carried out to value changes in farmer welfare and preferences for different options for implementing the burning ban. Increases or decreases in the yearly land registration fee were used as the payment vehicle. The survey was undertaken with 300 farmers, and calculated their welfare losses from the disappearance of windbreaks as well as their willingness to pay to ensure a legally-enforced ban on burning (as opposed to a voluntary-initiated moratorium).

The calculation of other costs and benefits relied mainly on secondary data sources. The impact of crop residues on soil nutrients and moisture was valued using an integrated water balance model, AquaCrop. This showed the gains and losses in crop yields and production costs that would result from different burning regimes, which were valued at market prices. Income from the sale of straw (an opportunity cost of retaining residues on the farms) was calculated using local market prices, and global estimates of the social cost of carbon were applied to value carbon emissions. The material, enforcement and awareness/capacity costs of establishing and maintaining the alternative SLM measures were based on estimates from the Ministry of Environment.

AquaCrop used as an integrated water balance model

Case study 12

Georgia

...contd.

It sought to make the case to agricultural and environmental decision-makers (including farmers themselves) for investing in sustainable land management practices, and to identify the most effective and beneficial way of implementing the burning ban.

Which Methods were used?

The cost benefit analysis was run for a time period of 10 years, starting from the date that it was assumed that the residue burning policy would be enacted. Future cost and benefit were discounted using the Georgian real interest rate of 4 per cent, yielding indicators of the net present value and cost-benefit ratio of each land management scenario.

The study took 5 months to complete, and was carried out by a team consisting of an international and a national consultant with training in economics and soil science. The global ELD network also played a role in providing technical backstopping, quality control and peer review. The research was carried out through the Regional Environmental Centre for the Caucasus, an independent, non-for-profit organisation established to assist in solving environmental problems as well as development of civil society in the countries of the South Caucasus.

How were the results disseminated and what was their impact?

The study yielded a number of interesting results. The main finding was that any effort to reduce the incidence of burning would generate substantial private and public benefits. Even though a legally-enforced ban would incur the highest costs, it would eventually also give the highest social gains and farmer returns. For example, it is estimated that agricultural yields will increase by between 11-23 per cent if farmers integrate crop residues into the soil instead of burning them. The ban on burning would also help to avoid almost 50,000 CO2 equivalent tonnes of emissions. Overall, farmers would enjoy up to 3 USD of benefits for every 1 USD that they and the Georgian government need to spend to avoid burning and enforce a policy ban.

These results were disseminated through various means. A series of targeted workshops were held at both local and national levels with farmers and key decision-makers (including legal drafters from the government) to present and discuss the study findings and their implications. A technical report and short policy brief were also produced, which have been shared at both national and international levels.

EbA valuation case studies

Case study 12

Georgia

The study was carried out under the Economics of Land Degradation (ELD) Initiative, which deals with the economic benefits of land and land based ecosystems. ELD highlights the value of sustainable land management and provides a global approach for analysis of the economics of land degradation. It aims to make economics of land degradation an integral part of policy strategies and decision making by increasing the political and public awareness of the costs and benefits of land and land-based ecosystems. Working with a wide network of partner organisations and funded by the German Federal Ministry for Economic Cooperation and Development (BMZ), the ELD Secretariat is hosted by GIZ's Sector Project to Combat Desertification. The case study was carried out in partnership with the GIZ Biodiversity South Caucasus Programme, funded by Austrian Development Cooperation and working in Georgia in cooperation with the Ministry of Environment and Natural Resources Protection and other counterpart agencies.

For further information see http://www.eld-initiative.org/, http://biodivers-southcaucasus.org/

How were the results disseminated and what was their impact?

The evidence generated has proved to be fairly convincing to its main target audience: government decision-makers. The national government is now drafting a new policy on burning, which will eventually be translated into a law. Although the cost-benefit analysis was obviously not the only factor driving this, it played an important role in presenting concrete figures that justified taking these further actions. As the study took place in partnership with an existing project (the GIZ Biodiversity South Caucasus Programme), and focused on a topic that was already a core part of the project's work (the planting and rehabilitation of natural windbreaks), there were ample opportunities to follow up on the study and to take a longer-term and more applied approach to addressing the issues that it dealt with.

What are the key insights and lessons learned on valuing EbA-relevant benefits?

One of the key success factors in the study was its concern with stakeholder engagement at all stages of the valuation process, from design and inception through to final communication and planning for follow-up. This ensured that the study was seen as being useful and relevant by its target audience. It addressed an issue that was already a high priority, and of great interest, to decision-makers and farmers in Georgia (as well as to the host GIZ project). The land management intervention scenarios that were analysed were also chosen based on the stated needs and advice given by of civil society organisations and farmer in Dedoplistskaro District.

Stakeholder participation also engendered a sense of buy-in among both farmers and policy-makers. As data were gathered and analyses carried out, they were shared and validated with those involved on a regular basis. This ongoing consultation meant that the target audience for the study (local and national decision-makers) already had a strong interest in the study by the time its findings were presented, and felt that the economic evidence it provided was both believable and relevant. The study also gained credibility by working through an existing project which had on-the-ground presence in Georgia, had built up good relationships over time.

Another strategic decision which proved to be important in making the study findings acceptable and interesting to users was its focus on the positive aspects of sustainable land management measures, rather than on the negative aspects of a continuation of the status quo of residue burning. Seeing how tangible public and private value could be added and costs could be avoided offered a convincing argument for the burning ban as being something that would be in the interest of both farmers and the general public. Again, it was an added advantage that the study was working with a project that was able take the study findings forward, and support the development of additional measures to advance the burning ban.

As is the case with many ecosystem valuation studies, it remained something of a challenge to access relevant and credible data which could be used to substantiate the biophysical linkages and causalities between changes in ecosystem status, effects on farm production, and economic impacts. For example, it was not possible to find statistically robust leading variables that could predict the incidence or severity of future fire hazards, and even the data that were available took much longer to locate and access than had been anticipated.

EbA valuation case studies

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This case study is based on information provided by Mark Schauer and Hannes Etter (Coordinator and Science Desk Officer of the GIZ Economics of Land Degradation Initiative) and presented in the following documents:

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Case study 13

Physical effectiveness, cost-effectiveness and cost-benefit analysis of flood risk management measures in Germany

This case study evaluates the physical and economic impacts of flood risk management measures at two sites on the Mulde River, Germany. Three different approaches were applied to evaluate the flood control measures: physical effectiveness, cost-effectiveness and cost-benefit (efficiency) analysis. The aim was to demonstrate a methodology that could capture more fully the value of non-structural measures that are better in terms of effectiveness related to hydrological protection standards, and better make the case for these 'soft' techniques.

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What was being measured, and why?

This study was carried out to evaluate the economic efficiency of flood risk management measures at two sites on the Mulde River in Saxony, Germany. The benefits and costs of structural measures (dykes and floodwalls) were compared with those of non-structural measures (resettlement and early warning). The rationale was to demonstrate the need for methods that are based on a wider range of economic appraisal techniques than would conventionally be applied to infrastructure planning, which could capture more fully the value of non-structural measures that are better in terms of effectiveness related to hydrological protection standards.

The study was designed to investigate and critically assess the effectiveness and efficiency of non-structural measures in comparison to structural measures. The aim was to provide information which could help to overcome the barriers to implementation of these 'soft' techniques, and guide decision-makers on the most appropriate methods to use when evaluating different measures in a consistent, comparative and comprehensive way. In addition, the study yielded recommendations for the improvement of flood risk management strategies in the case study sites.

Which methods were used?

The research was one of six European case studies carried out under the FLOOD-ERA research project "Risk Assessment and Risk Management: Effectiveness and Efficiency of Non-structural Flood Risk Management Measures". It adopts a standardised framework and methodology for the evaluation of the effectiveness and efficiency of structural and especially non-structural measures.

Two case studies were investigated, both on the Mulde River. Each one evaluated and compared planned or already-conducted structural flood control measures with non-structural measures, with regard to effectiveness, cost-effectiveness and efficiency. For the Erlln case, dyke heightening and relocation was compared with a hypothetical resettlement plan. For Grimma, a local warning system was compared with an initiative that integrated flood protection into the old town wall.

The study applied three different approaches to evaluate the flood control measures: effectiveness, cost-effectiveness and cost-benefit analysis. It also measured the transactions costs associated with each alternative. The empirical work was based on various methods, including primary data collection, document analyses, hydraulic modelling and interviews with decision-makers.

Three different approaches to evaluate flood control measures

The effectiveness analysis measured the degree to which the measures achieved the specified target of no damages up to the 1:100 event (in other words providing protection against a flood event of a level of severity that has a one per cent risk of occurring each year). In order to evaluate the benefits of each measure their risk-reducing effect in terms of a reduction of the annual average damage compared to a baseline 'do-nothing' option was calculated. This was calculated by a meso-scale damage evaluation approach looking at the situation with and without the measures. It applied GIS-based methods based on data from official statistics (the net value of fixed assets for different economic sectors) which was then assigned to corresponding land use categories, and used to construct relative depth/damage curves in order to calculate the damaged share of these values, depending on inundation depth. Mean damages as well as minimum and maximum values were calculated for each grid cell. This yielded estimates reductions in the monetary costs of average annual damages that would be achieved by the different measures.

Case study 13

Germany

Which Methods were used?

The cost-effectiveness analysis compared the relative expenditures (costs) and outcomes (effects) of actions in terms of achieving flood-protection targets. These looked at the physical expenditures made on establishing and maintaining each option, and were based on actual project budget figures from the study sites and elsewhere. These were expressed as absolute amounts as well as the costs per percentage of achieving the target (in other words the expenditures required to avoid 1% of the damages caused by a flood event each year). The cost-benefit analysis then drew these data together, and considered both cost and benefits in monetary terms as a measure of efficiency. It yielded measures of benefit:cost ratios and net present values.

For the evaluation of transaction costs associated with the different types of measures, stakeholder interviews were carried out to gather qualitative statements on the efforts and costs associated with the decision making and implementation process, and to conduct a short semi-quantitative questionnaire on the different types of transaction costs. This yielded indices of the costs of information, design and planning meetings, communication, negotiation and conflict resolution, and other post-construction costs.

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What were the findings?

The results yielded specific conclusions for each site and flood control measure considered. For the Erlln site, it was found that that both of the measures evaluated were effective in achieving flood protection goals. In contrast, results of the benefit-cost analysis showed that neither was efficient, although the structural measures performed better than the non-structural resettlement option. For Grimma, the planned structural measure was demonstrated to be effective but not efficient, mainly due to its high costs. By contrast, the non-structural early warning system appears efficient, but much less effective.

Overall, the case study results showed that, when weighing up different flood control options, the choice of evaluation criteria can have a major impact on assessment results. In this regard, efficiency as an evaluation criterion was shown to be superior to cost-effectiveness and effectiveness. This is because cost-effectiveness and effectiveness are unable to consider all benefits in terms of damage reduction and might therefore favour structural over non-structural

Case study 13

Germany

measures. The results also indicated that transaction costs could play an important role, especially with non-structural measures associated with land-use changes. This could explain why, currently, decision-makers rarely select these kinds of non-structural measures when they are planning flood control interventions.

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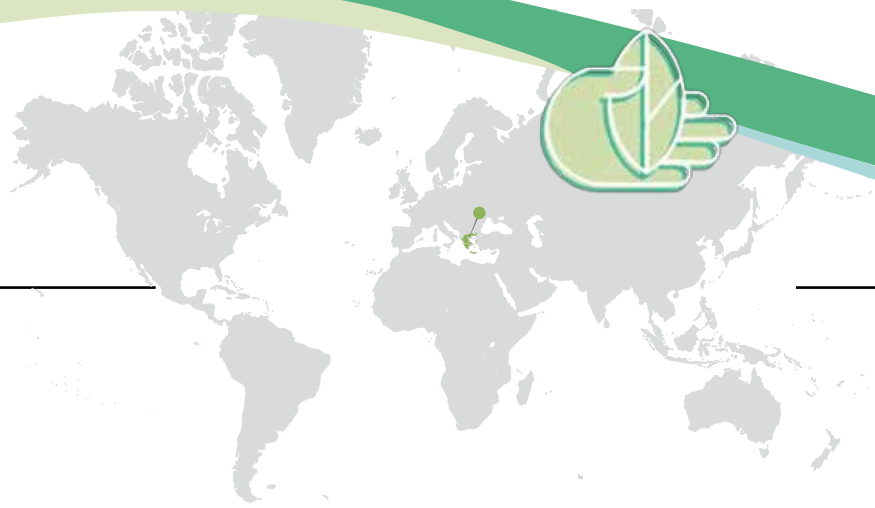
Case study 14



Choice experiments to value the public benefits of adaptation for river basin ecosystem services in Greece

This case study describes the application of choice experiment techniques to value local residents' preferences for undertaking climate adaptation measures which would maintain key ecosystem services in a river basin in Greece. The intention was to provide decision-support information that could assist in adaptation planning, and would highlight the need to invest in measures to secure the river basin in the face of climate change.

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What was being measured, and why?

This study was carried out to assess local residents' preferences for climate adaptation in the Aoos river basin, northwestern Greece. Choice experiment techniques were used to value the public benefits of implementing adaptation strategies related to four key river basin services: irrigation, rafting, hydropower production and ecological state. Currently, the Aoos River ecology is 'good' and thus meets the requirements of the EU Water Framework Directive 2000/60. Under climate change pressures and in the absence of adaptation measures, it is expected that river basin services will undergo a significant deterioration. Irrigated land will reduce substantially, rafting periods will decrease, electricity production will decline, and the ecological state will worsen to 'poor'.

Noting that conventional market data cannot reveal public preferences for adaptation activities, the aim was to develop a methodology that could illustrate the consequences of IPCC climate projection models for the Southern Mediterranean basin (which indicate a strong drought trend). The ultimate goal was to provide information that could provoke discussion and dialogue among policy-makers and stakeholders, assist in adaptation planning for the Aoos River basin, and help to highlight the need to invest in measures to secure key river basin services in the face of climate change.

Which methods were used?

The study used choice experiments techniques to value people's preferences for river basin adaptation measures. Choice experiments are a quantitative technique for eliciting people's preferences, allowing researchers to how individuals value selected attributes of an activity, service or outcome by asking them to state their choice over different hypothetical alternatives.

Four services were selected to demonstrate the economic impacts of climate change on river basin water resources, which were of high economic and social importance to the region: irrigation, rafting, hydropower production and ecological state. In addition the costs per month of the adaptation activities required to achieve different outcomes were included. Incorporating various combinations of attributes for each of the services and costs, this yielded 96 different adaptation alternatives, which were merged into pairs plus the status quo scenario. The generated 48 choice sets were blocked into 8 versions (of 6 choice sets), one of which was randomly allocated to each respondent

The survey was carried out over the course of two months, and involved 303 respondents, selected randomly from the local population. A questionnaire was formulated to frame the choice experiment, which elaborated various aspects of the issues being examined as well as the characteristics of the respondent. This was structured into five parts. First of all, respondents were asked broad questions about the local environment and river system. Next they were asked their opinions about global climate change issues and the effect on local water resources. Then the choice experiment was carried out. The final section recorded participants' socioeconomic profiles and asked several follow-up control questions.

303 respondents, selected from local population

Conditional logit, random parameters logit and latent class models were used to conduct an econometric analysis of the results. This provided utility estimates for each attribute, and also enabled respondents' willingness to pay for different adaptation alternatives to be estimated. An implicit price was derived for the marginal change in attributes. In order to calculate willingness to pay, two distinct scenarios were defined (moderate adaptation policy and strong adaptation policy) and compared with the 'do nothing' situation.

Case study 14

Greece

What were the findings?

The survey found that just under ninety per cent of the respondents were concerned about the future condition of the river Aoos, and something over a fifth identified the reduction in water flow as the most possible threat. Regarding river water priorities, around half of respondents identified the ecological status of the river as being most important, forty per cent opted for irrigation water, five per cent for hydroelectric production and just three per cent for rafting. Almost all recognized the need to initiate adaptation measures against climate change at a local level.

All of the responses indicated positive and significant economic benefits associated with river basin adaptation measures. The results indicate an implicit value for each local household of as much as 540 € per year for moderate adaptation measures, increasing to 780 € per year for a set of strong adaptation interventions which will maintain river basin services at current levels. This translates into a willingness to contribute voluntary payments of 2 € for every km2 of preserved irrigation area, 1.20 € for every additional month of rafting activities, 0.35 € for every 10 per cent increase in hydropower production, and 12 € for upgrading the ecological state to the next better provision level ('poor', 'fair', 'good').

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Greece

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December 2017

Guyana

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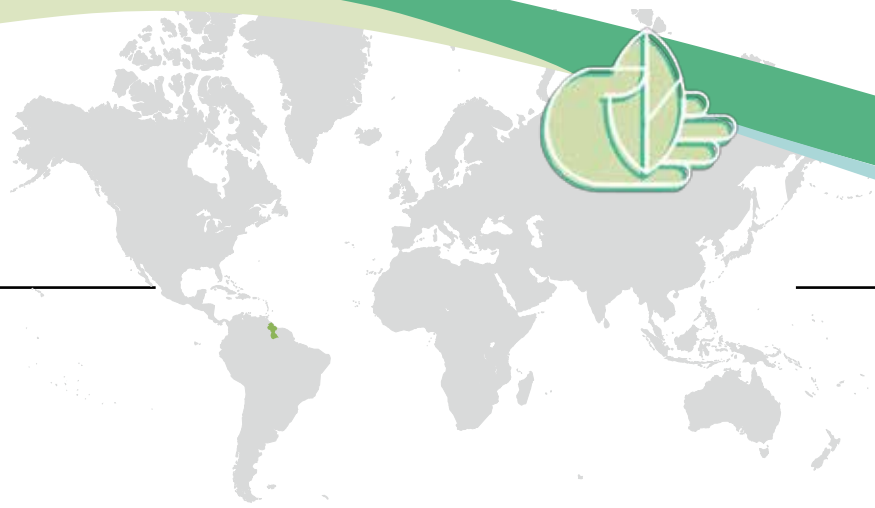

Measuring changes in climate change-related knowledge, attitudes and practices in Guyana

This case study describes a knowledge, attitudes and practices survey on climate change awareness and education in Guyana. The aim was to investigate current perceptions, identify gaps, and generate recommendations to help in addressing sustainable climate change adaptation, mitigation and disaster risk programming. The study was conducted using both qualitative and quantitative methodologies, involving structured questionnaires and interviews with key stakeholders.

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What was being measured, and why?

This knowledge, attitudes and practices (KAP) study was carried out to measure current status and gaps in people's knowledge, attitude and behavioural practices relating to climate change, including adaptation, mitigation and disaster risk reduction factors. This had five main aims: to explore knowledge and perceptions of climate change, identify how the causes of changing weather patterns are explained, investigate barriers to responding to climate change, assess media consumption patterns and preferences, and inform recommendations on the best methods of communicating on climate change.

The study was carried out by the United Nations Development Programme (UNDP), under the Japan-Caribbean Climate Change Partnership. This partnership aims to implement climate initiatives to support the beneficiary countries in designing and implementing climate initiatives. The study sought to generate basic information to inform the development of these activities, particularly by identifying where there are significant gaps in knowledge, attitude and behavioural measures to instil best practice and understanding.

Which methods were used?

The study used both quantitative and qualitative methods. Questionnaire surveys were carried out face to face with respondents, and with students. Qualitative information was collected via focus groups and key stakeholder/informant interviews, in Regions 4, 5, 7, and 9 if the country. As well as addressing knowledge, attitudes and practices separately, the surveys looked at the relationships between each element, namely:

- Knowledge and attitudes—how do people feel about climate change, once they are aware of the effects it has on them? Is there a change? Does knowledge lead to desirable attitudes?
- Knowledge and Practices —how proactive are people once they become knowledgeable of climate change issues? Does knowledge lead to positive behaviours?
- Attitudes and Practices—does a sentiment towards climate change correlate with desirable behaviours? Does good practice increase when desirable attitudes are achieved?

A national household survey was conducted to examine the levels of knowledge, attitudes and practices towards climate change. This commenced with demographic questions, followed by questions pertaining to knowledge of climate change, attitudes toward climate change and practices related to climate change. The survey ended with questions about media usage. The survey sample was chosen to represent +/- 4% of the total population, and respondents were chosen via a randomised sampling process but maintaining a 50:50 ratio between men and women. The students' survey incorporated many of the questions within the national survey, but was designed to be completed by fourth and fifth form students under supervision and guidance. Although students were chosen at random they were chosen from a sample of just three schools, within a specific age and class group. Quantitative data were analysed using SPSS software, overall and disaggregated by location, gender, age, educational status and occupational categories.

Students' survey for fourth and fifth graders

The qualitative research was conducted to introduce contextual information to the study to address "how" and "why" certain attitudes and practices exist. Hence, the qualitative component provides anecdotal data to establish a deeper understanding. The qualitative component of this survey involved in-depth interviews with key

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Which methods were used?

stakeholders from local community members, the media, national government, local leaders and non-governmental organisations. The sectors interviewed included the agriculture, fishing, goods and services and extractives industries. Key Informant Interviews were held with community members as well as national level government and international donor agencies, senior-level officials and ministers. Participants in focus group discussions represented a cross-section of the population, disaggregated by gender, age, and economic status.

What were the findings?

The KAP study found that the vast majority of respondents perceive that climate change is occurring and believe that climate change exists, although only around a half stated that they understood what climate change meant. Nearly all could however identify a range of causes of climate change, including deforestation, carbon emissions and burning of fossil fuels. Almost 90 per cent had experienced climate-related natural disasters, and around three quarters had suffered some kind of damage or loss as a result. More than two thirds stated that they had undertaken some form of adaptation action to cope with the effects of climate change, including ecosystem-based measures such as habitat restoration or conservation as well as actions to improve disaster risk reduction infrastructure, extend water security and conserve energy.

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India

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Extended cost-benefit analysis of drought and flood-related disaster risk-reduction and response interventions in India

This case study assesses the costs and benefits of flood disaster risk-reduction and response interventions in India. To do this, it considered a variety of economic, social, human and physical values that would not be included in conventional cost-benefit analyses. The aim was to provide evidence that investments in disaster mitigation and preparedness measures are well-spent, and to demonstrate a tool that can be used to choose between different intervention options.

