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PROVIA Guidance on Assessing Vulnerability, Impacts and Adaptation to Climate Change

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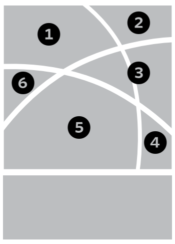

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Preface

In 1994 the Intergovernmental Panel on Climate Change published *Technical Guidelines for Assessing Climate Change Impacts and Adaptations*. These guidelines outlined a series of generic steps to be followed when designing and conducting a climate change impact and adaptation assessment. The guidelines were complemented in 1996 by the *UNEP Handbook on Methods for Climate Change Impact Assessment and Adaptation Strategies*. The IPCC Guidelines and the UNEP Handbook were applied in a range of country studies during the decade following their publication. They also inspired the publication of additional guidance, including the *International Guidebook for Vulnerability and Adaptation Assessments* carried out as part of the US Country Studies Program, and the *Adaptation Policy Frameworks for Climate Change: Developing Strategies, Policies and Measures,* published by UNDP.

The past decade has seen a shift from centralized guidance for climate vulnerability, impact and adaptation assessment to the development of specific, often sectoral or place-based approaches. There has been a proliferation of assessment methods and tools, and it has become increasingly difficult for potential users to understand the utility, benefits, requirements and tradeoffs of those methods and tools. Stakeholders' demand for knowledge on vulnerability, impacts and adaptation needs to be matched with the supply from the research community of clear technical guidance that takes into account both the academic developments of the past 20 years as well as user needs at local, national and international levels.

The Global Programme of Research on Climate Change Vulnerability, Impacts and Adaptation (PROVIA) has responded to this challenge by revising and improving existing guidance for assessing climate change vulnerability, impacts and adaptation, covering the range of available approaches, methods and tools. This document is the result of this effort, which has been a pleasure for me to coordinate. The PROVIA Guidance is meant to be informative rather than prescriptive; its intended users are researchers, adaptation practitioners, decision-makers and those involved in project, programme and policy formulation. The Guidance is conceived as a "living document": the current version is a consultation document that will benefit from feedback from users.

The PROVIA Guidance has been prepared by a ten-strong author team, supported by a large group of experts and reviewers (see opposite page). The conceptual basis, the decision trees and the methods and tools included in the PROVIA Guidance build on research conducted within the project MEDIATION: Methodology for Effective Decision-making on Impacts and Adaptation. MEDIATION was funded by the European Commission's 7th Framework Programme under contract number 244012. The preparation of the PROVIA Guidance was funded by UNEP, with additional support provided by the Government of Sweden.

October 2013

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Summary

Climate change poses a wide range of risks – and, in some cases, opportunities – to human and natural systems around the world. In order to understand and address these risks and opportunities, stakeholders need clear technical guidance that combines robust science with explicit consideration of user needs at local, national and international levels. This document responds to that challenge by updating and improving existing guidance for assessing climate change vulnerability, impacts and adaptation, covering the range of available approaches, methods and tools.

The guidance is structured along a five-stage iterative adaptation learning cycle:

1. **Identifying adaptation needs:** What impacts may be expected under climate change? What are actors' vulnerabilities and capacities? What major decisions need to be addressed?

2. **Identifying adaptation options:** How can the specific risks and opportunities that were identified be addressed? There may be several options available to achieve the desired goals.

3. **Appraising adaptation options:** What are the pros and cons of the different options, and which best fit the adaptation actors' objectives?

4. **Planning and implementing adaptation actions:** After an option is chosen, implementation can begin. The focus here is on practical issues, such as planning, assigning responsibilities, setting up institutional frameworks, and taking action.

5. **Monitoring and evaluation of adaptation.** As measures are implemented, the process is monitored and evaluated to ensure it goes as planned, identify any problems, document the outcomes achieved, change course as needed, and draw lessons from the experience.

This is an idealized model of adapting to climate change; "real-world" adaptation processes may not be linear, and in fact, may require refinement through iteration. This guidance therefore provides multiple entry points, highlighted in boxes throughout the document, to allow readers to enter (and re-enter) at various stages or sub-stages of the process.