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What was being measured, and why?

This study presents a cost benefit analysis of drought and flood-related disaster risk-reduction and response interventions in Andhra Pradesh and Bihar States, India. Its objective was to analyse the net benefits resulting from disaster mitigation and preparedness and to assess the cost-effectiveness of such interventions.

An important reason for carrying out the study was the concern that, historically, the response to disasters has been focused on relief, with governments, donors and NGOs providing post-disaster resources and aid. Whilst this work is essential to respond to people in need, the focus of disaster response has been shifting to encompass the wider issue of preparedness, risk-reduction and strengthening resilience. Yet, despite these shifts in thinking, the incorporation of disaster mitigation and preparedness into humanitarian and development work is argued to have been slow, with the priority remaining on relief and emergency responses.

The study therefore aimed to provide evidence-based research to confirm that investment in disaster mitigation and preparedness is money well spent from an economic point of view. It also intended to show how cost-benefit analysis can be used as an analytical tool to choose between different types of intervention. In addition, the study sought

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Which methods were used?

for the analysis, impacts were analysed in five categories — natural, physical, human, social and economic. Qualitative impacts were assessed in light of two important concepts – additionality (the incremental impacts of the project) and displacement (any negative impacts that may occur as a result of project impact). For example, the analyses in Dharbanga and Khamman looked at the impact of interventions on natural resources such as forests, soils and crops, physical assets such as houses and tools, human impacts such as injuries and lives lost, social impacts such as organisation, empowerment and equity, and economic impacts such as food security, education, employment and credit availability.

Second, a quantitative analysis of costs and benefits was undertaken. Data on programme costs were verified and grouped according to one-off (fixed) costs, and variable costs that occur on a regular basis. The Dharbanga analysis looked at materials and supplies, personnel and running costs. In Khamman, because it was not possible to quantify most of the benefits of the DMP intervention, project expenditures were limited to the installation of handpumps and provision of toolkits for their repair. Benefits were also assessed in terms of the reduced costs, losses and damages occurring with the intervention as compared to a without DMP situation. In Dharbanga, these included the avoided (flood-related) losses of handpumps, household possessions, tools and livestock, reduced injuries and loss of life, and reduced expenditures on boat rental for evacuations. All of these were valued at local market prices. In Khamman, as mentioned above, only a partial analysis was possible. The main focus was on the time and health savings associated with the installation of hand pumps, as well as the avoided costs of repairing government pumps.

Analysis of materials and supplies, personnel and running costs

For each year of the project lifetime, expected costs were subtracted from expected benefits to determine the net benefit for each year. These values were then discounted using the discount rate to calculate net present values and cost-benefit ratios for the project period (20 years). Lastly, sensitivity analyses are used to demonstrate any variation that may occur in the values presented. In this instance, one of the key uncertainties is the duration and intensity of the hazard.

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to provide information which could be used to advocate for increasing the funding and other resources allocated to specific disaster mitigation and preparedness interventions.

What were the findings?

The overall conclusion of the case studies was the DMP interventions studied showed a positive return on investment, generating greater benefits than the costs incurred. In Dharbanga, the intervention had cost Indian Rupees (INR) 1.33 million and generated INR 5 million of benefits, translating into a net present value of INR 3.70 million or British Pound (GBP) 46,000 or a benefit-cost ratio showing that ever INR or GNP invested had generated a local return of 3.67 INR or GBP. The Khamman project showed a net present value of INR 2.11 million or GBP 26,000, and a benefit-cost ratio of 13,38. Both sets of interventions therefore demonstrated a clear economic argument for DMP.

In addition, a number of useful broader lessons learned were generated by the study. One was that cost-benefit analysis was shown to be an important tool for monitoring ex-post project impacts, as well as for informing choices between potential future DMP interventions. This can help organisations in their planning, to develop measures that make the greatest impact on the community in question (both quantified and qualified), and to demonstrate to potential donors the cost-effectiveness of their proposed activities. In Dharbanga, for example, cost-benefit analysis was used to calculate the possible benefits of improved housing on stilts, and microfinance initiatives.

Another very important insight was that development must integrate DMP if it is to be effective in hazard-prone areas. The examples of the hand pumps in both Dharbanga and Khamman clearly demonstrate that investment in development could be rendered useless if it does not accurately take account of local conditions and integrate DMP.

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Indonesia

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Evaluating the biophysical and socio-economic effectiveness of hybrid "building with nature" coastal adaptation measures in Indonesia

This case study describes how the benefits of a hybrid "Building with Nature" approach to coastal restoration and adaptation were evaluated. A variety of methods were used to measure biophysical and socioeconomic effects such as coastal risk reduction, land and water quality improvements, mangrove re-establishment and livelihood gains. These included field observations and measurements, satellite and drone technologies, household surveys and community consultations.

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What was being measured, and why?

This key sheet reports on studies carried out to monitor and evaluate the impacts of hybrid, grey-green coastal restoration and adaptation measures along the severely eroded coastline of Demak Regency, Central Java. The "Building with Nature" (BwN) approach combines the construction of permeable brushwood dams and mud nourishments with mangrove rehabilitation, sustainable aquaculture and other livelihood diversification measures.

The project has so far passed through two stages, both of which have involved studies to measure benefits. The first focused on evaluating the effects of a small-scale pilot activity, aiming to demonstrate that the novel BwN approach could indeed work, and to make the case for scaling it up more widely. A monitoring protocol has now been designed to track the impacts of the larger five-year project that ensued. With the overall goal of ensuring that restoration objectives are met, it seeks to provide information that can be used to continuously update instructions for the design, construction, and supervision of the eco-engineering measures in the light of any new learning and knowledge generated, and in response to changing needs and circumstances in the project area.

It is planned that the collection of biophysical and socio-eco-

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Which methods were used?

While the pilot project evaluation focused mainly on collecting biophysical data to measure changes in sedimentation rates and mangrove colonisation, as well as to gauge the success and durability of the permeable dams, the technical monitoring protocol for the larger project looks at a wide range of indicators of coastal safety, mangrove re-establishment and socioeconomic change. These include restoration of the sediment balance, reduced salt water intrusion, decreased erosion rates, re-establishment of mangroves, recovery of pond fisheries production, improvements in income and livelihoods diversification.

A variety of direct and indirect methods are employed to collect this information. These include the physical measurements of variables such as sediment availability, salinity, water quality, mangrove extent and composition. Satellite imagery is being used to assess coastline change and erosion/deposition areas, while drone images offer a means of assessing on-the-ground mangrove recovery. Interviews and focus group discussions provide a major source of data about changes in local livelihood status and ecological conditions. This is supplemented by sampling surveys and direct observations made by community members themselves about mangrove rehabilitation and the recovery of pond fisheries. The principle of stakeholder participation plays a key role in the technical monitoring protocol. Local communities are actively engaged in collecting and recording monitoring information (for example through taking part in regular dialogues, helping with the collection of field measurements, keeping logbooks and other records).

Drone imagery used for assessing mangrove recovery

Monitoring is carried out on an ongoing basis, with data collection taking place at regular intervals. The monitoring team is diverse, and consists of ecologists, engineers, physical geographers and aquaculture experts as well as local stakeholders. These are drawn from project partner institutions, local and foreign universities, and also includes representatives from the Indonesian government, field facilitators and coastal villagers.

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nomic monitoring information will be supplemented with studies to quantify these effects in monetary terms. Economic valuation is seen as a particularly important way of making the case, especially to investors. This has bearings on the long-term sustainability of project activities. Although this has not yet started, efforts are underway to design an extended cost-benefit analysis approach that can reflect both direct market effects and indirect or non-market ecosystem values.

How were the results disseminated and what was their impact?

The pilot project was found to be highly successful from a hydro-sedimentological point of view, showing sedimentation behind the brushwood dam structures and the natural emergence of mangrove seedlings. It generated information that was used to demonstrate the efficacy of the BwN approach to coastal planners and decision-makers, thereby helping to gain their acceptance and support for the scaling-up of activities across the northern coastline of Java. It also fed into the production of a design and engineering plan for this larger project.

Technical monitoring of the ensuing project is still at a relatively early stage, with results only just beginning to be generated. Following the participatory processes that have been established to collect data, information dissemination is also guided by a strong principle of stakeholder engagement. A regular cycle has been established which brings together the various different agencies and groups that are involved in the project. Every six months, information is presented, analysed and discussed, and the design and delivery of interventions are updated as necessary.

In addition, various efforts are being made to share technical findings on the impacts of the BwN approach more widely – with the general public in Indonesia as well as with the national and international scientific community. This obviously demands a variety of approaches, including the use of blogs, websites and other social media, discussion papers, articles in peer-reviewed scientific publications and presentations at workshops and conferences.

The results of the technical evaluation and monitoring has provided evidence of intervention impact have generally been well-received by their target audience (coastal planners and managers, including local community members). The BwN approach has proved to be influential in shaping how coastal adaptation and disaster risk reduction policy and planning is carried out. The findings from the first small-scale pilot generated the initial buy-in to scale-up activities in Java, and there is now interest from the Government of Indonesia to adopt BwN approaches as part of coastal management and adaptation portfolios elsewhere in the country. At the community level, project partners have been invited to facilitate the development of 10-year village development plans and regulations that will guide resources man-

Government ready to adopt BwN approach elsewhere

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The Building with Nature Indonesia – Securing Eroding Delta Coastlines" project is funded by the Dutch Sustainable Water Fund, The Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety (BMUB) as part of the International Climate Initiative (IKI), Waterloo Foundation, Otter Foundation, Topconsortia for Knowledge and Innovation, and Mangroves for the Future. It is jointly implemented by Ecoshape, Wetlands International, the Ministry of Marine Affairs and Fisheries (MMAF), Ministry of Public Work and Human Settlement (PU), the Ecoshape Consortium, Witteveen + Bos, Deltares, Wageningen University & Research, UNESCO-IHE, Von Lieberman, the Diponegoro University and local communities.

For further information see https://www.wetlands.org/casestudy/building-with-nature-indonesia/

How were the results disseminated and what was their impact?

agement and define ambitions for both sustainable aquaculture and coastal security. The BwN methodology, and particularly the hybrid approach it embodies, has also sparked a lot of interest within the international conservation and development community, and many of its principles are now being incorporated into the design of other ecosystem-based climate adaptation and disaster risk reduction interventions.

The technical monitoring protocols, too, have generated a great deal of interest within both the Ministry of Marine Affairs and Fisheries and the Ministry of Public Works and Housing. The mainstreaming of hybrid approaches to coastal management and adaptation, based on engineering and ecological principles, would be translated into both investment programme design and monitoring procedures. The Demak Government has already taken up some of the monitoring methods developed in the project, in relation to both 'green' (environmental sector) and 'grey' (built infrastructure) public works.

What are the key insights and lessons learned on valuing EbA-relevant benefits?

One key lesson learned is the importance of generating evidence about both the biophysical and socioeconomic benefits of ecosystem-based coastal restoration and adaptation measures, so as to secure people's support and to ensure that activities are implemented in an appropriate and effective manner. This is especially important when introducing new design models such as the BwN approach. It is also relatively rare – in all too many cases, data are lacking about the physical effectiveness or economic efficiency of EbA and other 'green' adaptation and disaster-risk reduction approaches. Not only does this reduce the likelihood of their being able to compete, or to be judged, on equal terms with grey infrastructure approaches, but it also makes it difficult to make a convincing case to decision-makers of the wisdom of investing in them.

Perhaps the most significant insights arise from the 'learning by doing' approach that was employed, as well as the strong emphasis on stakeholder participation and communication. This has been instrumental in securing the buy-in and support that is required to sustain and scale-up the eco-engineering models that have been developed in Demak. While data and evidence were important to make the case, one of the most important success factors was entering

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into a joint learning process with coastal communities, local and national government agencies. At the same time, efforts were made to embed the BwN approach (both the hybrid restoration measures and the monitoring protocols) in subnational and national policies, plans and budgets. This alignment greatly increases ownership with regards to decision making and engagement.

While the monitoring approaches and indicators have been carefully designed to be appropriate and implementable in a local context, data availability and capacity have remained as major constraints for measuring impacts and monitoring the BwN approach.

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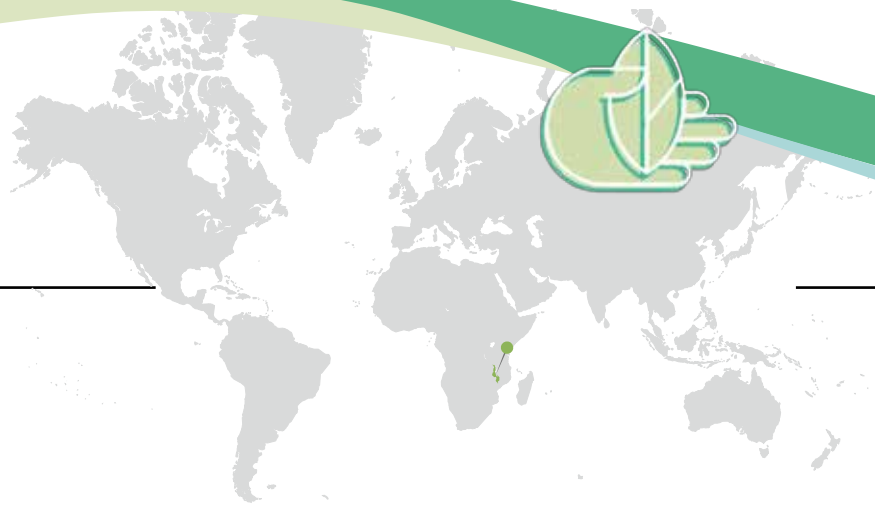

Bayesian Belief network to quantify the biophysical adaptation benefits of climate-smart agriculture, Malawi

This case study describes a study carried out to quantify the biophysical adaptation benefits of climate-smart agriculture in Malawi. It used a multiple-indicator Bayesian Belief Network based on assigning subjective probabilities to express a degree of belief in particular events or outcomes. This was used to compare the impacts of different farm interventions on climate change vulnerability. The aim was to demonstrate a simple methodology that could be used to generate evidence to justify and encourage higher investments in climate adaptation.

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What was being measured, and why?

This study was carried out to assess the adaptation benefits of climate-smart agriculture (CSA) in Malawi. It applies a multiple-indicator Bayesian Belief Network approach that allows for the assessment of climate change vulnerability. This can be used to identify appropriate adaptation strategies, and to quantify the biophysical adaptation benefits from activities that are implemented. It showed the impact of different CSA alternatives on biophysical vulnerability.

The study was prompted by the massive shortfalls that exist in the amount of funding available for climate adaptation in Africa. These financing gaps are argued to be at least partially caused by the difficulty of assessing and monitoring when adaptation is achieved. The study therefore aimed to demonstrate a simple methodology that could be used to describe and measure the adaptation benefits and impacts of CSA. The assumption was that being able to generate this kind of evidence offers a means of tracking the effectiveness and performance of adaptation interventions, and thus of better making the case for increasing investments in climate adaptation.

Which methods were used?

The study uses a Bayesian Belief Network approach, a graphical representation of a probabilistic dependency model which describes the probability of an outcome occurring by considering both the process that leads to that event and the state of information describing the process. It assigns subjective probabilities to express a degree of belief in events (and thus particular outcomes) occurring, thereby offering a framework into which decision-makers, beneficiaries or other stakeholders can input their knowledge, and assess the implications for the rest of the (linked) system.

The study focused on understanding the impacts of adaptation activities on biophysical vulnerability, although it should be noted that the approach followed would be equally suited to describing impacts on socioeconomic factors. It looked at various CSA interventions that are commonly practised in Malawi, including intercropping, alley cropping, legume fallows, crop rotation, later-maturing cultivars, water management practices, mulch cover and low/no tillage). Both adaptation activities and indicators of vulnerability were based on local perceptions, elicited from a survey of 50 households randomly selected from a total sample of 12,271 households for which relevant data were available.

Survey of 50 randomly selected households

The Bayesian Belief Network was composed of five subnets, designed to capture the adaptation process. Subnets 1-3 described the process variables: subnet 1 included a description of future climate projections, subnet 2 described the impacts upon the site, informed by subnet 1 (climate change projections) and subnet 3 (site description). Subnet 4 detailed the adaptation options. Subnet 5 consisted of output variables, which described the site's vulnerability to climate change. A multi-variable binary-state adaptation subnet was added that, when activated, would impact on either the climate impact or local resilience subnets. This allowed for a 'no adaptation' baseline to be created, against which a given set of CSA interventions could be measured in terms of their adaptation effectiveness and impact. The efficacy of the adaptation actions modelled relative to this no-adaptation baseline was demonstrated by the shift in frequency distribution that occurs.

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Malawi

Which Methods were used?

A vulnerability index was derived from the output variables, which expressed both the probability and magnitude of expected biophysical sensitivity to climate change. This enabled the effectiveness of different CSA interventions in increasing biophysical resilience at different sites to be compared. Sensitivity analysis was also undertaken, to assess which climate impacts were most responsible for higher vulnerabilities, and which site characteristics mostly affected these. A combinatoric approach was used to analyse which set of adaptation actions held most benefits and to assess whether some multi-adaptation responses hold less benefits than single-adaptation responses.

What were the findings?

The study demonstrates the potential of the Bayesian Belief Network approach for comparing adaptation approaches at a local level. Its results suggested that all of the CSA interventions investigated reduced vulnerability as compared to the no-adaptation baseline. Intercropping, alley cropping and legume fallows were the best approaches to mitigate the climate impacts of decreased water availability and increased pests. It also found that increasing the number of CSA actions increases total biophysical adaptation benefits. However, returns on biophysical adaptation benefits gained per adaptation action diminish as adaptation actions are added to the model.

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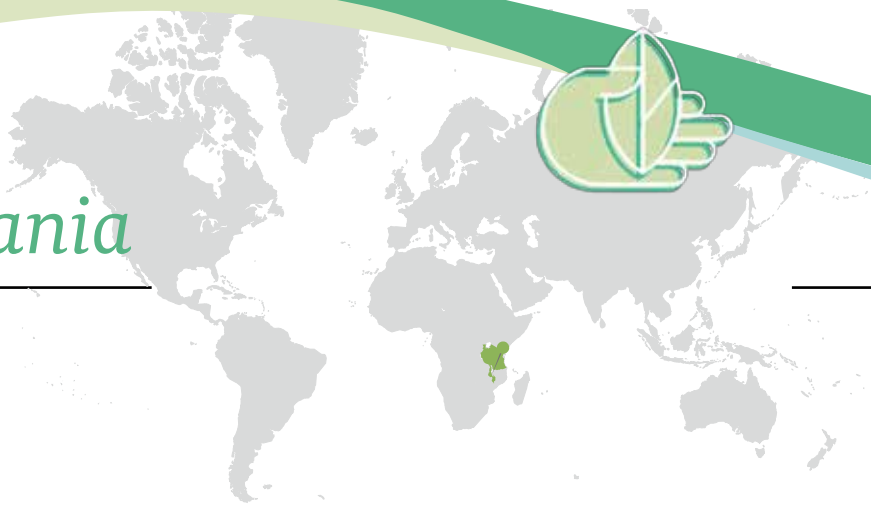

Malawi, Tanzania

Case study 19

Participatory mapping and valuation of farmers' land management costs, benefits and preferences

This case study describes the use of participatory methods to assess local perceptions and preferences for different land use management choices and agro-ecosystem services in Malawi and Tanzania. The study was prompted by the top-down nature of many of the assessment methods that are conventionally used to guide the design of agricultural projects, especially their failure to adequately consider farmers' own needs and priorities. It aimed to inform the selection, design and evaluation of sustainable land management (SLM) and climate-smart agriculture (CSA) interventions.

EbA valuation

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What was being measured, and why?

The study assessed community perceptions of and preferences for different agroecosystem services and land management choices. The aim was to build and demonstrate methods that could be used to guide the development of sustainable land management (SLM) and climate-smart agriculture (CSA) interventions in Ncheu District Malawi and Lushoto District Tanzania.

The overriding concern was to ensure that planning support information would be targeted towards farm-ers‘ own needs and constraints rather than being based only on what scientists and external experts considered to be the ‚best‘ technical and technological solutions to overcoming land degradation problems and sustaining agricultural productivity in the face of climate change. The main target audiences were district and local agricultural planners and implementers, as well as research scientists and development donors.

The study was motivated by the apparent contradictions that exist between what research recommends, projects promote and donors invest in as being the most effective measures to enhance on-farm climate adaptation and address land degradation, and those which farmers actually carry out. Most socioeconomic and biophysical studies assess the benefits of different adaptation and land management

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Which methods were used?

The study commenced with focus group discussions held at the community level, in order to build up a picture of the social, economic, institution-al and biophysical context in which farmers operate. This also provided a means of defining the agroecosystem services and land management features that would be further investigated later on. These broader interactions set the scene and established a basic understanding of how and why different community members are encouraged, enabled and empowered (or not) to make particular livelihood and land use decisions. It also provided a means of understanding the role and interaction of different livelihoods sources and strategies within the broader landscape.

Next, a participatory resource mapping exercise was carried out. This involved using free, high resolution satellite imagery from *Google Earth Pro* to present an aerial view of the landscape in fine detail. Community members then identified key features on the map, which helped to clarify the extent of the area the map represented. Next, discussions were held on natural resources (such as water, livestock, cultivated land and uncultivated land) and various key features were identified, such as where resources were located and how they were used, what changes had taken place in the supply of resources and how these changes were impacting livelihoods, and restrictions to access, conflicts over use and management of each resource in question. Mapping with different groups, such as men, women and youth showed which resources were the most important to different groups as well as differences in access and perceptions of change.

Drone images used for assessing mangrove recovery

Building on this information about how community members differentially manage, use and depend on land, resources and ecosystem services across the wider landscape, the next stage of the study focused on establishing how farmers valued different land management alternatives. This used the *Evaluating Land Management Options (ELMO)* tool, a novel method that had been developed by CIAT to investigate farmers‘ own perceptions and explanations of the costs and inputs, benefits and outcomes, advantages, disadvantages associated with different land management choices. Rather than calculating these values directly, various tools are used to rank, weight and score different land management options or in-terventions against metrics which have been deemed as being particularly important to the community or farmer being studied.

Case study 19

Malawi, Tanzania

...contd.

options according to externally-driven indicators of value, not in the light of what farmers themselves perceive as the main costs and benefits.

The study undertook spatial and economic assessments of agroecosystem service values. It sought to understand how and why people use land and resources (both on and beyond the farm itself), and how changes in their availability impact livelihoods across the landscape. Following on from this, the study investigated farmers' percept-ions of the costs, benefits and economic drivers that shape their willingness and ability to invest in CSA and SLM (or, conversely, encourage or even force them into situations which result in land degradation or undermine their adaptive capacity). This intended to show which on-farm land management measures would be the most effective and sustainable when judged in local terms, and to identify what additional interventions might be required to enable, encourage and empower farmers to capture the benefits from CSA and SLM.

Which methods were used?

The methodology is intended to be a rapid assessment, with each stage able to be carried out over the course of a few days. It relies solely on primary data collection, via community consultations, focus group discussions and individual interviews. It should however be noted that the approach is designed as part of a broader assessment process, integrated with other disciplines and other socio-economic and biophysical survey techniques. In Ntcheu and Lushoto, these included land use/land cover change mapping, soil analysis, land degradation surveillance frameworks, household surveys and a range of complementary participatory rapid appraisal tools such as transect walks, focus groups, key informant interviews and participatory video. The study team incorporated anthropological, environmental economic and agricultural expertise. Research was conducted by local partner NGOs and universities, with technical backstopping being provided by an international research centre.

Approach is part of a broader assessment process

How were the results disseminated and what was their impact?

The study yielded a number of interesting insights, which would have been unlikely to have been revealed by more conventional socioeconomic and biophysical survey techniques. One key finding from the participatory resource mapping was that local perceptions of ecosystem service benefits, and how these change over time, vary widely between different stakeholders (for example between men and women, young and old, rich and poor). The implication is that, if CSA or SLM interventions are being evaluated or planned, then they need to address these different constraints and objectives.

Meanwhile, ELMO made it clear that many of the CSA or SLM techniques that are most commonly practised and which farmers express the great-est preference for are not those which yield the highest production gains, generate the greatest income, or entail the lowest costs (the characteristics that would traditionally be deemed important when land management interventions are selected and designed). Meanwhile, other apparently profitable inter-

Case study 19

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The AGORA project 'Acting Together Now for Pro-poor Strategies Against Soil and Land Degradation'. The project is carried out by the International Center for Tropical Agriculture (CIAT), Institute for Advanced Sustainability Studies (IASS) of Germany, Selian Agricultural Research Institute (SARI) of Tanzania, and Lilongwe University of Agricultural and Natural Resources (LUANAR) and Total Land Care (TLC) of Malawi. It is funded by the funded by the German Federal Ministry for Economic Cooperation and Development (BMZ) and the CGIAR Research Program on Water, Land and Ecosystems (WLE) and CGIAR Fund donors.

For further information see:
http://ciat.cgiar.org/where-we-work/africa/

How were the results disseminated and what was their impact?

ventions show relatively low rates of adoption. It is clear that, while perceptions of economic gain and loss are key to farmers' decisions to adopt or reject particular land management and adaptation techniques, it would be over-simplistic to assume that these concepts refer only to efforts to maximise short-term income and production or to minimise cash expenditures and direct outlays (the measures that conventional agronomic, soil science and economic analysis would point to as indicating the most desirable intervention options). The implication is that, if CSA or SLM planning does not recognise these different perspectives, then the resulting interventions may be of little interest or benefit to the intended targets.

These results were disseminated through a number of means, including technical papers and policy briefs (in both English and local languages), and via community validation exercises and dialogues at the district level. The heavy emphasis placed on stakeholder participation helped to enhance buy-in and understanding. District-level planners and decision-makers, in particular, were interested in the study findings, saying that this was a new kind of information to them, and stating that „we'd never thought of the landscape in this way".

What are the key insights and lessons learned on valuing EbA-relevant benefits?

One important feature of the study was that it formed a part of a much larger, integrated research process which also included agronomic, soil science, hydrological and ecological data collection on the biophysical effects and characteristics of different CSA and SLM practices. These other components of the research process were important. By themselves, participatory techniques cannot give a complete picture of ecosystem values or land management costs and benefits. They do, however, provide vital information to supplement the data gathered via more conventional techniques – which would not normally take community perceptions of ecosystem values, costs and benefits into account. This combination of research techniques and areas of focus were able to present a well-rounded picture to decision-makers, incorporating multiple perspectives and values.

The fact that the target audience (district-level planners and decision-makers) were directly involved in carrying out the studies was

Case study 19

Malawi, Tanzania

very important in fostering buy-in, and making the findings credible and understandable. This engagement was also enhanced by the fact that both of the survey techniques – participatory mapping and ELMO – were perceived by participants as being "fun" to undertake, and involved learning and applying new methods that neither government officers nor local farmers had encount-ered before.

Employing novel participatory approaches was not without its difficulties, It was often hard for community members to relate their own experiences by means of a map, and it also took time to explain the ranking, weighting and scoring exercises that formed the basis of ELMO. As is so often the case with participatory techniques, both exercises were time-consuming. Resource mapping took 3-4 hours to complete, and ELMO interviews often lasted as long as 2 hours.

Last but not least, capacity issues posed a real constraint. Neither the researchers from the international agricultural centre nor those from local-lev3l NGO and government partners were familiar with participatory survey techniques. Many made the assumption that, because socioeconomic techniques are based around talking to people, they require no special training or expertise to carry out. As a result, surveys were not always administered correctly, or with open participation from local communities.

EbA valuation case studies

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December 2017

Mexico

Case study 20

"Integrating Ecosystem Services into Development Planning" valuation of economic contribution of protected area ecosystem services in Mexico

This case study describes an exercise to value protected area ecosystem services, as part of a broader exercise to understand and act on ecosystem service dependencies, impacts and opportunities. The aim was to demonstrate their economic contribution to local, national and sectoral development processes, as well as generating information that could be used to address key conservation threats and management issues. Capacity-building formed a cross-cutting objective, and continuous area of focus in the valuation study.

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What was being measured, and why?

This key sheet reports on efforts to value the economic contribution of protected areas (PAs) in Mexico. The valuation studies were carried out in response to the general lack of attention paid to ecosystem services in most decision-making processes, especially in the sectors that depend and impact most on the natural environment.

The studies aimed to communicate the value of ecosystem services to decision-makers in both environmental and non-environmental agencies, and to make the case as to why PAS are key to economic development. They also served to build technical capacity in ecosystem valuation within Mexico's National Commission of Protected Natural Areas (CONANP), and to generate recommendations about policy actions and instruments that might be used to strengthen PA conservation effectiveness.

Three PAs were valued. Cabo Pulmo National Park is a marine PA on the east coast of the Baja California Peninsula, Cozumel Reefs National Park and Cozumel Island Flora and Fauna Protection Area form a PA complex located about 20 km off the east coast of the Yucatán Peninsula, and the mountainous Iztaccíhuatl-Popocatépetl National Park is situated just to the south-east of Mexico City.

Which methods were used?

The valuation studies adopted GIZ's "Integrating Ecosystem Services into Development Planning" (IES) approach. The IES approach addresses the environmental and economic trade-offs associated with development measures, and helps to systematically incorporate ecosystem service-related opportunities and risks into conservation and development strategies and plans.

In line with the IES approach, each of the studies therefore focused on a specific management issue and associated ecosystem services, according to the conservation priorities, threats and opportunities in the PA which was being valued. These were identified during intensive 2-day workshops held with PA managers and other local resource managers, users and experts. After identifying these focal areas and issues, stakeholder maps were produced to trace the dependencies and impacts of various different groups on ecosystem services. Valuation methods were chosen which were appropriate and applicable to the selected ecosystem services, could generate information that would be convincing and relevant to the target groups that the study aimed to influence, and were realistic and achievable in terms of their data and research requirements.

Choice of methods also determined by reasearch requirements

For example, in the Cozumel PA complex, the main conservation management and development planning issue was the threats posed to coral reefs, mangroves and other natural habitats and species by unsustainable tourism and coastal infrastructure development. The key concern was to generate information that could be used to better align policies and practices in these sectors with ecosystem services, and improve public budget allocations to PA conservation activities. Three sets of ecosystem services were selected for valuation: recreational and leisure activities (valued by means of choice experiments and benefit transfer techniques), protection against storms and flooding (valued using the spatially-explicit, map-based InvEST model), and other benefits provided by mangroves and coral reefs (valued using a combination of different techniques).

Although the studies were commissioned by the GIZ-funded EcoValor Mx project, the actual studies were carried out by an international organisation with wide experience in ecosystem valuation and

Case study 20

Mexico

capacity-building. The main project partner, CONANP, was closely involved in technical aspects of the study, as well as forming one of its main intended target audiences. The studies were carried out over the course of a year and a quarter.

How were the results disseminated and what was their impact?

The studies confirmed how valuable ecosystem services are, and underlined the importance of the three PAs to local, national and even global economies. In Cozumel, for example, the findings emphasised the significant value that mangrove and reef conservation generates for the tourism industry. It also showed how these natural habitats help coastal settlements and infrastructure to avoid substantial costs, losses and damages from the effects of storms and extreme weather events. It was found that, if well-preserved, Cozumel's coral reefs provide benefits worth USD 255 million a year for tourists, while their economic value in terms of coastal protection and nutrient cycling is USD 34 million. In total, 65% of Cozumel's population is less vulnerable to disasters as a result of the presence of coastal-marine ecosystems. Based on these results, it was recommended that a priority for decision-makers at all levels of government is to take actions to secure the ecosystem services provided by the PAs, which are the foundation of regional and national economies.

Coral reefs provide benefits worth USD 255 million/year

The study findings were shared by a variety of means. Short 2-page policy-briefs were prepared, specifically targeting sectoral decision-makers and focusing on the contribution of PA ecosystem services to local and national development processes. A webinar was also held, reaching a wide audience of more than 100 participants. Interestingly, PA Directors took the lead in presenting the valuation study findings at this webinar, as part of the project's capacity-building efforts. Although not yet completed, it is also planned that a guide on best practices in PA valuation will be produced (drawing on experiences and lessons learned during the studies), targeted at decision-makers in CONANP who will take the lead in commissioning and coordinating valuation studies in the future.

Case study 20

Mexico

The project "EcoValor Mx: Valoración de Servicios Ecosistémicos en Areas Naturales Protegidas" aims to enhance awareness of the value of Mexico's protected area ecosystem services and incorporate valuation into public policies and programmes. It is funded by the German Ministry of Environment, Nature Conservation, Building and Nuclear Safety BMUB, and operates in partnership between GIZ, Comisión Nacional de Áreas Naturales Protegidas (CONANP) and Secretaría de Medio Ambiente y Recursos Naturales (SEMARNAT).

For further information see http://www.ecovalor.mx/

How were the results disseminated and what was their impact?

The valuation findings have generally been well-received by decision-makers in CONANP and other conservation agencies, and in the sectors that depend and impact on PA ecosystem services (such as fisheries, tourism, agriculture, climate change, water, construction, etc.). While the studies have undoubtedly served to raise awareness of the economic importance of PAs, they did not aim to directly influence policy in these sectors. The main impact is in building technical capacity and making available tools to assist CONANP to better represent their interests as regards PA conservation and to mainstream ecosystem values into sectoral policy and planning.

What are the key insights and lessons learned on valuing EbA-relevant benefits?

One of the most successful aspects of the valuation exercise was that it combined information-generation with capacity-building. The aim was to equip the main project partner – CONANP – with the means to use ecosystem valuation as a tool to assist in PA planning and management. Establishing long-term valuation capacity and awareness at the institutional level should also help to secure the sustainability of the study results, and ensure they have a lasting impact. It is important to emphasise that the intention was not to create a body of staff that were technically trained to conduct ecosystem valuation, but rather to provide conservation managers and decision-makers with the knowledge and understanding that would enable them to identify, commission and supervise valuation studies to assist them in their work.

Another key lesson learned was the importance of phrasing information about ecosystem values in practical, policy-relevant and jargon-free terms, and to express it through indicators that were of interest and concern to the target audience that the studies aimed to influence. The main concern was to demonstrate to sectoral decision-makers that PAs made a tangible contribution to output, income and employment. The focus of the studies, and the IES framework that they were based on, was on showing how ecosystem services offer development opportunities and can act as an engine for economic growth. This kind of orientation to real-world issues and needs ensured that the valuation studies were of credible, relevant and useful, rather than being purely academic exercises to generate numbers.

Case study 20

Mexico

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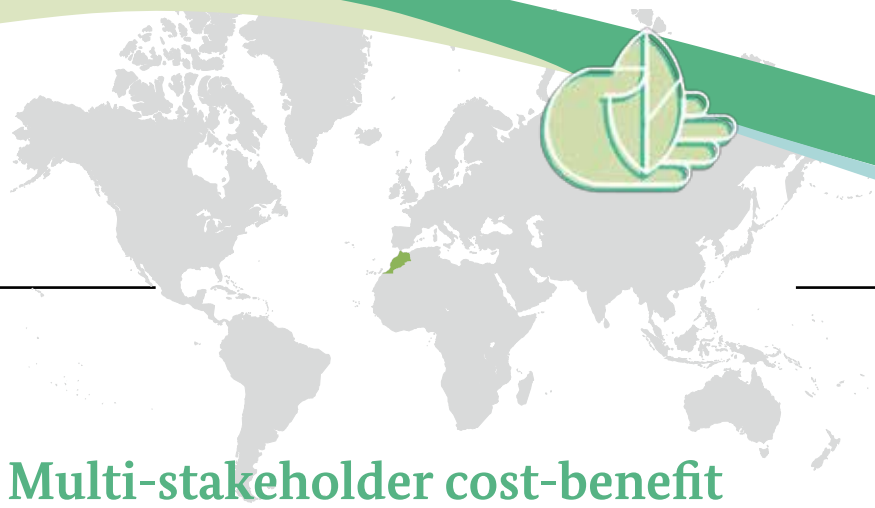
Morocco

Case study 21



Multi-stakeholder cost-benefit analysis and contingent ranking of climate adaptation in Morocco's irrigation sector

This case study evaluates economic aspects of adaptation interventions in the irrigation sector in Morocco. It employs a cost-benefit analysis focused, multi-stakeholder approach which takes account of the wider effects of adaptation measures on different sectors and groups, as well as the potential synergies and trade-offs between them. The intention was to provide a fuller picture of adaptation impacts as well as to generate information that could be used to make the case for adaptation and encourage uptake.

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What was being measured, and why?

This study was carried out to assess the economic costs and benefits of irrigation adaptation interventions in the Tadla region of central Morocco. As well as more conventional financial cost-benefit techniques, participatory, stakeholder-based method were applied which could identify cross-sector benefits and highlight areas of mutual interest among different stakeholder groups.

The reason for the study was to provide decision-support information and demonstrate evaluation methodologies which would have application to Morocco's climate adaptation strategy. With water and agriculture having been identified as two of the most vulnerable sectors to climate change, the main adaptation strategy is the conversion from surface, or flood, irrigation to drip irrigation. Yet, even though many different groups and sectors stand to be affected by these adaptation interventions, no stakeholder-focused cost-benefit analysis had been conducted. The study thus sought to assess what the benefits and costs of drip irrigation were so as to provide a fuller picture of the impacts of adaptation in the irrigation sector, as well as to generate information that could be used to make the case for adaptation and encourage uptake among potential beneficiaries.

Which methods were used?

The study methodology combined cost-benefit analysis with a more participatory stakeholder analysis. To these ends, two data collection and analysis methodologies were used: structured interviews for the cost-benefit analysis and rapid rural appraisal for stakeholder analysis.

Data for the cost-benefit analysis were collected through a survey of 50 farmers. This collected information on the costs of establishing a drip irrigation network, the water use for drip irrigation technology at farm level and the yields for different irrigated crops. The increase in gross and net income as a result of conversion to drip irrigation was estimated. This enabled an analysis of the financial feasibility of conversion to drip irrigation, yielding measures of the net present value of interventions. This was modelled with and without the subsidy that the government currently provides to drip irrigation (set at 80 per cent of the initial investment).

For the contingent ranking-based stakeholder analysis, four main categories of stakeholders were identified: private sector drip irrigation companies, public sector agricultural and water agencies, farmers and agricultural workers, and agricultural/environmental researchers. A total of 36 stakeholders were consulted with, contributing a variety of different information. A list of farmers' benefits and costs was drawn up, including both monetary and non-monetary variables. Farmers were asked to confirm the reported costs and benefits by providing details of each in the context of their specific circumstances (crop mix, farm size, etc.), and percentage measures of monetary benefits where applicable. The purpose of this was to ensure full awareness of the options, in order to provide a meaningful basis for carrying out a contingent ranking exercise. The ranking exercise then ranked all the relevant benefits in order of importance, thereby eliciting the value of non-monetary impacts and providing an estimate of their relative magnitude for different stakeholders.

Ensure full awareness of all options before ranking

Case study 21

Morocco

What were the findings?

The cost-benefit analysis showed that considerable water savings were associated with the uptake of drip irrigations. Although operations and maintenance costs were found to be lower, and – after a small time lag — crop yields to be higher than surface irrigation systems, the fixed costs for drip irrigation are typically larger due to the greater initial investment required to purchase and install them. Only with a government subsidy is the switch to drip irrigation financially viable to farmers.

Yet, despite this negative financial return, drip irrigation can provide opportunities to improve both farm-level net returns and net public benefits in areas with limited water resources. Possible farm-level benefits include reductions in water and labour costs, higher crop yields and a broader set of production opportunities. Potential public benefits include higher farm-level net returns and the net values generated by agriculture and the other uses for water made available when farmers replace flood irrigation with drip irrigation. Public benefits can also arise when drip irrigation reduces or eliminates negative impacts such as inefficient water use, nutrient leaching, and the rapid depletion of non-renewable groundwater resources.

All stakeholders agreed that conversion from flood irrigation to drip irrigation system is the only solution to the irrigation water deficit partly caused by the observed climate changes. The stakeholder analysis identified that all the primary stakeholders of the adaptation project were also experiencing non-monetary welfare gains, as is commonly observed in adaptation projects that aim to build adaptive capacity. Some groups of private and public stakeholders favoured these non-monetary gains over the monetary ones, with small-scale farmers the most reliant on the non-monetary benefits of adaptation. The majority of farmers were however not aware of the non-monetary benefits of the drip irrigation system.

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case studies

Case study 21

Morocco

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Myanmar

Case study 22

Using InVEST to conduct a natural capital assessment of ecosystem service values and trade-offs in Myanmar

This case study describes work carried out in Myanmar to map and value natural capital at the national level and in Tanintharyi Region. A broad range of ecosystem services were considered, including sediment retention, waterflow regulation, flood attenuation and coastal protection. Future climate impacts were incorporated into the valuation scenarios that were modelled.. The information was intended to feed into various land use planning applications, including understanding trade-offs and identifying options for protected areas, infrastructure development and climate adaptation.

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What was being measured, and why?

This key sheet reports on a natural capital assessment carried out to measure ecosystem service values and trade-offs in Myanmar. It sought to show where the country's natural capital is located, what benefits it provides to people, and how those benefits will change under different climate change and development scenarios. As well as producing national-level data, the study had a special focus on land use change in Tanintharyi Region in the southern part of the country, in which the Dawei Special Economic Zone Development Project plans to establish a large industrial zone and transport infrastructure network linking across the Myanmar-Thai border. Climate adaptation was a special focus in the assessment, which sought to provide guidance on strengthening the resilience of natural ecosystems, and safeguarding the services they provide in strengthening the resilience and adaptive capacity of human systems.

The intention was to generate information that could be used by decision-makers when formulating plans and policies related to economy, energy, agriculture, land use, foreign investment, climate adaptation and more. The main target audience was decision-makers and planners in Myanmar at both national and sub-national levels, including public and private sector investors in-

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Which methods were used?

The assessment was based on InVEST (integrated valuation of ecosystem services and trade-offs). This is a spatially-explicit, software-based tool for modelling ecosystem service values and trade-offs that uses maps as information sources and produces maps as outputs. InVEST has various modules dealing with different biomes and ecosystem services. These models are based on production functions that define how changes in an ecosystem's structure and function are likely to affect the flows and values of ecosystem services across the landscape, expressing the results in either biophysical or monetary terms.

The natural capital assessment was initially carried out in Tanintharyi Region, focusing on carbon, water yield and soil retention services. It was then scaled up to the country level, and extended to incorporate climate change, considering sediment retention for water quality, regulation of dry-season water availability, reduced flood risk and protection from coastal storms. These particular ecosystem services was chosen based on their relevance in Myanmar, and the availability of the necessary data and models to evaluate them at a national scale.

Inputs into the model combined physical, biological, and socio-economic data, including aspects such as land use, vegetation type, soils, climate, infrastructure, and demographics. These were all obtained from secondary sources. InVEST software was then then used to map and quantify the biophysical provision of ecosystem services, and the results were combined with data on the location and needs of people and infrastructure, so as to assess demand for and delivery of ecosystem service benefits. Climate information came from downscaled projections for Myanmar on temperature, precipitation and sea-level rise. To capture uncertainty in climate projections, a high and low climate scenario was evaluated for each time period.

InVEST software was used to map and quantify

No monetary estimates of natural capital or ecosystem service values were produced. The main outputs were a series of maps showing ecosystem service provision under different future development and land use scenarios, and indicating the spatial overlap between

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Myanmar

...contd.

volved in land, resource and infrastructure developments in the . Dawei corridor and elsewhere. The information generated by the study was envisioned to have the potential to feed into a wide range of land use and development planning applications, including understanding the trade-offs and identifying alternative options for protected areas, infrastructure development and climate adaptation, as well as providing inputs to strategic environmental assessments and environmental impact assessments and developing sector-specific guidelines for investments.

Which methods were used?

areas of high ecosystem service provision and important biodiversity conservation sites. The assessment was carried out over a period of about a year, involving a multidisciplinary team of GIS specialists, biologists, ecologists, climate specialists and conservation planners drawn from international institutions (WWF, Columbia and Stanford Universities) as well as local universities and government conservation agencies.