All of these tasks are complex, and many need to be carried out by experts. There is no "one size fits all" approach, and this document emphasizes the diversity of adaptation challenges and the variety of methods and tools available to address them. We use decision trees to identify key criteria that may indicate the need for a particular kind of analysis or method, but never prescribe an approach as the only valid one. The aim of the document is to provide an overview of the range of activities that make up climate risk assessment and adaptation, and a coherent and integrated structure for addressing them.

Generally, this document is targeted at professionals such as researchers, consultants, policy analysts and sectoral planners who have some prior knowledge on climate risk assessment and adaptation. Some of the material is technical and requires some relevant experience. The guidance should also be of use to those leading or initiating planned and collective adaptation, such as community-based organizations or NGOs. Below we provide brief overviews of the four sections of the document, with an emphasis on Section 2, which guides readers through the adaptation cycle and suggests approaches to different tasks. ■

Section 1: Introduction

This section introduces the basic structure and terminology used in the guidance, including how to frame the adaptation process, how to differentiate adaptation challenges based on different criteria, and how to identify the most relevant (salient) tools and approaches to address those challenges. In differentiating adaptation challenges, we emphasize two key empirical criteria: the stage in the adaptation cycle, and the type of adaptation situation: public or private, and individual or collective. Private individual situations are those in which persons act in their own interest, such coastal dwellers flood-proofing their homes. Private collective situations are those in which groups of people take action together in their own interest, and may involve interdependence and, sometimes, conflicting interests. Public situations are those in which public actors, such as governments, take action with a fiduciary duty to act in the public interest – either seeking to influence individual or collective actions, or coordinating collective actions.

The guidance also highlights three other key sets of empirical criteria: the characteristics of the climate risks (or opportunities) involved, such as whether they are already present; the characteristics of the affected actors, such as whether they are aware of the risks and have the capacity to adapt; and the characteristics of the available adaptation options, such as their relative cost and flexibility. In addition, we note other types of criteria that may inform the choice of approach, including theoretical criteria, such as whether methods from economic theory or social psychology are preferred; normative criteria, or the values and priorities that define what options are acceptable; and pragmatic criteria, such as time, skill or funding constraints.

Finally, we stress the importance of stakeholder participation at all stages of the adaptation learning cycle, which should cover the full range of affected groups, including women and marginalized populations. This is particularly the case for collective adaptation situations, to understand and take steps towards harmonizing the diverse and potentially conflicting perspectives of different actors. ■

Section 2: Choosing approaches for addressing climate change adaptation

This section goes through each stage of the adaptation cycle and identifies tasks that may arise and different approaches that may be applicable. We start by explaining how we use the term "vulnerability" here: in the most general sense, as the propensity to be adversely affected by climate change, rather than adopting any of the more specific formulations in the literature. We describe methods that model climate change impacts as "impact analysis", and methods that analyse the institutional context of vulnerability – including political, social and economic factors – as "institutional analysis". The latter include methods for assessing "social vulnerability", considering rights, entitlements and power in the analysis. Finally, we use the term "indication" to describe methods that use indicators (individually or in indices) to measure climate impacts, adaptive capacity, or both.

Identifying adaptation needs

Identifying adaptation needs involves two equally important and complementary sub-tasks: 1) analysing observed or expected *impacts* of climate change (with and without adaptation); and 2) analysing the potential *capacity* to prevent, moderate or adapt to these impacts. In most adaptation situations, both types of analysis are likely to be relevant, but resource constraints and/or the characteristics of the adaptation challenge may make it necessary to prioritize one type of analysis over the other.

In choosing approaches to impact analysis, we identify several decision nodes: Are studies on future impacts available? Are the available studies comprehensive and credible? Are the results of these studies ambiguous regarding impacts? If future impacts need to be projected, are impact models available to do so? Should adaptation be included in the projection? Are monetary values involved and not known? If impact models are not available, can a trend be detected and attributed to climate change? When no impact studies or models are available and no trend can be detected and attributed to climate change, then the identification of adaptation needs and opportunities must rely on indication methods – impact indication, capacity indication, or vulnerability indication, which combines both.