How were the results disseminated and what was their impact?

The assessment generated new quantitative and visual data on the scope, nature and location of ecosystem service provision in Myanmar. It showed where and how Myanmar's natural capital contributes to clean and reliable drinking water sources, reduced risks from floods inland and storms along the coasts, and to maintaining the functioning of reservoirs and dams by preventing erosion.

The findings of the assessment were disseminated through a number of channels. A series of technical reports and a consolidated synthesis document were produced, the latter in both Myanmar and English languages. Results were primarily presented on maps, showing ecosystem service provision under different future development and climate scenarios as well as the overlap of important ecosystem service-producing areas with the country's network of protected areas and key biodiversity areas. A website was also set up, providing a means of presenting these visualisations in order to highlight key findings. These various communications products were launched at a formal event, as well as through a media campaign, photo exhibit, displays at schools and TV and newspapers articles.

Campaign with exhibition, school displays and articles

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Myanmar

The study was carried out jointly between WWF-Myanmar, WWF-US, Stanford University and Columbia University and the Government of Myanmar, with funding support from the Helmsley Charitable Trust. It forms a part of This study was carried out as part of WWF's programme in Myanmar, which aims to support Myanmar's development ambitions with a focus on spatial planning and biodiversity conservation in parallel with ecosystem services protection and sustainable livelihoods.

For further information see http://www.myanmarnaturalcapital.org/en, http://www.naturalcapitalproject.org/invest/

What are the key insights and lessons learned on valuing EbA-relevant benefits?

Although it is too early to generate any substantive lessons learned (the assessment had only recently been completed and released at the time of putting together this case study), a number of interesting insights arise from the process of carrying out the study and presenting its findings. One is the importance of stakeholder participation. Both the Ministry of Natural Resources and Environmental Conservation and local universities were closely involved in the assessment process, and participated in the technical studies to generate the data it used. The assessment process also emphasised training and skill-sharing, with the aim of generating a permanent capacity to use and apply InVEST. These high levels of involvement of Myanmar partners made a significant contribution towards increasing national acceptance and buy-in to the study findings.

Ministry and universities involved in data collection

A great deal of effort was invested into the presentation and communication of the study findings. Considerable thought was also given to ensuring that both the study scope and its results would be considered nationally-relevant, and were tied to priority information and decision-making needs in Myanmar. Maps and visual presentations, in particular, provide to be a popular and interesting way of communicating the findings to a wide audience.

Case study 22

Myanmar

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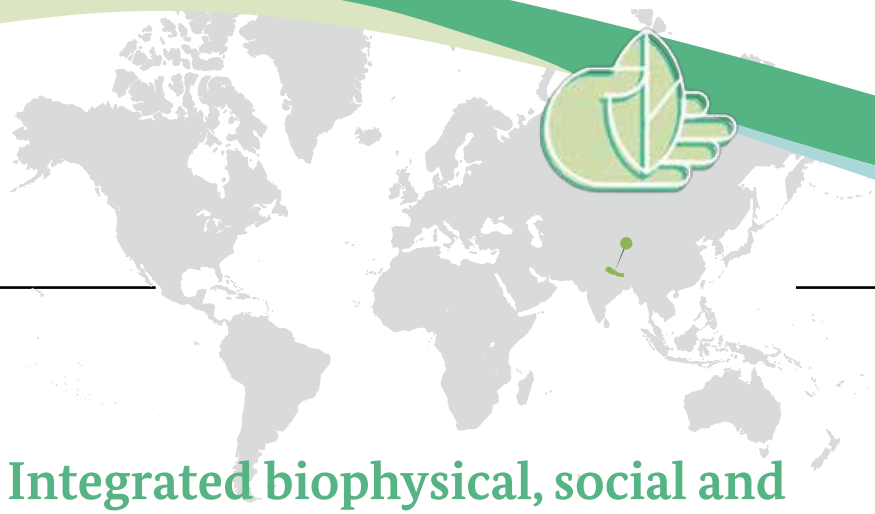

Integrated biophysical, social and economic assessment of ecosystem-based disaster risk reduction approaches to road construction in Nepal

This case study describes a cost-benefit analysis to compare green and grey options for road development in Nepal. This integrated biophysical, social and economic methods in order to cover a wide range of different effects and values. The main aim was to generate evidence to make the case for bio-engineering and ecosystem-based disaster risk reduction to planners, budget holders and policy makers at both district and national levels.

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What was being measured, and why?

This case study reports on a study to compare the biophysical, social and economic costs and benefits of different road engineering options in three districts of Nepal's Western Development Region (Kaski, Parbat and Syangja Districts). The study had a particular focus on the use of bio-engineering techniques to deliver ecosystem-based disaster risk reduction outcomes. This is because roads are one of the major causes of shallow landslides in rural Nepal. It compared 'grey' engineering options (earthen or unmanaged roads) with 'green' roads (eco-safe infrastructure which involves soil bio-engineering along the roadsides and makes use of natural vegetation to stabilise soils and slopes).

The study aimed to show how bio-engineering techniques could be adapted to the local environment and serve to reduce landslide instabilities. The main objective was therefore not to build eco-safe roads or reduce community vulnerability in the demonstration sites per se, but rather to show how knowledge could be generated, shared and upscaled. The case study had three major intended target audiences and levels of influence. One was to communicate the multiple benefits of bio-engineering approaches to local community members who are involved in building and maintaining green roads.

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Which methods were used?

The study followed an integrated methodology that brought together biophysical measurements, social impact assessment and economic valuation. These involved primary data collection via field surveys and consultations in the demonstration sites, as well as the use of secondary data sources and existing statistics.

The biophysical component involved assessing the erosion occurring around different types of road. LIDAR was used to measure rates of soil loss both before and after the monsoon. Surveys were also carried out to assess plant survival and root structure. The social component used a combination of methods, A social vulnerability assessment was carried out by means of a household survey, and a variety of participatory techniques were used to elicit community opinions and knowledge on road-related costs and benefits. These included focus group discussions, participatory mapping, problem and solution analysis.

The economic component looked at the direct costs and benefits of road construction and maintenance, as well as valuing the ecosystem services generated in terms of erosion control and protection against landslides. It compared grey and green roads over a 40 year time frame, modelling five scenarios based on different patterns of rainfall, labour costs, benefit generation and discount rates. Unlike the other two components of the study, this was based mainly on secondary data gathered through a desk study, supplemented by focus group discussions. The main components in the costs-benefit analysis were road establishment and maintenance, income from the sale of products derived from soil-stabilising plants and enhanced access to markets, other facilities and services.

Desk study supplemented by focus group discussions

The study components were undertaken by an interdisciplinary team composed of soil scientists, (bio)engineers, economists and rural sociologists. This combined national and international consultants and university researchers. Field surveys were carried out over the course of two monsoon seasons in 2015-16.

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Nepal

...contd.

The second was to influence national decision-makers to integrate bio-engineered road approaches at the policy level. The third was to promote the integration of ecosystem-based approaches into global policy instruments and multi-lateral environmental agreements.

How were the results disseminated and what was their impact?

The main finding of the study was that investing in bioengineered or eco-safe roads is the most cost-effective means of road construction. It also generates substantial co-benefits in terms of livelihood support and disaster-risk reduction. In addition, it shows the highest rates of success and sustainability at the local level, with high levels of uptake and ownership by communities.

These results were disseminated through various means. In Nepal, findings were shared at the community level through a series of consultations and dialogues. This was accompanied by the provision of training in green road construction techniques, with practical exercises using locally appropriate low cost bioengineering techniques. A training manual on roadside bio-engineering which was used and distributed at each training and workshop opportunity. A short policy brief was produced which was targeted at planners and decision-makers, and two national workshops and two regional workshops were held to raise awareness about ecosystem-based disaster-risk reduction, using the specific case of 'green' roads. These workshops were attended by journalists, parliamentarians and decision-makers, who were brought to the field so as to be directly exposed to practical knowledge of the issues and solutions. Considerable time was invested in media outreach, involving TV and newspaper articles as well as training and education for journalists. At the global level, presentations were made at various workshops and conferences, and several peer-reviewed articles were produced targeting researchers and the scientific community.

Parliamentarians and decision-makers attend workshops

The study generated considerable interest, particularly because it was able to offer 'hard' evidence of the efficacy of green roads and ecosystem-based measures for disaster-risk reduction in biophysical, social and – especially – economic terms. At the global level, the case study offered valuable information to assist in making the case for integrating ecosystem-based approaches into the Sendai Framework for Disaster Risk Reduction, as well as the dialogues and processes surrounding the Convention on Biological Diversity. Within Nepal, the Department of Soil Conservation and Watershed Management have already taken up much of the learning generated by the case study, and have increased the priority given to bioengineered options for road development. Plans are underway, to incorporate environmental criteria into road planning and selection, and to undertake additional cost-benefit analyses of green roads. Efforts

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are also being made to mainstream ecosystem-based approaches in national policies related to road construction, land management and disaster risk reduction.

What are the key insights and lessons learned on valuing EbA-relevant benefits?

One unique feature of the case study, and important lesson learned, relates to the importance of taking an integrated approach to assessing ecosystem-based approaches. This exercise combined biophysical, social and economic measures, and thus considered multiple benefits and costs. Most studies look only at one aspect or dimension. Three aspects of the study combined to create a more comprehensive picture of the relative merits of green road approaches over grey ones, that also resonated with different sectors and interest groups.

Integrated approach appeals to various interest groups

The issue of co-benefits was particularly important. Many studies only look at the direct benefits and costs of ecosystem-based measures, and thereby under-represent their value. In addition to protecting against landslides (and thus contributing towards disaster-risk reduction), green roads also create benefits for communities through the generation of extra income. In this instance, investing in ecosystem-based disaster risk reduction and adaptation was perceived as a 'no-regrets' solution: in addition to reducing erosion and landslide risk, it was seen to create multiple benefits to populations and increases resilience during droughts and other climate vagaries.

The example of green roads was a good one to make the case for ecosystem-based disaster risk reduction more generally. Because both roads and landslides are considered a high local and national priority, the case study attracted a lot of interest from many different groups, and was considered both relevant and useful.

This case study was carried out as part of the project "Ecosystems Protecting Infrastructure and Communities (EPIC)", funded by the German Federal Ministry of the Environment, Nature Conservation and Nuclear Safety (BMUB) under the International Climate Initiative (IKI). EPIC is co-ordinated by IUCN, working in partnership with with the University of Lausanne (Switzerland), l'Institut National de la Recherche Agronomique (France), the Mangrove Action Project (Thailand) and the Swiss Federal Institute for Forest, Snow and Landscape Research. EPIC is a global project involving six countries (Nepal, Peru, Thailand, Senegal, China and Burkina Faso), which seeks to demonstrate the multiple benefits and effectiveness of environmental management as a potentially important Disaster Risk Reduction (DRR) strategy in vulnerable communities.

For further information see https://www.iucn.org/theme/ecosystem-management/our-work/environment-and-disasters/ecosystems-protecting-infrastructure-and-communities-epic/nepal

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Nepal

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Niger

Case study 24

Extended social cost-benefit analysis to evaluate 'hard' and 'soft' community-based adaptation measures in Niger

This case study evaluates community-based adaptation measures in Niger. Unlike more conventional cost-benefit analysis techniques, it incorporated a wide variety of quantified indicators to measure changes in communities' economic, social and environmental capital. The study sought to demonstrating the effectiveness of community-based adaptation approaches for building resilience and adaptive capacity across a broad range of outcomes.

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What was being measured, and why?

This study was carried out to compare and contrasts the benefits and costs of a package of 'hard' and 'soft' community-based adaptation interventions in Dakoro, Niger. It applied extended social cost-benefit analysis techniques which take account not only of direct physical expenditures and income, but also measure the broader evolution of community economic, social and environmental capital. The study thus aimed to accounting for triple bottom-line impacts, unlike conventional economic appraisal techniques which look at a much narrower range of financial and economic benefits.

The study was prompted by the need to be able to identify which adaptation strategies are most likely to build resilience and enhance societal capabilities to deal with adverse climate evolutions and shocks, particularly in rural communities of the Global South. Its primary focus was on demonstrating the effectiveness of community-based adaptation approaches. The study thus aimed to address the question of whether, and to what extent, community-based adaptation is an efficient and effective strategy for building local resilience and adaptive capacity, measured through a broad range of outcomes.

Which methods were used?

The study evaluated CARE International's Adaptation Learning Programme activities carried out in Dakoro, Niger. These combined a variety of 'hard' solutions (including small-scale infrastructure and physical measures) and 'soft' approaches (such as livelihood interventions, environmental measures, capacity-building and empowerment). The extended social cost-benefit analysis techniques that were used merged traditional cost-benefit analysis with the principles that underpin social return on investment. This followed a three pronged approach: building theories of change; measuring quantitative social and economic capital outcomes; and assessing quantitative environmental capital evolutions and climate variability. It had a strong focus on community engagement and participation, reflecting the principles of the community-based adaptation measures that it was evaluating.

First of all, a theory of change was developed through community focus groups, in order to understand the impact of climate change before the interventions, and the strategies and outcomes experienced from the adaptation measures.
Then, indicators for the main social, economic and environmental outcomes were selected, based on empirical research with primary stakeholders (these are described in the paragraphs below). Tools to collect the data were developed, piloted, refined and modified. Extensive empirical research was then undertaken to collect qualitative information and quantitative data directly from a sample of participating households. Literature reviews and secondary, desk-based research was undertaken to fill any remaining data gaps.

Theory of change helps understand climate impacts

Data analysis and interpretation involved two main components: modelling communities' resilience to shocks relative to a business-as-usual trend, and then modelling how this resilience impacts on their longer-run prospects. It explored how the adaptation interventions had created value, relative to investment, on three forms of capital: economic, social and environmental. A questionnaire to measure quantitative change in key economic, social and environmental indicators was drafted and applied.

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Niger

Which methods were used?

The economic capital outcomes measured included crop and livestock income (both cash income and the value of subsistence consumption), as well as the value of savings (both monetary and in-kind). Various indicators were used to quantify social capital outcomes. These include quality-adjusted life years (for health), school attendance and length of schooling (education) and number of persons in household solidarity networks (social capital), as well as ranked scales of women's influence and participation in decision-making (gender) and perceptions of capacity and knowledge to establish resilience strategies (community empowerment and adaptive capacity). Environmental capital outcomes were evaluated according to two variables relating to desertification: sustainable land management and restoration of degraded lands, and avoided deforestation and reforestation. These were measured in terms of trees planted or maintained, and hectares of land restored.

Adaptation outcomes were measured in absolute terms ('gross impact'), as well as relative to a business-as-usual scenario ('net/additional impact'). Importantly, to deal with the challenge of attribution, information was also collected on other trends and variables that might also have contributed towards changes in economic, social and environmental capital. This allowed for the net, or additional, impact of the interventions to be calculated not only by comparing the 'with adaptation' situation with business as usual, but also by attempting to assess what proportion of the change observed could be attributable to other actors or factors in the area. Communities were asked to list the organisations and actors that contributed to the outcomes observed, and estimate the proportion of contribution from these different actors to the outcomes. In addition, regression analysis was carried out to understand the extent to which evolving climate patterns might have determined any increase of crop and livestock production and productivity in the beneficiary communities.

The extended social cost-benefit analysis yielded three main monetary indicators: net present value, benefit:cost ratio and value for money (benefits generated per unit of spending). These were measured over the duration of the project (four years). In addition, in order to capture the future value of community-based adaptation in these communities, the evaluative model was further extended to forecast capital evolutions to 2020. This required the use of three core climate scenarios (worst, moderate and best cases), as well as comparison of 'with' and 'without' project scenarios. A sensitivity analysis was also undertaken, to gauge the effect that changing key cost and benefit variables would have on the results.

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Niger

What were the findings?

The results of the study suggested that the community-based climate adaptation interventions carried out in Dakoro had yielded high returns. They had managed to increase the economic capital of communities in terms of revenue and savings, as well as 'soft' social and environmental capital measured in terms of health, education, empowerment, reforestation and avoided land degradation. Just taking into account the benefits generated to date, since the interventions were initiated, every GBP 1 invested in communities has leveraged a return of more than GBP 4. Over a longer-term scenario, even under a high discount rate, results remain positive and returns are high.

The study makes the point that it is also important to compare these returns with others' experiences and evaluation figures, so as to get a sense of scale. One of the aims of the study was to demonstrate the effectiveness of community-based adaptation approaches. A review of previous economic analyses of adaptation and disaster risk reduction interventions showed that the returns that had been calculated for Dakoro were comparatively high. The returns on investment to community-based adaptation appear higher than returns on investment to interventions that focus only on disaster risk reduction. This was reinforced by the results of the sensitivity analysis, which also indicated positive returns even if benefits were reduced. The study thus showed that there is a strong rationale for designing holistic adaptation interventions that serve to enhance long-run adaptive capacity, and that community-based measures can be a promising avenue for building cost-effective adaptation strategies to climate change.

Community-based adaptation yields high returns on investment

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Peru

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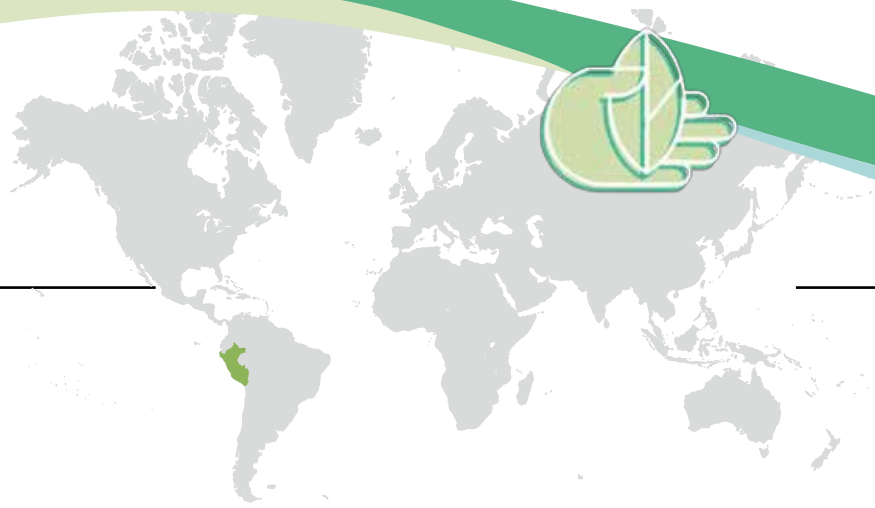

Physical impact assessment and cost-effectiveness analysis of green water interventions in Peru

This case study valued both the physical and economic impacts of ecosystem-based water supply interventions in Peru. This yielded indicators of potential effects on baseflow and cost-effectiveness. The aim was to make the case for integrating and prioritising green options into water planning and investments, at the same time as developing and demonstrating a practical assessment methodology that could be applied more generally to infrastructure in other sectors.

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What was being measured, and why?

This study was carried out to assess the economic desirability of various ecosystem-based infrastructure options to ameliorate and overcome Lima's dry-season water shortages, when reservoirs, streams, and rivers run low because of low seasonal rainfall. The interventions centred around improving land and resource management in the upper watershed. They were evaluated in both biophysical (potential impact on baseflow) and economic (cost-effectiveness) terms.

The study was prompted by the need to generate evidence on the effectiveness of ecosystem-based approaches. While substantial built or 'grey' infrastructure projects had been planned and implemented to address the water crisis in Lima, green interventions were still not yet routinely considered as a part of the solution. The study therefore aimed to make the case for investing in ecosystem-based water infrastructure solutions, and provide the information that would be required to integrate them into project planning and selection frameworks. In addition, the study sought to develop and demonstrate a methodology that could be applied and used in infrastructure investment planning elsewhere.

Which methods were used?

First of all, a scoping exercise was carried out, involving the study team, National Water Authority and other regional stakeholders. This defined the main parameters to be investigated, including the hydrological benefit metric, interventions to be considered and geographic scope. Baseflow was selected as the criterion against which the performance would be assessed (the lowest rate of surface water flow in the year, expressed in cubic metres per second). Four interventions were selected: exclusion of livestock from overgrazed grasslands, introduction of rotational grazing practices on currently overgrazed grasslands, hydrological restoration of drained wetlands and restoration of ancient infiltration infrastructure (amunas). Several other measures were identified as relevant (including reforestation, riparian buffers, improvement of irrigation systems and restoration of pre-Incan terraces) but were excluded due to a lack of data or low likelihood of implementation. The geographical boundaries of the study were set as the Chillon, Rimac, and Lurin watersheds, which together supply almost all of Lima's water.

Rather unrealistic measures discarded from the study

The potential hydrological performance of different interventions was based on causal relationships recorded for agricultural programmes and credited watershed services markets in the United States, as well as local projects where possible. A variety of watershed mass equations and simple mass balance equations were applied to estimate improved baseflow for specific site-level sub-projects. The potential impact of each intervention was then estimated by projecting site-level baseflow benefits across the entire area of the watershed that each intervention would cover. Cost calculations looked at expenditures made on materials, labour and project management (including community engagement and quality assurance). Because nearly all of the costs would be incurred in the early stages of establishing the measures, they were not discounted. Cost calculations also did not include any estimates of the local opportunity costs of land and resource uses foregone.

The cost-effectiveness analysis brought these two measures together. In order to calculate the marginal cost of each intervention, the annualised cost of the project was divided by the baseflow benefit, and presented as USD cost per m3 of waterflow. These indicators of cost-effectiveness were compared with 11 projects that are underway or planned for increasing water supply to Lima. Absolute

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Peru

EbA valuation case studies

Which methods were used?

figures on the monetary value of costs and volume of added water benefits were also presented.

The study was designed and implemented by a consortium of partners including US-based non-governmental organisations and consulting companies, Aquafondo (the water fund for Lima and Callao) and a Peruvian non-governmental organisation focused on sustainable development in the Andes.

What were the findings?

The main finding of the study was that green interventions could substantially contribute to addressing Lima's dry season waterflow deficits, at costs that are competitive with the grey infrastructure options considered (well within a $0.25/m^3 price point). The total potential impact on baseflow of the four interventions considered, if implemented at full-scale, was shown to be considerable, offering the potential to reduce up to 90 per cent of Lima's baseflow deficit. At a total annual volumetric impact of 2.74 m^3/s, this translates into a best estimate of more than 58 million cubic metres of dry season flow. The restoration of ancient infiltration infrastructure had the greatest potential impact and also stood out as being particularly cost-effective intervention, and the contribution of improved pasture management was also demonstrated to be significant.

Promising impacts from restoration of ancient infrastructure

In addition, although not quantified in the study, it was pointed out that Implementing these types of ecosystem-based interventions in Lima's upper watershed can result in additional social, cultural, and environmental benefits. These are particularly important in remote, underprivileged areas such as the upper watersheds, where local communities face limited and insecure livelihood opportunities. Ecosystem-based options (unlike grey measures) also offer possibilities to increase local income, environmental conditions and water security, to engage upstream communities in supporting management efforts and even to investigate new markets and payments for ecosystem services.

Case study 25

Peru

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EbA valuation case studies

Imprint

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December 2017

Philippines

Case study 26

Cost-benefit analysis and total economic valuation to make the case for ecosystem-based coastal adaptation in the Philippines

This case study describes two climate adaptation-related ecosystem valuation exercises carried out in the Philippines. One compared the relative costs and benefits of grey and green coastal adaptation options, while the other was a broader exercise that looked at both adaptation and non-adaptation related benefits of ecosystem restoration and conservation at the river-basin level. It makes the point that both targeted and general information on ecosystem values can help to make the case for green adaptation measures.

EbA valuation

case studies

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What was being measured, and why?

This case study reports on a case study which examined different approaches to using ecosystem valuation to generate economic evidence to support and encourage investments in ecosystem-based adaptation (EbA) in the Philippines. One exercise assessed the costs and benefits of managing mangroves for coastal protection relative to built engineering measures. The other involved a total economic valuation exercise carried out across an entire river basin.

The objective of the case study was to increase the knowledge base regarding the effectiveness of EbA, by collecting evidence from the field. It sought to make the case for EbA, in comparison to other adaptation activities, by generating evidence of its economic benefits. The reason for the analysis was to encourage discourse between both national and global decision-makers on the merits of EbA and other integrated nature-based solutions, in terms of their utility in dealing with climate impacts, as well as their broader social and economic co-benefits. The main target audience was development donors, planners and policy-makers both within and outside the environment sector.

Which methods were used?

The valuation study described in this key sheet was coordinated by IUCN, and synthesised others' work. It thus involved no primary or secondary data collection. It merely compiled and interpreted two already-existing data sets and published reports.

The first of these studies had been carried out by Conservation International Philippines. It was an economic analysis of three different adaptation options in Calapan City, Mindoro Oriental Province which aimed to enhanced coastal protection. Two EbA measures were assessed (mangrove protection and mangrove rehabilitation) and one grey option (building a seawall). These were compared with a business as usual scenario, where no new coastal protection measures would be undertaken. The study was entirely based on secondary data sources.

The economic analysis of coastal protection measures in Calapan had three components. First of all, a least-cost analysis was undertaken to show which of the three adaptation options was the most cost effective. This used data obtained from existing mangrove and coastal engineering projects to cost each intervention. Secondly, a damage costs avoided technique was applied to estimate the monetary value of the benefits of the different adaptation measures. This looked at the costs associated with floods, storm surges and typhoons. These included damages to local housing, lost fisheries income and recreational revenues, and monetary expenditures that would have to be made by local government to provide relief and other services to affected populations. They were estimated based on records of actual costs from other coastal flooding and storm events in the locality. Hypothetical estimates were made of the carrying levels of storm and flood protection that could be attributed to the different adaptation options. Third, a cost- benefit analysis was undertaken, which yielded estimates of the overall benefit-cost ratio and net present value of each coastal adaptation option.

What costs arise from floods, storm surges and typhoons?

The second study had been conducted by the Department of Economics of Xavier University-Ateneo de Cagayan. It comprised a total economic valuation of the Cagayan De Oro River Basin in Mindanao, covering water regulation, flood control, fishing and tourism ser-

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vices, as well as existence, bequest and other non-use values. A variety of valuation techniques were used including market price techniques (for marketed goods and services such as fisheries and tourism), contingent valuation methods (for non-market goods as well as water services) and damage costs avoided (for flood control). This yielded 'snapshot' estimates of the absolute value of river basin ecosystem services.

How were the results disseminated and what was their impact?

The review of the two valuation exercises yielded a number of useful findings. The common theme was the extremely high economic value of ecosystem services. Overall, the rehabilitation and preservation of the Cagayan De Oro Basin was shown to be worth between USD 2.4-3.5 million a year to local households. Meanwhile, in Calapan City, mangrove-based adaptation options were demonstrated to be highly cost-effective as compared to grey engineering measures, as well as providing the highest economic benefit in terms of avoided damages.

Ecosystem services worth USD 2.4-3.5 million to households

A country-level technical report was published on the findings of these two valuation exercises, the main points from which were also incorporated into a larger global synthesis report on making an economic case for investing in nature based solutions for climate change. The global synthesis report was one of the outputs of a bigger initiative by IUCN to compile and showcase other's work on the economics of EbA. The Philippines work formed one of six case studies considered in the global initiative – the other case studies were compiled from work carried out in Costa Rica, India, Mexico, Peru and Tanzania to measure and identify the economic costs and benefits associated with EbA adaptation.

The main focus of the dissemination and communication strategy was therefore at the global level, and on awareness-raising and information-sharing, targeting international policy-makers and

This work was carried out as part of an IUCN study identifying the economic costs and benefits associated with ecosystem-based adaptation. The intention was to identify knowledge gaps and generate lessons learned which will make it easier for policy makers to compare EbA options with engineered solutions. The study was carried out with the financial support of the French Government, and reviewed projects and assessed existing data from Costa Rica, India, Mexico, Peru, the Philippines and Tanzania. The case study was based on compiling and interpreting work that had already been carried out by Xavier University-Ateneo de Cagayan and Conservation International, funded from other sources.

For further information see https://www.iucn.org/theme/ecosystem-management/our-work/ecosystem-based-adaptation-and-climate-change, https://www.iucn.org/content/ecosystem-based-adaptation-knowledge-gaps-making-economic-case-investing-nature-based

How were the results disseminated and what was their impact?

donors. There were no expectations that concrete policy or decision-making changes would arise as a result of the valuation exercises. The case studies were launched together with the project donor, the French Ministry of Foreign Affairs and International Development, at a series of high-level meetings in Paris and at other global events (such as the World Conservation Congress). Representatives from the Philippines government and other national-level institutions, as well as community leaders from the sites in which the valuation studies were carried out, attended these meetings.

The meetings prompted active dialogue on the topic of EbA, and the study findings stimulated a great deal of interest among all levels of participants. While monetary estimates of costs and benefits helped to attract people's attention, it was the overall political and development arguments about the social and economic benefits of nature-based solutions to climate adaptation that provide most convincing (for example saved lives, support to poor fishermen and protection of vulnerable communities).

What are the key insights and lessons learned on valuing EbA-relevant benefits?

Two key insights and lessons emerge from the case study. One concerns the value of bringing together different information and institutions in order to make the case for EbA. The case study involved a number of different partners, projects and processes. While IUCN took the lead in compiling and synthesising the information to present at the global level, the actual valuation exercises had been carried out by two national-level institutions in order to guide and inform site-level development and conservation planning (one the country programme of an international conservation NGO, Conservation International, and the other the Economics Department of a local university). The relatively small amount of funding that was available to produce the case studies was able to leverage a fairly high level of cooperation and exposure, created synergies between a number of different organisations, and built a larger process and influence than any one of the three partners would have been able to accomplish alone.

The juxtaposition of two valuation exercises that were quite different in their focus, methods and spatial scope also generated

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interesting learning. It showed that, even when data do not exist to permit a cost-benefit analysis of specific adaptation measures (such as in the Calapan City case study), ecosystem valuation can still provide a useful tool. More general valuation exercises, which look at a broad range of ecosystem services over a relatively wide area (such as the Cagayan De Oro River Basin study), can provide information about the economic productivity of natural ecosystems which is relevant to making the case for EbA.

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Case study 27

Integrated ecosystem accounting in the Philippines

This case study describes how ecosystem accounts were developed for two sites in the Philippines. The aim was to demonstrate to local decision-makers the environmental and economic consequences of various land use trade-offs for different groups and sectors, so as to help to inform the development of strategies for managing competing claims on natural resources. The study adopted the UN System of Environmental-Economic Accounting, combining spatial, biophysical and economic data and integrating various ecosystem valuation tools.

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What was being measured, and why?

This case study reports on the development of ecosystem accounts at two sites in the Philippines. Ecosystem accounts provide a way of integrating environmental information into standard measures of economic activity. In the Philippines, an overriding aim was to provide information to decision-makers about how different land use and development choices would impact on the provision of ecosystem services and the economic wellbeing of different groups.

Working in two sites, Laguna Lake (located east of Metro Manila) and Southern Palawan (in the southwest of the country, between the South China Sea and the Sulu Sea), the studies sought to provide inputs into local development planning by articulating the environmental and economic consequences of different land use trade-offs, and helping to identify strategies for managing competing claims on natural resources. In Lake Laguna, the key concern was the management of the broader watershed to maintain downstream water quality, fisheries production and flood mitigation services. In Southern Palawan a number of alternative development paths and demands over land and resources involving the expansion of tourism, mining and industrial agriculture were considered, especially in relation to needs of local indigenous groups. At

...*contd. overleaf*

Which methods were used?

The studies followed the System of Environmental-Economic Accounting (SEEA) developed by the United Nations Statistics Division. This provides a framework for producing internationally comparable statistics on the environment and its relationship with the economy, following a similar accounting structure to the System of National Accounts that is used in most countries of the world (including the Philippines) to measure national economic activity.

Having selected the two pilot sites, scoping visits were made to determine which ecosystem services to include in the accounts. One requirement was to be able to generate the information needed to address key development challenges and environmental trade-offs. Practical considerations such as the availability of data and statistics were also important.

Following SEEA technical guidelines, a hierarchy of spatial, physical and economic accounts were constructed, looking at the extent of ecosystems, their condition and changes over time, as well as the stock, flow and use of ecosystem services. The Lake Laguna ecosystem account provided information on flood mitigation capacity, water quality and supply and fisheries resource management. In Southern Palawan land, forest and carbon accounts were developed at various levels of scale, alongside ecosystem service condition, supply, use and asset accounts. A number of scenarios were modelled for each site, based on two period assessments and reflecting alternative development paths (for example the expansion of cash crops and mining in Southern Palawan, and increasing urbanisation around Lake Laguna), their effects on ecosystem services (for example changes in waterflow and quality, flood protection or fisheries productivity) and impacts on ecosystem accounts.

Existing data turn out insufficient

Environmental-economic accounting systems are usually based on existing data. Although both studies depended heavily on already-available statistics and secondary sources (for example satellite imagery and land cover data, hydrological and meteorological records, reports on resource use and users), it was soon found that these were not sufficient. Certain key information was not available. In addition, existing statistical collection methodologies were not always consistent with SEEA requirements, meaning that not all of the available data was actually useable. It was therefore also necessary to carry out some primary data collection, for example fisheries surveys were carried out at both sites, and

Case study 27

Philippines

...contd.

a broader level, the results of the ecosystem accounting exercises were intended to feed into government strategies being considered in the next Philippine Development Plan.

Which methods were used?

consultations with farmers in Southern Palawan provided information on water needs and availability for different crops.

The process of constructing ecosystem accounts took several years, and was guided by multi-agency national and local Technical Working Groups. At the site level, data collection and analysis was led by the Laguna Lake Development Authority and, in Southern Palawan, the Provincial Environment and Natural Resources Office and the Palawan Council for Sustainable Development. National government agencies (such as the National Economic and Development Authority, Department of Environment and Natural Resources and Philippine Statistics Authority) played a key technical and facilitating role. As ecosystem accounting is a relatively new technical area which requires a specialised skillset, additional support was provided by national consultants, the World Bank and international experts.

How were the results disseminated and what was their impact?

The studies yielded a number of important findings for decision-makers. In Laguna Lake, the study showed that land conversion due to urban sprawl and industrial development is causing a decline in forest cover, which is in turn impacting on soil erosion, downstream flooding, declining water quality and reduced fisheries production. This provided information to assist in identifying priority areas for habitat protection, pollution regulation and erosion control, as well as inputting into water pricing and sustainable urban and industrial development planning. In Southern Palawan, it was found that even though forest cover has been restored over recent years, changes in land use are threatening water supplies and irrigated crop production, while the dramatic decline in mangroves and coral reefs that has occurred has implications for coastal protection, fisheries and tourism prospects. Various policy recommendations were drawn relating to the management of competing land and resource demands between protected areas, indigenous communities and industrial activities such as mining and commercial cash crops.

Study detects decline in mangroves and coral reefs

Case study 27

Philippines

Wealth Accounting and the Valuation of Ecosystem Services (WAVES) is a World Bank-led global partnership that aims to promote sustainable development by ensuring that natural resources are mainstreamed in development planning and national economic accounts. It currently operates in 8 core implementing countries in Africa, Asia and Latin America. WAVES also partners with UN agencies – UNEP, UNDP, and the UN Statistical Commission – that are helping to implement natural capital accounting. WAVES is funded by a multi-donor trust fund resourced by Denmark, the European Commission, France, Germany, Japan, The Netherlands, Norway, Switzerland, and the United Kingdom. In the Philippines, the lead government agency for WAVES activities is the National Economic and Development Authority (NEDA), assisted by a steering committee composed of representatives from the Department of Budget and Management (DBM) – designated as vice-chair; Department of Finance (DOF); Department of Environment and Natural Resources (DENR); Department of Agriculture (DA); Philippine Statistics Authority (PSA); Climate Change Commission (CCC); Office of the Presidential Adviser on Environmental Protection (OPAEP); and the Union of Local Authorities of the Philippines (ULAP).

For further information see https://www.wavespartnership.org/en/philippines

How were the results disseminated and what was their impact?

This information was shared through detailed technical reports and short policy briefs, as well as via a series of policy dialogues, stakeholder consultations and workshops at both site and national levels. The results of the studies were also presented to the various component bureaux of the Department of Environment and Natural Resources Presented, explaining both the methodology and the policy conclusions. Decision-makers were for the most part interested in and convinced by the findings of the ecosystem accounting exercises, at least towards the latter part of the exercise. It did however take some time for key stakeholders to become fully engaged, and to understand the new approach of ecosystem accounting.

One of the main factors that contributed towards this support and interest from decision-makers was that key government agencies had been directly involved in the study. At the national level, the Department of Environment and Natural Resources, National Economic and Development Authority and Philippine Statistical Authority participated in technical activities. This fostered a sense of ownership and a stake in the process which was particularly important to institutionalising ecosystem valuation and accounting approaches (it is these agencies that are responsible for environmental and economic planning, and for the generation and analysis of development statistics). Similarly, at the site level, the participation of Laguna Lake Development Authority and the Palawan Council for Sustainable Development has proved instrumental in the study findings being taken up at a policy level. In addition, the fact that the studies were explicitly targeted towards addressing real-world environmental and economic issues that key stakeholders considered a priority (and were mandated to deal with), and offered a concrete methodology for doing this, meant that decision-makers and planners were for the most part very receptive.

The studies have already had a number of impacts on planning and policy-making. Laguna Lake Development Authority continues to use these approaches to inform planning decisions – one example is the use of ecosystem accounting results to measure the performance of local government, via institutional and water quality scorecards. A Province-wide ecosystem accounting exercise is being considered in Palawan, and there are plans to scale up the pilot case study approaches across other sites and to the national level. An ecosystems accounting task force has been created within the Department of Environment and Natural Resources, and the Philippine Statistical Authority has set up an environmental and natural resources accounting division. The National Economic and Development Authority is currently weighing up the possibility of institutionalising the ecosystem accounts methodology.

Case study 27

Philippines

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What are the key insights and lessons learned on valuing EbA-relevant benefits?

One of the most insights from the Philippines ecosystem accounting experience is the importance of engaging stakeholders from the start. The local and national government agencies responsible for economic and environmental planning and decision-making took a technical and administrative lead in the accounting exercises. This meant that they were closely tailored to addressing real-world decision-making priorities. It also resulted in decision-makers having a clear understanding and sense of ownership of what the findings meant and how they had been generated. These aspects of credibility, legitimacy and relevance are key to policy-uptake and influence, and require strong government ownership and a robust participatory and consultative process.

A second important lesson is the importance of allowing sufficient time to develop the capacities, processes and data required to introduce a novel approach such as ecosystem accounting. Capacity-building formed a cross-cutting and continuous theme throughout the project, and was required to create a permanent capability to undertake ecosystem accounting. New protocols and systems for data collection, analysis and sharing also had to be created. The process of institutionalising approaches was however slow – both in terms of establishing the responsibilities and capacities to continue to undertake ecosystem accounting, and in mainstreaming its additional activity and staffing costs into existing budgets.

Capacity-building throughout the project

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Portugal

Case study 28

Cost-benefit analysis of coastal protection interventions to safeguard ecosystem services in Portugal

This case study adopts a spatially-explicit approach that allows for both the physical and financial-economic assessment of coastal protection investments options at the local scale in Central Portugal. This uses a shoreline evolution model is used in combination with a benefits transfer approach for the valuation of coastal ecosystems to assess the costs and benefits of a wide range of types, locations and combinations of coastal protection investment options. The aim was to make the case that it is worthwhile to undertake investments to protect natural, as well as settled, coastal areas.

EbA valuation

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What was being measured, and why?

This study was carried out to assess the costs of past coastal erosion and the potential benefits of future coastal protection interventions along the stretch of coastline between between Porto and Nazaré in central Portugal. Coastal erosion in this area mainly results from sea-level rise, increasing storm surge frequencies, reduced sediment delivery to the coast and human-induced modifications of natural coastal areas. Addressing these impacts therefore forms a key part of adapting to climate change.

To date, most investments in coastal protection have targeted strategic protection, emergency interventions and rehabilitation works for urban territory protection. The study aimed to make the case that it would also be worthwhile to extent this protection to natural areas along Central Portugal's coastline, given the important ecosystem service values they provide. In addition, it sought to contribute towards the goals of the larger project under which it was carried out ("Mitigation of Spatial Relevant Risks in European Regions and Towns"): to generate knowledge, experiences and lessons learned on risk mitigation in spatial policies that could be shared with other EU member states and beyond.

Which methods were used?

The study involved an interdisciplinary team of civil engineers, environmental economists and geographers, working together as an integrated team. This reflected the integrated, spatially-explicit approach that allowed for both the physical and financial-economic assessment of coastal protection investments options at the local scale.The first stage in the study was to estimate how ecosystem values had been impacted over time by coastal erosion. This was done based on historical coastal land use maps (to determine historical land use losses) and benefit transfer techniques (to value coastal ecosystem services).

Shoreline evolution model demonstrates future land use loss

Next, the study involved identifying and analysing of the costs and benefits of a wide range of types, locations and combinations of coastal protection investment options. The shoreline evolution model LTC (Long-Term Configuration) was used to assess future erosion-related land use losses as a function of coastal protection interventions. As in the previous stage, the use of benefit transfer techniques allowed for the valuation of coastal ecosystem services as well as investment.

Cost-benefit analysis was then used to compare the costs and benefits of a number of different protection options. These included groynes, longitudinal revetments and artificial nourishments, constructed in addition to existing coastal protection interventions. Both physical measures of the effectiveness of different measures in halting erosion (area of land losses avoided), and financial-economic measures of the return on investment (net present value and internal rate of return) were calculated and compared. The cost-benefit analysis was performed relative to the base situation, meaning that costs related to establishment and maintenance of extended or new coastal defence interventions, while the benefits related to the ecosystem service values from the area not (yet) lost due to these interventions. This yielded measures of the net present value and internal rate of return of each intervention option being considered.

Case study 28

Portugal

What were the findings?

The study found that the value of coastal ecosystems in the study area had declined over the last 30 years, from about 290 m€/year in 1975 to under 245 m€/year in 2006. The cumulative loss over this period amounts to more than 1 billion €. Nearly 10 per cent of these losses (3.5 m€/year or 80 m€ in total) were due to coastal erosion.

Longitudianal revetments: effective and safe investments

Meanwhile, from a physical perspective, it was shown that all of the coastal protection interventions assessed would lead to reduced erosion and land losses. Longitudinal revetments and artificial nourishments were the most effective in biophysical terms. From a financial and economic perspective, the construction of new groynes was not found to be attractive, while artificial nourishments, the extension of existing groynes and (especially) the construction of longitudinal revetments provided positive returns to investment.

EbA valuation case studies

Case study 28

Portugal

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Saint Lucia

Case study 29

Cost-benefit analysis of the adaptation benefits of climate-proofing community infrastructure in Saint Lucia

This case study describes efforts to value the adaptation benefits arising from climate-proofing a community centre in Saint Lucia. A cost-benefit analysis was carried out which looked both at the direct costs of retrofitting and the foregone damage costs and various other social and environmental benefits. The aim was to show how economic analysis can be used to guide decision-making, as well as to convince policy makers that investments in adaptation can be worthwhile.

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What was being measured, and why?

This study was carried out to assess the costs and benefits of carrying out works to climate-proof a community centre in Saint Lucia. This involved upgrading structural aspects so that the building could withstand hurricanes, as well as adding other facilities and features which aimed to reduce community vulnerability and enhance adaptive capacity.

The study aimed to set out the practical application of cost-benefit analysis to help clarify and guide decision making within highly climate vulnerable countries of the Caribbean to build resilience, both economically and socially, and to cope with the impacts of climate change. Specifically, it was hoped that the application of cost-benefit analysis to adaptation interventions would convince policy makers that the investment in such options can be worthwhile.

Which methods were used?

The intervention that was being assessed was a retrofitting of the Marchand Community Centre to withstand categories four and five hurricanes. Additional features to enhance adaption were also added, including rainwater harvesting and water storage capacities, water conservation technologies, solar energy generation and food and emergency items storage. The costs and benefits associated with the climate-proofed building were compared with a 'do nothing' scenario where no emergency shelter was in place to protect community members against hurricane impacts, and the continued dilapidation of the centre would hinder community activities.

Most data were retreived from secondary sources

The study was carried out as part of a broader project to use cost-benefit analysis to assess climate adaptation interventions in the Caribbean region (case studies were also carried out in other parts of Saint Lucia, as well as St. Vincent and the Grenadines and the Commonwealth of Domenica). It followed a five step approach that was common to all the case studies: examining the adaptation objectives, reviewing the 'without intervention' baseline, quantifying and aggregating the costs, quantifying and aggregating the benefits, and calculating net benefits. The analysis relied primarily on secondary sources, although some primary data was gathered via observations and interviews. Secondary data was obtained from various project documents, accounting records, previous surveys and studies, journals articles and other published reports and statistics.

Retrofitting the community centre and establishing associated hybrid rainwater, sewerage and irrigation systems would incur additional design, building, outfitting and maintenance costs. These were calculated at existing market prices.

Various benefits were calculated. Implementation of climate-proofing would result in significant reductions in health, mortality and other social costs, as well as providing a model for replication elsewhere in Saint Lucia and the Caribbean. These were estimated by looking at the frequency and impact of different classes of hurricanes in Saint Lucia, and the damages that these gave rise to. Benefit transfer techniques were then applied to calculate avoided losses due to hurricane winds, using secondary informa-

Case study 29

Saint Lucia

tion from reports of the United Nations Economic Commission for Latin America and the Caribbean (UNECLAC).The electricity generated by the solar system was valued at 70 per cent of the market value of a unit of electricity in Saint Lucia. The benefit of housing and storage was estimated as the expenditures forgone in not having to rent that space, costed at local rental prices. Rainwater harvests were valued at the going water rate charged by the Water & Sewerage Company to government buildings. The new building code developed and demonstrated for this project was assumed to have far-reaching benefits, and a rate of 50 per cent of estimated cost for damages associated with the earlier Hurricane Dean was used to value the avoided loss in building infrastructure after a hurricane if the new building code is adapted by schools, hospitals, other public buildings, businesses and private individuals on the island.

Water rate charged to government used as basis for valuation

The analysis combined cost and benefit information, projected into the future. Discount rates of 2%, 4.5% and 7%, were applied based on benchmark rates established for Saint Lucia by the Caribbean Community Climate Change Centre to reflect the social rate of time preference. Various scenarios for maintenance costs were also modelled. This provided lower bound, midpoint and upper bound estimates of the project's net present value (NPV), benefit cost ratio (BCR) and the internal rate of return (IRR).

What were the findings?

The analysis generated positive net present values for the project under all discount rate scenarios and maintenance regimes. The desirability of the project was however found to be sensitive to the inclusion of the benefits associated with the wider effects of developing and demonstrating a new building code. When these values were excluded, the net present value became negative under all maintenance regimes.

Case study 29

Saint Lucia

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Samoa

Case study 30

Cost-benefit analysis of community-level coastal protection measures in Samoa

This case study carried out an economic assessment of a seawall and associated 'green' and 'soft' adaptation measures to protect a coastal village in Samoa against erosion and storm surges. Cost-benefit analysis techniques were used, looking at direct expenditures on constructing and maintaining the measures, and on avoided damages to land and infrastructure. The aim was to determine whether the adaptation intervention represented a worthwhile use of funds and should be scaled up elsewhere.

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What was being measured, and why?

This study was carried out to assess the economic benefits and impacts of a pilot adaptation project in Samoa, and in particular to measure the effectiveness of the investment. The project being evaluated consisted of a 'hard infrastructure' sea wall to protect a vulnerable coastal village against coastal erosion and sea surges, combined with a variety of 'soft' adaptation strategies which combine ecosystem-based interventions measures with capacity-building and governance measures.

The aim of the study was to assess whether the construction of the sea wall represented a worthwhile use of funds, and ascertain whether it would be justified to be scaled up elsewhere in Samoa. A secondary objective was to establish a methodology to evaluate the effectiveness of hard adaptation strategies such as the construction of sea walls. The intention was that the methodologies, lessons learnt and results would provide be a helpful tool for policy makers in future decision making processes.

Which methods were used?

The study followed a standard cost-benefit analysis framework. It measured the costs and benefits of a package of 'hard' and 'soft' adaptation options implemented in Tafitoala Village on the south coast of Upolu. Island. This aimed to protect lowland areas from extreme sea surges and coastal erosion, and compared them with a no project situation. The main adaption measure was a stone seawall, which was supplemented by the replanting of salt-tolerant coastal plants to create natural barriers along the coastline and reforestation of riparian buffers with community capacity-building, awareness-raising and formulation of water resource management laws.

The first step was to list all the project costs and benefits. On the cost side these included the capital and recurrent costs of building and maintaining the sea wall, as well as impacts of the sea ecosystem (with consequent impacts of fisheries) and alteration of long-shore drift patterns (affecting neighbouring villages). Of these, only the direct physical costs of construction and maintenance were quantified in monetary terms, based on actual data from the project and other projects. The lack of data, time and resources available to the study meant that it was not possible to carry out more complex valuation techniques.

A wide variety of project benefits were identified. These included avoided coastal erosion, which was measured by looking at the reduced levels of land and infrastructure loss. The expected coastal erosion area (in the absence of the project) was measured by comparing satellite images and aerial photos, and local land prices and asset values were applied to calculate the avoided damages. The reduced damages to infrastructure caused by cyclones and sea surges, along with reductions in associated clean-up costs, foregone income, lost revenues and decreased stress and trauma, were described in qualitative terms, but not valued. In addition, no attempt was made to measure the co-benefits and ecosystem service values associated with the revegetation of coastal and riverine areas.

Some parameters only receive qualitative description

The cost-benefit analysis then brought these figures together. Costs and benefits were modelled over a 25-year period (the assumed

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Samoa

Which methods were used?

lifespan of the seawall), and an eight per cent discount rate (as recommended by the Samoan Ministry of Finance was applied) to come up with estimates of the net present value and benefit:cost ratio for the project. In order to account for uncertainty, a sensitivity analysis was conducted. This was done in order to assess the robustness of the results and hence the confidence that can be placed in them for informing decision-making.

What were the findings?

The study indicated that the project was a worthwhile use of funds. It had a positive net present value of just under USD 400,000, and a benefit:cost ratio of 2.25. These results were however moderately sensitive to the price of land, and highly sensitive to the assumed future rate of coastal erosion.

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Case study 30

Samoa

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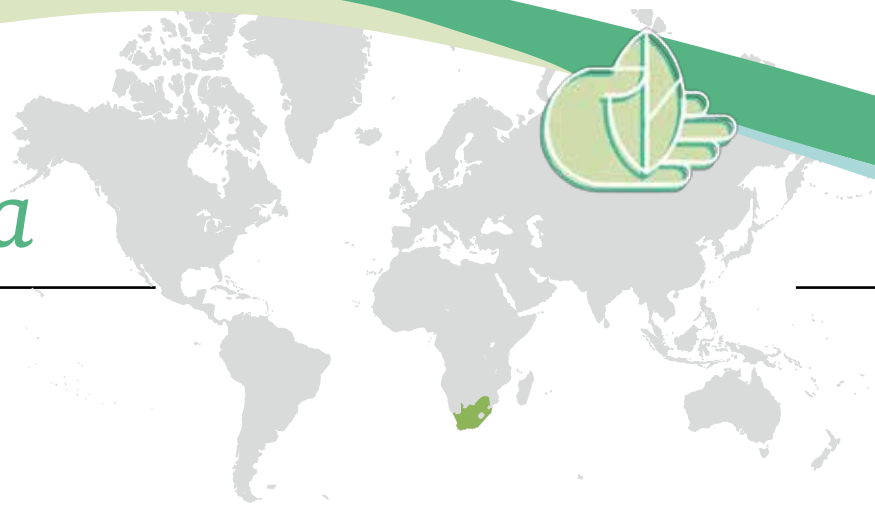

Assessment of the employment benefits of climate adaptation in South Africa

This case study describes work carried out to measure how climate change affects employment prospects in South Africa. This involved modelling both climate-related job losses and the employment-creation potential of climate adaptation and mitigation measures. The effects were modelled for major sectors of the economy, and at the national level. The intention was to better understand the labour impacts of climate change and climate-change responses, so as to guide the development of policy responses to sustain and enhance jobs.

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What was being measured, and why?

This case study reports on a study to measure how climate change would affect employment in key sectors of the South African economy, and to identify how adaptation measures contribute generate job-related benefits. It was carried out to inform the Government of South Africa on the labour impacts of climate change and climate-change responses, and to guide the development of policy responses to sustain and enhance jobs. The study also offers a methodology and data which can assist in monitoring and evaluating the national climate change programme.

The study represents an innovative approach to valuation and impact assessment. It attempts to move beyond the conventional emphasis on monetary cost-benefit measures, and instead looks at broader indicators of economic impact and performance which have a significance influence on people's social and economic wellbeing. The issue of policy relevance is also key. The focus on job impacts was chosen because employment is a major priority in South Africa's development and economic policy, and is considered to be a particularly critical vulnerability that could be severely worsened by climate change. One of the key goals of the National Climate Change Response is to reduce the impact of job losses and promote

...contd. overleaf

Which methods were used?

The study had two parts. First, a national employment vulnerability assessment was carried out. This looked at the likely impact of climate change on jobs in key sectors of the economy and at the national level. It considered both direct and indirect, and positive and negative, effects. For example, the study investigated how projected reductions in farming possibilities or declines in coal mining and steel production might lead to job losses, as well as how adaptation and mitigation actions could result in employment creation.

The national employment vulnerability assessment model depended entirely on existing work and secondary information sources. The focus was on reinterpreting and reanalysing these data to calculate climate-related employment costs and benefits. For example, a mitigation potential analysis had been carried out the year before which involved modelling job creation prospects, and detailed studies were already available on climate impacts in key sectors such as agricultural, water and mining. In order to assess the employment effects of adaptation measures, the study used job indicators based on projected costs, and translated this into an average number of jobs per unit of spending. For instance, in the case of ecosystem-based adaptation measures, it was possible to look at past and current biodiversity-related interventions (such as the Working for Water and Working for Ecosystems Programmes). Recent work by the Development Bank of South Africa on the potential for the green economy to create jobs also provided a source of data.

Job creation prospects had been modelled before

The main output of this first stage of the study was estimates of the numbers and types of jobs created and lost in different sectors and at the national level as a result of climate change and climate change responses. The broader linkages within the economy were also analysed. Indices of vulnerability were also generated, which measured the severity of these different effects and showed which kinds of jobs would be affected and for whom.

The study did not however stop at generating numbers. It also sought to inform the development of policy responses. Having identified which sectors or sub-sectors needed special attention, the next stage focused on informing the development of Sector Job Resilience Plans. These are public sector programmes which aim to incentivise employment creation for sectors that are most vulner-

Case study 31

South Africa

...contd.

job creation, for example through using adaptation actions to new jobs to which workers can migrate from affected sectors. Job creation and loss is also one of the core indicators in the national climate change monitoring and evaluation system.

Which methods were used?

able to climate change, and to support the creation of sustainable investments and jobs. Based on the information yielded from the vulnerability assessment on potential gainers and losers (both from climate change impacts, and from the measures that might be used to mitigate and adapt to them), the study now focused on policy responses to enable affected workers to shift jobs. It investigated mechanisms for enhancing the job-creation potential of adaptation and mitigation interventions.

The work was led by the Department of Environmental Affairs (DEA) in partnership with the Economic Development Department (the section of the South African government responsible for economic policy, planning and development). Technical support was provided by a multidisciplinary team of national consultants, consisting of economists and climate change experts. The study was carried out over the course of a year.

How were the results disseminated and what was their impact?

The key findings of the study were that climate change is likely to give rise to significant employment effects in the South African economy, particularly affecting agriculture, coal mining, water, electricity and gas sectors. While these outcomes were not unexpected, the value of the study was that it provided concrete figures and 'hard' evidence. It also provided a more nuanced understanding of these job impacts (for example, that grape-growing showed a much higher vulnerability than other agricultural sub-sectors, or that changes in crop-growing potential would have further, knock-on effects on the consumption of fertilisers and other agro-chemicals).

Climate change may have considerable employment effects

The data also showed that adaptation measures would likely have positive consequences for employment. The anticipated contribution of ecosystem-based approaches was identified to be particularly high, both in terms of the number of jobs created and in their potential to absorb unskilled or rural workers who might be displaced through climate-change impacts on farming and mining.

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This study was carried out as part of the Climate Support Programme, funded by the German Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety (BMUB) under the International Climate Initiative (IKI), and carried out in partnership between GIZ and the South African Department of Environmental Affairs (DEA). This programme supports the government of South Africa in implementing its national climate policy and playing a leading role in international climate negotiations.

For further information see https://www.giz.de/en/worldwide/17807.html

How were the results disseminated and what was their impact?

The findings have so far been presented only as a written report, aiming to provide information to the Department of Environmental Affairs and Economic Development Department that can be used in wider discussions with other decision-makers from affected sectors, including representatives from trade unions, companies and businesses. A series of multi-stakeholder forums are planned to share these findings. At the time of compiling this case study, the draft report had only just been released, and the process of dissemination had only just commenced.

What are the key insights and lessons learned on valuing EbA-relevant benefits?

One key lesson learned from the study was that the process of design, data collection and analysis often takes much longer than planned. The topic it addressed represented a completely new area of study in South Africa, for which no prior methodology or case history existed. The process of coming up with a methodology and set of indicators that were technically sound, relevant and credible to decision-makers, and could be accomplished on the basis of existing data, was not an easy one. In particular, early parts of the study required lengthy discussions about what the study focus would be, and how the study should be carried out.

Study covered an innovative area of expertise in RSA

Another important realisation was that information on the employment effects of adaptation measures is still patchy and partial. Adaptation plans are only in the early stages of being initiated. It will probably be necessary to update the study once these programmes and projects have progressed further, and have generated more on-the-ground data.

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Bibliography

This case study is based on information provided by **Hugo Van Zyl** (Director and Lead Consultant, Independent Economic Researchers).

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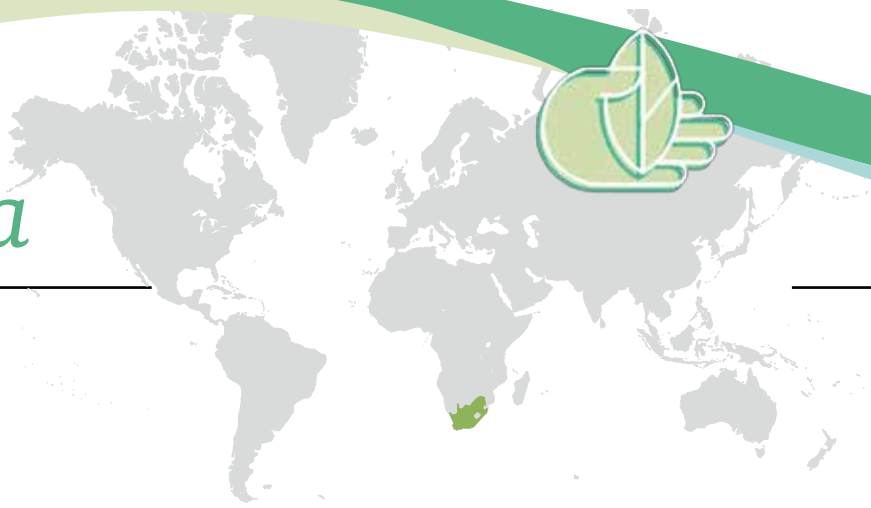

Cost-effectiveness analysis to value rangeland rehabilitation measures in Namaqualand, South Africa

This case study describes efforts to assess the relative desirability of rangeland rehabilitation as compared to other grey and hybrid adaptation measures to control erosion an floods in South Africa. It aimed to provide an evidence base which could be used to make the case to support the implementation of ecosystem-based adaptation strategies. Cost-effectiveness analysis was used to value the different adaptation measures in terms of their impacts on rangeland productivity, livestock production and damages to road infrastructure.

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What was being measured, and why?

This study was carried out to assess the cost-effectiveness of climate adaptation measures based on undertaking rangeland rehabilitation for erosion control in Namaqualand, South Africa. This sought to address two notable climate change vulnerabilities in the local municipalities: the detrimental impact of floods and soil erosion on road infrastruct-ure, and a reduction in rangeland productivity and thus livestock production.

The study compared three packages of adaptation measures combining different combinations of green and grey options with a continuation of the status quo. The basic aim was to provide an evidence base which could be used to make the case to support the implementation of ecosystem-based adaptation strategies.

Which methods were used?

The three adaptation options considered were an engineering scenario (all roads would be upgraded, but fodder assistance would continue to be provided to livestock), EbA scenario (a quarter of rangelands were rehabilitated) and a hybrid scenario (fifty percent of roads would be upgraded and fifty per cent of rangelands would be rehabilitated). The continuation of the status quo reflected existing infrastructure and fodder assistance.

Less erosion — less cost for road construction and maintencance

Each scenario implied differential levels of costs for road construction and maintenance, rehabilitation maintenance, as well as the provision of fodder assistance to livestock. Under the EbA and hybrid scenarios, road maintenance costs would decline due to a reduction in erosion and flooding, fodder assistance would reduce or become unnecessary, livestock productivity would increase as a result of improved water availability and plant cover, and ecotourism co-benefits would be generated. The engineering scenario would see opposite trends, with increases in road maintenance and fodder assistance costs, coupled with reduced livestock productivity. The cost effectiveness analysis came up with net present value (NPV) estimates as well as least-cost indicators.

The study was based primarily on secondary data, sourced from consult-ing technical heads of local municipalities, experts of related fields, and the available documentation and literature. It was carried out by an expert consultant on behalf of *Conservation South Africa*.

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What were the findings?

The study found that none of the adaptation options were cost-effective. All of the scenarios considered returned negative net present values with benefit:cost ratios of less than one. The lowest cost option was a continuation of the status quo, while the full ecosystem-based adaptation option was the most expensive. Despite these results, the study recommended that investments should be made in the hybrid scenario, or some variation of it, to address both the ecological and socio-economic needs of the study area. Livestock is of key importance to Namaqualand's local economy, and the biodiversity in the area is globally significant. Any further decline in these important assets will incur considerable costs to repair, underlining the importance of taking proactive steps to curb land degradation before it progresses and is intensified under conditions of future climate change. A key message from the study is that even when adaptation is not cost-effective, and EbA is the more expensive than grey options, there is still a broader social, economic and environmental justification for taking action.

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Sudan

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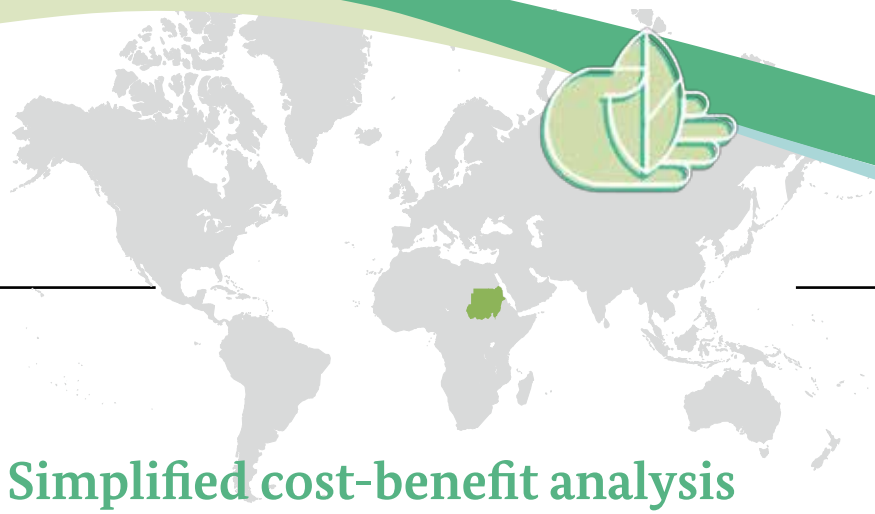

Simplified cost-benefit analysis techniques to evaluate drought-related disaster risk reduction measures in Sudan

This case study measured the costs, benefits and impacts of drought-related disaster risk reduction measures in Sudan. Simplified, rapid cost-benefit techniques were used to weigh up the physical costs and outputs from interventions, and show their relative return on investment. Quantitative and qualitative community-based indicators of resilience were also developed. The aim was to evaluate the site-specific effects as well as to contribute towards global efforts to improve disaster risk reduction performance measurement and impact analysis.

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What was being measured, and why?

This study was carried out to assess the economic efficiency and community resilience impacts of drought-related disaster risk reduction measures undertaken in Sudan's Red Sea State. It involved a qualitative examination of intervention impacts, monetary cost-benefit analyses and the development of community-based indicators of resilience. Together, these three tools can provide a relatively holistic and balanced picture of the local-level effects and performance of disaster risk reduction measures.

The study aimed to generate project-specific information on qualitative and quantitative aspects of the extent to which a given set of disaster risk reduction interventions had contributed towards reducing the vulnerability of the indigenous nomadic Beja pastoralist community to recurrent droughts, and had assisted in building their resilience to disasters by protecting community assets. At a more global level, it was also intended to contribute to an effort across the International Federation of Red Cross and Red Crescent Societies (IFRC) to improve disaster risk reduction performance measurement and impact analysis.

Which methods were used?

The study considered a variety of disaster risk reduction measures that had been implemented in Red Sea State. These included handpumps, wells, underground rain water storage reservoirs (hafirs), earth dams, embankments and terraces, as well as 'soft' measures such as agricultural livelihood diversification, construction of classrooms and health centres, support to education and women's centres. This study had three stages or components. The first observed the impact of the interventions undertaken, the second attempted to undertake a cost benefit analysis to determine whether the interventions undertaken were economically efficient, and the third determined community based indicators of resilience by engaging with local beneficiaries.

First of all, the impacts of the interventions were assessed by conducting field visits involving observations, key informant interviews and focus group discussions. Then, simple cost-benefit analyses were carried out, relying data that were readily-available at the local level or from secondary sources. These involved comparing the effects of drought hazards on the community under 'with project" and 'without project' situations.

Mainly because of data constraints, it was however only possible to do a cost-benefit analysis of four interventions: terraces, earth dams and embankments, community vegetable gardens and hafirs. The direct physical costs of constructing and maintaining the measure as well as the material benefits and damages avoided were calculated. These included, for example, increased income and reduced food and medical expenditures arising from enhanced and more secure crop production, time and cost savings permitted by more accessible water sources, increased herd productivity and reduced mortality resulting from new livestock watering points. Each calculation generated a benefit-cost ratio, showing the amount of benefits that had been generated for each unit of expenditure made.

Five indicators to measure community resilience

The study team also identified, through consultations and dialogues with the beneficiary population, five context-specific indicators of community resilience which could be measured through either quantitative or qualitative means. The first indicator selected, terms of trade, was measured via the ratio of sale of livestock to purchase of cereal grain. The second, involuntary slaughter of animals, was measured against a reference point of no slaughter of animals apart

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Which methods were used?

from social and religious occasions. The third and fourth quantitative indicators were rates of household migration to urban centres and the ratio of the casual labour wage rate to cereal purchase price. The fifth indicator, ability to meet social obligations, was purely qualitative.

What were the findings?

The cost benefit analysis provided ample economic justification for the disaster risk reduction interventions studied. It indicated that these measures were economically efficient, with benefit to cost ratios of 2 or more. This provided a quantitative, monetary metric that had previously been lacking to judge the success and impact of disaster risk reduction interventions.

Study showed how ownership of the results is essential

The study also showed the importance of incorporating community perceptions and ownership of the results. By developing context-specific indicators of community resilience, it offered a means of representing local needs, aspirations and goals in the project design and evaluation process. The community-based indicators allowed for local-level perceptions of costs and benefits to be weighed up against those used by project developers and implementers in cost-benefit analysis calculations.

The study also revealed the difficulties of comparing cost efficiency between different disaster risk reduction measures. This is a particular challenge in integrated multi-sectoral programming, because individual measures are designed to work together, in tandem, towards the overarching goals of reduced vulnerability and improved resilience. It is much easier (and in most cases more useful) to measure the cost efficiency of the whole package of interventions.

Despite the advances made in measuring and quantifying the costs and benefits of disaster risk reduction interventions, the study was unable to quantify most social impacts. This is because social benefits typically have a non-tangible nature, and are often transmitted outside of the direct beneficiary community. This makes it difficult

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to track their effects and economic value. For example, as is often the case with rural communities, Beja pastoralists rely heavily on social obligations and kinship networks for their survival, especially in times of stress and emergency. Many respondents suggested that their ability to draw on social obligations was the fundamental determinant of their ability to prepare for and cope with risk and disasters.

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As at
December 2017

Tanzania, Indonesia

Case study 34

Technical suitability and physical impact assessment of community-level flood adaptation measures in Tanzania and Indonesia

This case study describes a study carried out to measure the technical suitability and physical effectiveness of community-initiated flood adaptation interventions in informal urban settlements in Tanzania and Indonesia. The methodology combined qualitative and quantitative techniques to investigate and measure the extent to which adaptation measures conformed to engineering standards, and were effective in protecting against flood impacts.

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What was being measured, and why?

This study was carried out to assessing and comparing the technical suitability of adaptation strategies to flooding in the informal settlements of Surakarta, Indonesia and Dar es Salaam, Tanzania. This was because many informal settlements in Indonesia and Tanzania (as in other developing countries) are located in high risk areas (for example deep gullies, river banks and low-lying lands such as floodplains and wetlands). An approach combining dialogue, observation and physical measurements was employed to gauge the physical effectiveness and benefits of different flood adaptation interventions undertaken by communities themselves.

The aim of the study was to provide an answer to why the vulnerability of people and properties in informal settlements is increasing, even though residents have taken to the use of various structural adaptation strategies as a means of reducing impacts of flooding. By doing this, it sought to make recommendations and enhance awareness amongst residents, public organisations and government agencies about viable options for mitigating flood-related risks and improving adaptation strategies in urban informal settlements. Another important aspect that that study sought to fill a key information gap: the dearth of technical information on the physical benefits of flood adaptation strategies in informal settlements.

Which methods were used?

The study sought to answer four basic questions, namely: Are there adaptation strategies at household level? Are adaptation strategies employed by households technically suitable? What factors contribute to technical suitability not being achieved? How do different adaptation strategies compare in terms of relevance to flood risk reduction? And how might adaptation strategies in flood-prone urban informal settlements be improved?

First of all, the study sites were selected in each city. Five criteria were developed in order to identify and select cases that were suitable for conducting the study. These were: existence of informal housing development, settlements traversed by rivers, settlements that experienced the problem of intensified flooding over time, residents who demonstrated effective responses for containing flooding and settlements which needed critical intervention in terms of flood control measures. Then the sample of households to be surveyed was determined using qualitative procedures, which were then checked with a mathematical formula designed to establish whether or not the determined sample size was adequate and representative. This resulted in a sample size of 70 households in each study site.

Formula helps determine adequate size of samples

The study was based mainly on qualitative assessment methods. These included household interviews, mapping, physical observations (involving visual inspections for signs of damage and deterioration such as cracks and dampness), photographing and in-depth interviews with selected respondents. Household interviews were held with flood victims to identify which adaptation strategies were being used, as well as to establish whether or not technical factors (for example the use of experts, flood damage-resistant materials, standard measurements and proper maintenance) had been incorporated into the design and implementation of the flood protection structures. The only quantitative assessment technique was to take simple measurements of the structural height of retaining walls, plinths, raised pit-latrines, raised foundations and raised stairs.

The study identified a number of adaptation strategies that local residents had chosen to apply to protect against flooding, comprising both structural and non-structural measures. These included the use of sandbags, protective walls, raised foundations and stairs, placing properties over blocks or raised plinths, use if water-resistant materials, elevated pit latrines, boiling and chemical treatment

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Tanzania, Indonesia

Which methods were used?

of drinking water, seasonal migration, the use of manual drainage and outlet pipes. Various verbal, visual and written information was collected about these different adaptation strategies and how they had been undertaken.

Measurements of the structural height of flood control structures were taken for retaining walls, plinths, raised pit-latrines, raised foundations and raised stairs. The technical suitability of these different adaptation strategies to protect against flooding was then assessed – in other words the extent to which they met formal engineering criteria. This was measured via a series of indicators of biophysical effectiveness and benefit, including the use of experts or professionals in design and construction, use of flood damage-resistant building materials, use of standard measurements (such as height in relation to base flood elevation) and proper maintenance.

What were the findings?

The study found that in both sites, flood mitigation and risk minimisation interventions through structural adaptation strategies were ineffective in technical terms. The measures were constructed with little or no attention to acceptable technical considerations. There was limited or no use of experts for structural design, and the choice of building materials and construction techniques did not meet basic flood control specifications.

Financial constraints were identified to be a major factor contributing to this situation. The decisions made by flood victims to employ adaptation measures of different standards depend on their level of income and the construction cost. With limited financial resources, priority is normally given to other, more immediate needs, such as food, education and health. For most people in informal settlements, little money remains for investing in flood control infrastructure.

In addition, at the institutional and capacity level, both countries face critical shortages of trained workers on disaster issues. Local bodies or committees for disaster management – where they exist – were generally not adequately equipped to deal with either preventing or dealing with the effects of flooding and other extreme weather events. Consequently, flood victims did not get sufficient

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Tanzania, Indonesia

help and guidance in dealing with flooding situations nor did they receive guidance and education about the most effective adaptation strategies.

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Thailand

Case study 35

Biophysical and economic evaluation of climate adaptation options in Thailand's watersheds

This case study describes biophysical-economic evaluations of climate adaptation options at the watershed level in two of Thailand's key river basins. The focus was on assessing the potential of ecosystem-based approaches to protect against extreme weather events, as compared to conventional 'grey' options. The aim was to support local water planners and national decision-makers to design and implement effective measures for the prevention of flooding and drought in the face of climate change.

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What was being measured, and why?

This sheet reports on studies to assess the biophysical and economic value of alternative climate adaptation measures in two key watersheds in Thailand: the Huai Sai Bat River sub-basin in Khon Kaen Province and Tha Di basin in Nakhon Si Thammarat Province. The proposed interventions aimed to minimise the effects of extreme weather events such as floods, low river flows and droughts. Various ecosystem-based approaches were considered, including the management of natural floodplains and wetlands as silt traps, living weirs, riparian zone conservation as well as erosion control and forest rehabilitation in upstream areas. These were compared with the grey measures specified in existing river basin and infrastructure plans, such as physical control structures and dredging.

The reason for carrying out the studies was that local water management institutions lacked technical capacity and innovative concepts to address extreme weather events in an effective, low-cost manner that can also generate broader benefits to society and the economy. Water-providing and regulating ecosystem services offer a set of untapped adaptation potentials which in many cases outperform more conventional grey engineering options in terms of both technical and economic performance.

...***contd. overleaf***

Which methods were used?

The studies had three, iterative, components: biophysical vulnerability analysis, scoping of engineering design options, and economic appraisal of costs and benefits. The vulnerability analysis looked at the biophysical characteristics of each basin (including land use, soil characteristics, natural ecosystems, meteorology, hydrology, water use, infrastructure, demography and existing water resources engineering). Using secondary data and field observations, it traced the proximate to the root causative factors behind the priority concerns to be addressed, and proposed options for potential policy interventions. Leading on from this, engineering design studies were carried out to preselect potential adaptation measures and locations across the whole river basin.

Economic evaluations then took up the identified EbA measures as well as the 'business as usual' grey engineering options that were already being implemented in the pilot river basins. In the Huai Sai Bat basin, water scarcity during the dry season was considered a major threat, and a comparison was made of natural floodplain and wetland-based sediment traps, riparian zone improvements and conventional dredging techniques. In the Tha Di basin the main challenges were flooding during the rainy season, water scarcity during the dry period and water quality deterioration due to human activities. Six different grey and green adaptation measures were considered, including living weirs, flood control with wetland development, constructed wetlands, riparian zone improvement, concrete weirs and a wastewater treatment plant.

Study considered six grey and green adaptation measures

Three economic appraisal techniques were used: least-cost analysis, cost-effectiveness analysis and cost-benefit analysis. First the direct investment and recurrent costs of each adaptation measure were calculated, using actual market prices. This enabled a least-cost analysis to be carried out which showed which intervention options were the cheapest to implement. Next, benefit data was computed, using a combination of market prices, effects on production and damages avoided valuation techniques. This looked at the benefits (or avoided damages) associated with each adaption option in terms of changes in water quality and supply as well as crop yields and income. The broader ecosystem service co-benefits from the selected EbA measures were also estimated, using benefit transfer techniques calculated for each hectare of wetlands and forests.

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...contd.

The studies sought to make the case to provincial and national decision-makers for investing in ecosystem-based adaptation options. The target audience included the Department of Water Resources and the Royal Irrigation Department, as well as farmers and the general public in the demonstration sites.

Which methods were used?

Various scenarios were developed, representing different combinations of ecosystem-based and grey engineering measures. A time horizon of 25 years was considered, and a discount rate of 3 per cent was applied to future cost and benefit streams. Cost-benefit analysis were carried out to indicate net present values and cost-benefit ratios, as well as show annual and overall costs avoided, and cost advantage per 1 m^3 of water (cost-effectiveness).

The vulnerability analyses and scoping of engineering design options took around six or seven months in each site, while the two economic appraisals were carried out together over a period of six months. Both involved international consultants, working with Thai and German Universities and technical counterparts from government partner agencies. A diverse range of expertise was involved, including economists, hydrologists, climate change experts, water planners, private sector, engineers, civil society.

How were the results disseminated and what was their impact?

The overarching finding of the studies was that a number of technically-feasible EbA options existed for each basin, which could help to address the identified needs to protect against extreme weather events, and which also made sense in economic terms. For example, in the Huai Sai Bat basin the overall costs for water storage could be reduced by up to 65%, and in the Thad Di basin EbA options displayed benefit:cost ratios over 25 years of between 2 to 6 as compared to 1.4 for a conventional waste water treatment plant.

Overall costs for water storage could be reduced by 65%

Results were shared through both Thai and English language reports and verbal briefings. Both national and regional events were organised to discuss and disseminate the study findings, involving an estimated 2,000 participants. As the study took place as part of a longer-term project, based within the Department of Water Resources and Royal Irrigation Department, there were also many opportunities to communicate and learn on a day-to-day basis, and to influence ongoing decision-making processes.

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The project "Improved management of extreme events through ecosystem-based adaption in watersheds (ECO-SWat)" is implemented by GIZ in partnership with the Department for Water Resources of Thailand. It is funded by the German Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety (BMUB) under the International Climate Initiative (IKI). The project operates in two pilot watersheds that are threatened by the impacts of climate change. To improve adaptive capacities in the two watersheds, the project advises experts from government bodies and universities on how to combine their knowledge, activities and sources of information. The involvement of the local population in stakeholder platforms ensures their inclusion in the process. The project is implementing innovative ecosystem-based adaptation approaches, complemented with training courses. Building on the experiences gained in the pilot watersheds, these approaches are being fed into national strategies and policies.

For further information see https://www.giz.de/en/worldwide/29951.html, http://ecoswat-thailand.com/

How were the results disseminated and what was their impact?

Initially, there was less interest in the findings of the cost-effectiveness analysis and cost-benefit analyses. Efforts were therefore made to make the results more relevant and applicable to decision-makers' priorities, mandates and concerns, by communicating the implications in terms of the effects of different adaptation options on water costs and on economic damages and losses. This also helped to foster a much greater sense of institutional ownership over the study findings in the Department of Water Resources.

The studies helped to convince decision-makers of the gains from investing in natural solutions, and the Royal Irrigation Department has now officially changed their strategy to accord a greater priority to EbA measures. Reviews are being undertaken of existing plans for grey engineering projects, with the aim of integrating green measures. However, at the regional level, water and infrastructure planning is still carried out based on grey measures. It will take time to extend and deliver this strategy, and to move from a policy statement to the level of actual implementation.

What are the key insights and lessons learned on valuing EbA-relevant benefits?

A key aspect of the studies was the fact that they were both iterative and integrated, and dealt with biophysical, engineering and economic aspects of adaptation planning and design. Each of these components fed information into the next stage of the process: for example the engineering design was based on the findings of the vulnerability assessments, while the cost-benefit analysis weighed up the economic implications of the different design options that had been proposed. This meant both that each stage of the integrated assessment was well-informed and well thought-through, and that the overall study was directly rooted in tangible solutions. As such, it was possible to present a strong and convincing case for EbA to decision-makers from different sectors and agencies. Often, evaluations of adaptation options look only at social, technical or economic feasibility and impacts, and remain largely hypothetical: they do not give this kind of holistic, practice-oriented picture.

Study could convince because it was rooted in tangible solutions

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Thailand

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This case study is based on information provided by **Roland Treitler** (Project Director, GIZ-ECOSWat) and presented in the following documents:

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What are the key insights and lessons learned on valuing EbA-relevant benefits?

Another important lesson concerned the need to tailor valuation approaches and methodologies to the practical purpose of the study, the context in which it is being carried out, and the decision (and decision-makers) that it aims to influence. This learning arose particularly in relation to the economic component of the study. The initial approach was based on prior experiences and applications in Germany, and focused on national measures of Gross Domestic Product (GDP). The on-the-ground conditions and priorities in rural Thailand however proved to be very different, demanding a set of approaches and indicators that were geared to the local context. Coming up with a meaningful, convincing approach and data required detailed expert consultation and dialogue at the community level.

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Uganda

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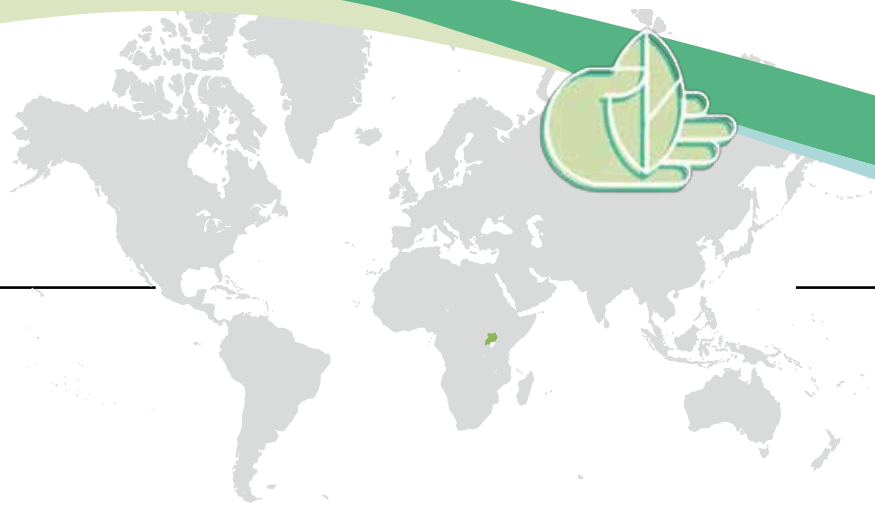

Cost-benefit analysis of farm-level adaptation measures in Uganda

This case study involved an economic assessment of different project options for farm-level adaption measures addressing crop production, livestock production and water management. It used standard cost-benefit analysis techniques. The aim was to assist in prioritising the interventions according to their relative economic viability and profitability under different climate futures.

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What was being measured, and why?

This study was carried out to appraise alternative farm-level adaptation options in Uganda, comprising various climate-smart measures and associated water management practices. This built on the findings of an earlier vulnerability assessment that had been carried out to identify potential adaptation options in Uganda's agriculture, water and the environment sectors. It carried out cost-benefit analyses to assess the net benefit and return on investment for these different measures. The aim was to assist in prioritising the interventions according to their relative economic viability and profitability under different climate futures.

Which methods were used?

The first stage of the analysis was to choose the adaptation options that would be subjected to economic anlaysis. These were selected according to a list of criteria relating to their relative costs, benefits, community acceptability and long-term applicability as well as data needs and availability. This yielded a list of nine priority interventions: cover crops, agroforestry and climate-smart agriculture for Coffea arabica, improved maize varieties, improved rice varieties, improved cassava varieties, improved beans varieties, zero grazing livestock production, water harvesting and low cost drip irrigation systems.

The methodology was based on a conventional financial cost-benefit analysis approach. It considered four climate/adaptation scenarios: without climate change or adaptation (the 'business-as-usual' baseline), with climate change and without adaptation, with climate change and adaptation, and without climate change but with adaptation. First of all, current and future costs and benefits were modelled for each of these scenarios. Next, these streams of costs and benefits were discounted to give present value estimates and benefit:cost ratios for each adaptation option under different scenarios. Finally, the findings were brought together and synthesised, and potential impacts of non-quantified costs and benefits were described.

Benefit:cost ratios for each option under different scenarios

For the crop and livestock interventions, estimates of baseline 'business-as-usual' costs and benefits were based on actual data on production, yields, prices and farm budgets. Climate change impacts on crop yields were taken from four climate models (CNRM, CSIRO, ECHAM and MIROC) for the A1B emissions scenario only. For livestock production, climate impacts were estimated based on information provided in other studies. The incremental impact of the new varieties or techniques introduced under the adaptation interventions on inputs, yields, costs and income were assumed based on field visits made under the study as well as secondary field trial and survey data. Data on the direct costs of implementing the specified adaptation intervention, including 'soft' measures (such as training), were taken from other projects as well as budgets constructed under the current study. For water harvesting, water was valued at market price, and additional value of time calculations were incorporated to account for improved access to a nearby water source.

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What were the findings?

Although all of the adaptation options assessed were profitable in the sense that the benefits generated outweighed the costs incurred, the study underlined that their economic viability varies both with and without climate change. Most of the interventions assessed were robust in the face of climate change, and many were shown to be both viable and profitable even under a continuation of current conditions. Improved varieties of maize and rice and, to a lesser extent, cassava showed particularly high benefit:cost ratios. Drip irrigation also returned a favourable result, with the added advantage of being able to combine with providing water during periods of drought.

Cassava shows particularly high benefit:cost ratio

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Uganda

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United Kingdom

Case study 37

Bayesian Belief network to assess the water quality and flood mitigation benefits of riparian buffer strips in the UK

This case study describes the application of a Bayesian Belief Network approach to assess the effectiveness of different riparian buffer strip management options in delivering water quality and flood risk mitigation services in the UK. The aim was to develop and demonstrate the ecosystem approach via a joint model which integrated biophysical and socioeconomic aspects, and was geared towards generating results that are of use to decision-making.

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What was being measured, and why?

This study developed an ecological-economic model based on the application of a Bayesian Belief Network to assess and value the delivery of water quality and flood risk mitigation services from riparian buffer strips. It was used to explore the effectiveness of different agricultural land management options at a regional scale in the East and West of England.

The study explicitly sought to respond to the complexities and interdependencies among components within and between ecosystems which make describing and quantifying their interactions a considerable challenge. It also recognised that there was a need for methods which recognised that policy decisions affecting any part of those interactions, be they economic or ecological, can cause changes across multiple services and ecosystems. By capturing the interactions underlying ecosystem processes and the delivery of services, the study attempted to demonstrate and further operationalise an ecosystem services approach within a joint model which integrated biophysical and socioeconomic aspects and was geared towards generating results that are of use to decision-making.

Which methods were used?

The study uses a Bayesian Belief Network approach, a graphical representation of a probabilistic dependency model which describes the probability of an outcome occurring by considering both the process that leads to that event and the state of information describing the process. It assigns subjective probabilities to express a degree of belief in events (and thus particular outcomes) occurring, thereby offering a framework into which decision-makers, beneficiaries or other stakeholders can input their knowledge, and assess the implications for the rest of the (linked) system.

In this study, the model was developed through a series of workshops held under the UK Valuing Nature Network, involving natural and economic scientists interested in identifying approaches for valuing the provision of ecosystem services across agricultural and aquatic ecosystems. These resulted in the choice to focus on water quality and flood risk mitigation as two high-profile services which are a particular concern of the European Water Framework Directive and Floods Directive. Buffer strips were identified as a relevant management instrument, already widely employed in the UK through various agri-environment schemes for the delivery of these two services.

Study lined up with priority concerns of European Directives

The first workshop included a broad group of science and policy stakeholders, and produced a complex mapping of ecosystem process and service linkages for services in agricultural and freshwater systems. A second, smaller, workshop then focused on the specific management intervention of riparian buffer strips on agricultural land, and explored the use of a Bayesian Belief Network approach to model the interactions between improving water quality and mitigating flood risk. A final workshop was held to review the model and explore how it could be further developed to integrate a valuation component and include a wider range of socio-economic drivers.

First of all, a conceptual model was constructed to specify the cause-and-effect relationships among the system components. The objectives (the physical output nodes) of the model were defined; in this case: flood risk and water quality. The policy tool (buffer strip node) was also described. Various other system variables and interrelationships were elaborated, grouped into four categories: states of nature, terrestrial processes, management interventions and aquatic processes. The Bayesian Belief Network was then created

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using Netica software, and was further developed to include decision, nature and utility nodes.

The next step was to populate each conditional probability table with probability values. This involved evaluating general patterns of riparian ecosystem functioning relevant to buffer strips, based on data drawn from the literature and from expert knowledge. A satisfaction or utility index of between 0-100 was constructed which showed the benefits associated with different combinations of states for the flood risk and water quality outcomes. The model was then compiled and the decision network 'solved', showing the satisfaction or utility values associated with each management action, and allowing the 'optimal solution' to be identified. For each land use and buffer strip management option a utility score was calculated as the sum of utility values associated with each combination of flood risk and water quality outcome, multiplied by the probabilities of those outcomes occurring.

Utility values enable prioritization of solutions

Alternative scenarios relevant to the East and West of England were developed, offering contrasting climatic, topographic and land use conditions. Three scenarios were examined relative to 'no buffer strips' (the status quo or baseline): 'grassland', 'natural vegetation' and 'mixed'. The results presented both the utility or satisfaction values associated with each of the scenarios for the different buffer strip management options, and the changes in the probabilities of the management objectives occurring under each of these options.

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What were the findings?

The study generated findings on two levels: conclusions about the effectiveness of different riparian buffer strip management options in delivering water quality and flood risk mitigation services in the UK, and insights on the application of a Bayesian Belief Network to capture the interactions underlying ecosystem processes and the delivery of ecosystem services.

All of the scenarios modelled indicated natural vegetation as the optimal buffer zone management practice on arable land. This held both scenario A, representing the East of England where there is low

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rainfall, light soils with high infiltration capacity and a relatively flat landscape, and for scenarios B and C, representing a higher level of overland flow. It is however for scenario C, representing the highest overland flow and steepest slopes, has the highest relative impact on utility as compared to the no action baseline (even though it is associated with the lowest absolute levels of utility).

Two potentially important gaps in the model were highlighted. One was that it did not consider the costs or (perhaps more importantly) opportunity costs of the different buffer strip options. These would be needed to fully evaluate whether the gains in utility or changes in the probabilities of water quality and flood risk are sufficient to justify investing in particular land management interventions. The study also highlighted uncertainty as a major issue. This has particular implications for the approach to valuation, especially where preferences might exhibit non-linearities or thresholds. The interaction between probabilistic outcomes and the statistical nature of valuation estimates suggests the need for further exploration of sensitivity in these kinds of models.

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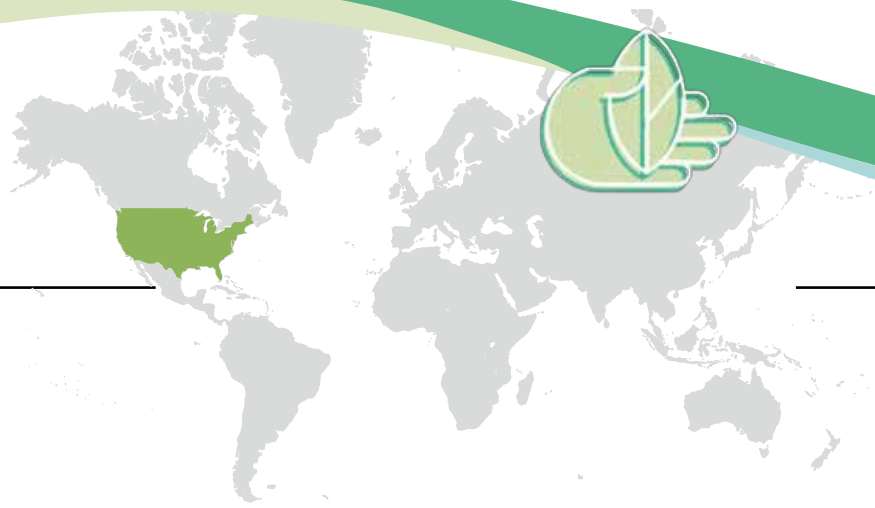

Contingent valuation techniques to measure the public benefits of wetland restoration in the USA

This case study measures public perceptions of the benefits of wetland restoration in the USA, and analyses these values by assessing their willingness to pay to mitigate the negative consequences of wetland loss. The aim was to overcome current methodological and knowledge gaps about the general public's perceptions of wetland values, including storm protection, ecosystem services and recreational benefits. The study demonstrates the importance of including public opinion, as well as scientific 'expert' data, in coastal decision-making.

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What was being measured, and why?

This study was carried out to investigate public perceptions of wetland restoration benefits, and analyse willingness to pay for large-scale coastal restoration in Louisiana, USA. It evaluates the extent to which the general public is aware of (and convinced by) the beneficial functions of wetlands restoration, and assesses the levels at which they are willing to financially support wetland restoration projects. This willingness to pay serves as an indicator of the value that the general public ascribes to maintaining wetland ecosystem services.

The rationale for the study was that, although coastal wetlands have long been recognised as one of the most productive kinds of natural ecosystems because of the services and functions they provide, they are particularly vulnerable to the natural effects of erosion, subsidence, storms and hurricanes, and sea-level rise exacerbated by climate change. To protect these valuable and vulnerable coastal areas, wetland restoration has been cited as a critical component of Louisiana's comprehensive coastal protection plan. Yet little or no research exists which investigates the general public's perception of restored wetland benefits, even though it is perception that dictates people's preferences and behaviour. Decision-making continues to be in-

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Which methods were used?

The study used a referendum-style contingent-valuation survey. Contingent valuation is a non-market valuation method that specifies a good or service to be supplied at a payment, and asks respondents to choose between making this payment and continuing with the status quo.

A questionnaire was compiled containing 37 questions about general awareness of wetland loss and restoration efforts, the perceived relationship between wetland loss (and wetland restoration) and increased (decreased) storm risk, willingness to pay for wetland restoration projects in Louisiana to prevent expected future losses, as well as individual demographic information.

Respondents' willingness to pay for wetland restoration was elicited by asking them to vote on a proposed coastwide restoration project to preventing expected future land losses in coastal Louisiana, which would involve a additional tax on households for the next 10 years (ranging between USD 50 to USD 1,189 per year, computed based on the actual costs of wetland restoration projects in Louisiana). Some respondents were also asked if they would be willing to accept a tax refund in lieu of the project going ahead.

Survey explores readiness to pay special restoration tax

The survey was mailed to a random sample of 3,000 Louisiana households. Each questionnaire included a prepaid USD 1 cash incentive with the first mailing, and a replacement survey was sent 1 month later. This yielded 681 useable responses. Ordered probit and binary probit regression models were run to analyse the responses, and show the effect of different participant characteristics and variables. Welfare estimates were generated which expressed willingness to pay and willingness to accept compensation.

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formed mainly by 'expert' scientific opinion. By making public benefits and values explicit, and demonstrating a methodology that can be used to assess them, the study aimed to fill this research gap, and provide practical and relevant information to coastal policy-makers and planners.

What were the findings?

That study found that the vast majority of respondents (about 90 per cent) were aware of the wetland loss problem in Louisiana. The most popular cause of wetland degradation was cited as being the impact of storms and hurricanes, followed by subsidence/erosion, dredging of navigation channels, sea-level rise and oil/gas exploration. A reduction in hurricane protection functions was perceived as the leading consequence of coastal wetland loss, followed by impacts on ecosystems/biodiversity and settlements/infrastructure. The majority of respondents (94 per cent) stated that the State of Louisiana should address wetland loss immediately.

The analysis also indicated that the public perceives both a strong relationship between increased wetland loss and an increased storm risk, and a substantial likelihood of increased storm-protection benefits from wetland restoration. However, even though almost 90 per cent of respondents thought that there was a very or somewhat strong relationship between wetland loss and increased risk of storm impacts, only 60 per cent perceived that wetland restoration could reduce tropical storm impacts "where they live".

Average household ready to pay as much as USD 580

Overall, more than three quarters of people surveyed were willing to pay for wetland restoration measures via an additional tax, regardless of their perceived likelihood of storm protection benefits. The average willingness to pay was USD 580 per household per year, and average willingness to accept compensation (through a tax refund) was USD 1,042. In total, this translates into an aggregate public value for wetland restoration across Louisiana ranging from USD 0.4 billion to USD 4.1 billion.

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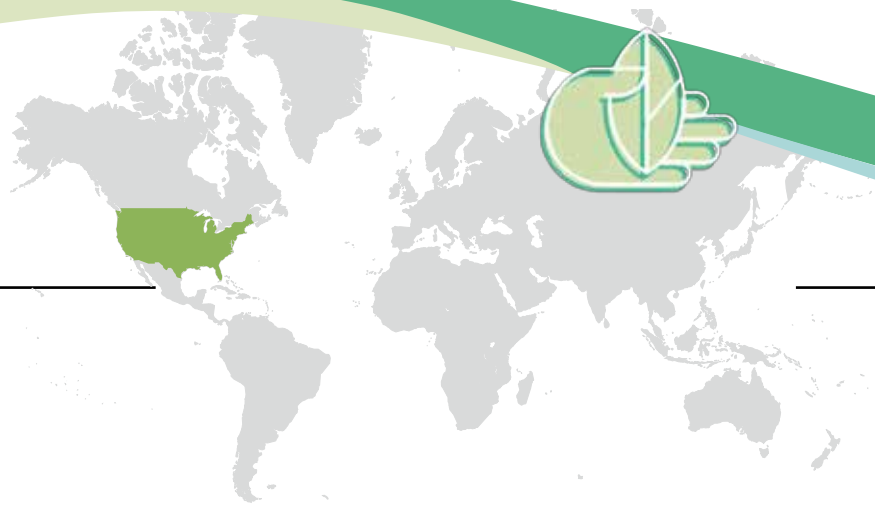

Integrated biophysical and economic valuation to weigh up coastal adaptation options in the USA

This case study investigates the effectiveness of different adaptation options in addressing coastal erosion, flooding hazards and sea level-rise in the USA. An integrated valuation methodology was applied which combined hazard projections with biophysical modelling and economic analysis. The aim was to provide decision makers in the region with the tools they need to compare a suite of possible adaptation strategies to combat accelerating coastal erosion in their jurisdictions.

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What was being measured, and why?

This study provides a detailed, integrated analysis of the costs and benefits of various different coastal climate change adaptation in the southern Monterey Bay, USA. Physical process modelling projected how the coast would change in response to the implement-ation of each of these strategies, considering different rates of coastal erosion and flood hazards as well as sea level rise. The economic analysis then considered the market and non-market costs and benefits arising from the adaptation interventions, including measuring the damages avoided to grey infrastructure, private and public assets, commerce and industry, as well as natural ecosystems.

The aim of the study was to provide decision makers in the region with the tools they needed to compare possible adaptation strategies to combat accelerating coastal erosion. It explicit-ly aimed to go beyond conventional appraisal and evaluation models which consider only a very narrow range of direct, physical costs and benefits and which therefore may not give an accurate picture of the relative viability and profitability of different adaptation options. The integrated model allows decision makers to compare how different adaptation strategies will impact their jurisdiction economically as well as physically.

Which methods were used?

The analysis considered a variety of different sites, adaptation options and climate/hazard scenarios. These were defined based on stakeholder input. These consultations resulted in the division of the study area into four reaches (based on geomorphology), within each of which a discrete shoreline management strategy was investigated. Several different coastal protection measures were identified, both structural and non-structural (land use based), including beach nourishment, shoreline armouring, elevating infrastructure, property acquisition and conservation easements. Three to five of these adaptation intervention were assessed for each of the four study reaches. The analysis had two, sequential, components: physical process modelling and economic cost-benefit analysis. Hazard projections and biophysical models were applied to each coastal reach, and economic analysis was carried out for each adaptation approach at each site.

Shoreline management strategy explored in four reaches

The first step was to examine the physical impact of different strategies, as well as of the baseline 'do nothing' situation. The response of shoreline change, beach width, coastal erosion and storm event hazards was modelled over time under a range of sea level rise projections (based on the high and medium projections recommended in the *IPCC Fifth Assessment Report*, using time horizons of 2010, 2030, 2060 and 2100). This allowed the dynamics of beach erosion, beach nourishment and other physical processes to be modelled.

The physical costs of implementing different adaption options were estimated using market prices and budgets from actual projects. This incorporated a number of elements. For structural interventions, construction and maintenance costs were included for new engineering measures, as well as the costs of structural modification of roads and buildings and replacement costs for any infrastructure (such as sewer lines and pump stations) that would be damaged or have to be moved. For the land use-based alternatives, the costs associated with the purchase of property or a right to that property were used.

Benefits were calculated by looking at damage costs avoided. This was based on an economic analysis of the private and public property, infrastructure, recreational and ecosystem service values associated with the coastal and inland resources that would be affected by coastal hazards. This process was also informed by stakeholder con-

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Which methods were used?

sultation, via a stakeholder workshop which asked participants to note areas, assets, and issues of particular concern on large maps of the study area illustrating sea level rise and coastal hazard flooding projections for 2100. An asset register was compiled, and GIS to evaluate the exposure of assets to coastal hazards described above, under current and future conditions, and under each adaptation scenario. The GIS analyses were used to develop an asset exposure inventory, to determine the timeline and ‚trigger points' where replacement would occur. The economic damages from storm events were estimated using *US Army Corps of Engineers (USACE)* depth-damage curves, coastal erosion damages were estimated by relating the landward extent of erosion to the market value of the land and/or structure at each exposed parcel. Losses to physical property and infrastructure (such as buildings, roads and water supplies) were valued at replacement cost, applying actual market prices.

What were the findings?

The study demonstrated the value of taking a wide perspective, and of considering both biophysical and economic impacts, market and non-market values. The analysis presented a much fuller picture of the consequences, strengths and disadvantages of alternative adaptation interventions than do the methods that are commonly used by coastal planners. It showed that only considering the direct physical costs and benefits of coastal protection measures excluded a very large component of value, especially that associated with broader public benefits and ecosystem services. As such, this kind of approach which integrates the economic value of property and grey infrastructure with estimates of the value of coastal recreation and ecology has far greater potential to lead to better-informed and more inclusive decision-making in coastal areas, which can serve the interests of a far greater proportion of the population.

The specific results generated by the analysis for southern Monterey also called into question the conventional wisdom that coastal armouring is the best response to coastal erosion. The study showed that when judged in these broader terms, coastal armouring was in

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fact the least economically-beneficial alternative, especially over the long-term. Rather, the scheduled nourishment option (which involves much smaller projects scheduled over a longer time period), showed the highest net present value and the greatest cost-effectiveness.

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Saved health, saved wealth approach to compare the benefits of coastal adaptation options in Viet Nam

This case study describes how a “saved health, saved wealth” approach was used to weigh up the benefits and impacts of grey and green coastal adaptation options in southern Viet Nam. Two alternative interventions were considered: a concrete dyke and mangrove rehabilitation. The methodology compared economic assets and life expectancy under a baseline business-as-usual scenario with the economic damages, illnesses and mortality that would be avoided through undertaking adaptation measures.

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What was being measured, and why?

This study was carried out in Viet Nam's Mekong Delta to compare the benefits of different coastal adaptation measures. The study site, Soc Trang Province, suffers from severe shoreline erosion, leaving coastal villages vulnerable to the effects of tidal surge, storms and floods. These effects are expected to worsen with climate change and accompanying processes of sea level rise. Two adaptation options were considered: a concrete dyke (the grey option) and a combination of an earth dyke and mangrove rehabilitation measures (the green option).

The aim of the study was to communicate the concept of quantifying adaptation benefits to project developers, policy-makers and related stakeholders, provide a methodology for doing this, and show how it could be applied to weigh up different adaptation option. It also sought to demonstrate how ecosystem-based adaptation approaches could generate a return as compared to grey measures, and to thereby help to justify project investments in mangrove rehabilitation.

Which methods were used?

The study used an innovative valuation framework: the "saved wealth, saved health" approach. This represents a move beyond the sole reliance on monetary-based measures which characterises conventional economic approaches to investment appraisal and project analysis. The aim is to measure the benefits and impacts of adaptation activities in terms of metrics that are both standardised and universally comparable. The reason for rselecting health and wealth indicators is to reflect issues that are of primary concern to decision-makers in developing countries.

Challenge to find comparable metrics

The study first of all established a baseline scenario (a continuation of business as usual), and computed the percentage of wealth and health projected to be lost over time due to climate change. Two alternative adaptation intervention scenarios were then modelled: the actual mangrove rehabilitation programme, combined with an existing earth dyke, and a hypothetical concrete dyke upgrade. Saved wealth, saved health and environmental benefits and impacts were calculated for each scenario, as compared to the baseline.

Both monetary and non-monetary metrics were used to measure these impacts. Saved health looked at avoided disease, disability and life loss, measured through DALYs or disability-adjusted life years. Saved wealth was measured in terms of (avoided) expenditures, incorporating damages to private property, public infrastructure, agricultural and fisheries income, as well as the costs of erosion control and land desalinisation. Environmental co-benefits were described (but not quantified) via a checklist of indicators such as air quality, water quality, soil conditions, biodiversity, quality of employment, livelihoods of the poor and cultural heritage.

The study relied on a combination of primary and secondary data to describe and project local demographic and socioeconomic conditions, sources of income and livelihoods, land use and land cover, ecosystem services and the costs of the adaptation measures being considered. In order to model the effects of extreme weather, historical data from the study village and other parts of the country were also collected on the frequency, incidence and impact of both periodic and severe storm and flood events.

The data were inputted into two comprehensive spreadsheets (included in the methodology), consisting of pre-defined formulas and databases which performed the calculations that were neces-

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sary to compute saved health and saved wealth results. A damage frequency function of flood events was the main tool underlying these calculations. As future conditions are highly uncertain, the methodology also included a sensitivity analysis. This explored the implications of changes in key parameters such as the intensity, duration and frequency of extreme weather events, value of public and private property, number of deaths and incident cases, and annual maintenance costs of the adaptation measures.

How were the results disseminated and what was their impact?

The study found that the mangrove-based adaptation option gave a high return in terms of both saved wealth and saved health. The wealth benefits for the local population were almost five times higher than for the dyke upgrade option, which was unable to generate a return to even justify its investment. In addition, mangroves were found to offer a wide range of co-benefits which would not be provided by the concrete dyke. These include providing fuelwood, and serving as habitat and breeding grounds for commercially and nutritionally important fish, crustaceans and snails. In addition, the protection against salinity offered by mangroves meant that land would be able to be returned to agriculture, something that would not be possible with the dyke option.

The study's main target audience was coastal planners and developers at national, provincial and local levels. These include the government agencies that are mandated to manage coastal zone development and disaster-risk reduction in Soc Trang Province and Viet Nam, as well as private sector investors and development donors. The main mechanisms used to share information were technical reports, workshops and web-based resources. Although the intention was not to change or influence coastal adaptation planning at the study site (this was an ex-ante study), the findings confirmed and reinforced the project's decision to invest in mangrove rehabilitation, and helped to demonstrate evidence of its impact in health, economic and environmental terms.

Info shared by way of reports, workshops and web resources

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The study was carried out under the project "Management of natural resources in the coastal zone of Soc Trang Province" which ran between 2011 and 2014. The project supported Integrated coastal zone management with a focus on adaptation to climate change, including approaches based around mangrove rehabilitation and community co-management. Funded by the German Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety (BMUB) under the International Climate Initiative (IKI), the project was implemented by GIZ in partnership with People's Committee of Soc Trang Province; Sub-department of Forest Protection; Sub-department of Aquaculture; Sub-department of Capture Fisheries and Resource Protection; Sub-department of Rural Development (Department for Agriculture and Rural Development); Sub-department of Environmental Protection (Department of Natural Resources and Environment); Department of Education and Training and District; Commune People's Committees; Women's union and village-level farmers associations. The second phase of the Integrated Coastal Management Programme continued this work between 2014 and 2017, aiming to institutionalise and scale up the solutions that had already been developed, in order to ensure their full impact on a broader scale.

For further information see https://www.giz.de/en/worldwide/18661.html, http://daln.gov.vn/en/icmp.html

What are the key insights and lessons learned on valuing EbA-relevant benefits?

The methodology applied in Soc Trang Province addressed one of the key challenges facing adaptation project developers: how to consistently estimate, monitor and evaluate the outcomes of adaptation activities from different project types in different sectors and geographies. The saved wealth, saved health approach is able to directly compare the benefits of competing projects by using an identical set of applied indicators. This standardisation and comparability, as well as the use of wealth and health indicators, resonated with coastal planners and decision-makers in Viet Nam and helped to ensure that they considered the study findings to be interesting, useful and credible.

Detailed local level information proved difficult to assess

Although the methodology was relatively straightforward to apply, and had the advantage of being accompanied with a spreadsheet model which performs most of the calculations that are necessary to generate results, the quality and availability of the data it required posed something of a challenge. Whereas national data for natural disasters and extreme events as well as predictions of increased exposure are available, detailed local-level information for areas such as Soc Trang Province is more difficult to access. This may have compromised the precision of results, and also means that it is difficult to compare adaptation options or transfer study results between sites. The high levels of uncertainty concerning climate change and ecosystem impacts/causality give particular cause for concern, and can hamper the accurate quantification of adaptation benefits.

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This case study is based on information provided by **Michel Köhler** (independent climate policy consultant and Founding Partner, the greenwerk) and presented in the following documents:

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