Capacity analysis, meanwhile, explores the availability of a wide range of resources – such as natural, financial, cognitive, social, and institutional capital – that may be mobilized for adaptation. Several assessment methods are available, depending on the type of adaptation situation. In public situations, a public actor may wish to understand the adaptive capacity of private actors in order to influence their actions at later stages in the adaptation process. Towards this end, capacity indicators or indices are used. It is important to note that adaptive capacity indicators and indices only provide a rough and rapid assessment of actors' potential capacity to adapt. Whether this potential capacity is realized in the context of a specific climate threat depends on many contextual institutional and cognitive factors, which may need to be explored through behavioural and/or institutional analysis. In collective private adaptation situations, organizational self-assessment methods may be relevant.

Identifying adaptation options

Once specific adaptation needs have been identified, the next step is to identify ways to address them. For example, a climate impacts and vulnerability analysis might have found that due to sea-level rise and changing weather patterns, coastal communities will be exposed to major floods during storm surges. We refer to the different pathways that can be taken as *adaptation options*. For example, for a municipality, protecting the coast might involve building new infrastructure, such as a sea-wall, or working to restore natural barriers such as dunes and mangroves, or both. Individual homeowners might consider raising or fortifying their houses, or getting better insurance. The public sector might consider financial incentives to encourage individuals to pursue those measures, or if it considers retreat a better option, it might provide incentives to leave, or change zoning laws to prevent further development.

The nature of this task is different for private and public actors. Private actors act in their own interest, and can focus narrowly on the adaptation options available to them. Public actors, on the other hand, are mandated to act in the public interest, and thus need to consider a much wider array of measures and criteria, such as distributional effects and potential conflicts that may arise. In collective situations, some options that are theoretically possible – say, choosing not to further develop a high-risk coastal zone – might not be feasible without first building consensus. At the same time, actors' awareness of the limits of their influence might lead them to not even consider measures beyond their immediate control.

In identifying public options for influencing individual action, two key factors must be considered: actors' *potential capacity* – the resources, including material resources, skills and networks or social capital available to them – and their *actual capacity* – whether they can actually go through the whole adaptation cycle. Actual capacity can be enabled or constrained by institutional and cognitive factors, which are referred to as *barriers to adaptation*. Another key consideration is whether adaptation would conflict with private interests. If so, considering the relative costs of action may help identify appropriate policy instruments to encourage adaptation. If adaptation does not conflict with private interests, behavioural analysis should be undertaken to identify the relevant cognitive and institutional barriers. Possible approaches fall into two broad categories: economic (e.g. utility maximization or bounded rationality) and social psychological (e.g. protection motivation theory, which posits that actors are motivated by the perceived severity of a threatening event, the perceived probability of the occurrence, the efficacy of the recommended preventive behaviour, and their perceived self-efficacy).

In many situations, conflicts can arise between the individual preferences of private actors and social welfare, such as when a common pool resource is over-exploited. In order to identify appropriate policy measures, one needs to understand the nature of the interdependences and conflicts between actors. This can be done through institutional analysis, looking not only at formal laws, policies and governance structures, but also at informal norms, customs and shared strategies. Different approaches can be used to identify a coordination solution, or to try to design institutions or policies to achieve the desired goal.

Appraising adaptation options

There are many methods that can be applied to appraise adaptation options, from the fields of organizational learning, decision analysis, policy analysis, and institutional and behavioural analysis. A key first choice is whether to apply a formal approach, a deliberative/participatory approach, a combination of both, or none – and make a decision based on intuition. Formal decision appraisal methods are based on formalizing the decision and then applying mathematical reasoning to indicate which options *should* be chosen. Examples of such methods are multi-criteria analysis, cost-benefit analysis or robust decision-making. In contrast, deliberative approaches appraise options by eliciting information from the actors involved and harmonizing their preferences. Intuitive decision-making relies on cognitive processes that have been developed through a great deal of experience and learning.

Formal decision-making requires a well-defined decision, with a specific set of options, known outcomes of implementing each option (computed using either risk assessment methods for present climate extreme event risks or residual impact projection methods for future climate, and one or several metrics by which to compare the options, at least one of which involves the costs of planning and implementation.

Only a limited set of adaptation decisions can be formalized due to, among other factors, the intensive time, resource and capacity requirements of formal decision-making methods. For individual decisions, there is good evidence that when information is limited or ambiguous, some informal patterns consistently lead to better decisions than attempts to apply more formal methods. For collective decision appraisal, informal methods may be more deliberative. For example, consensus-based decision-making involves discussing options to familiarize everyone with the issues and build a shared understanding and a sense of shared control over the decision – which, in turn, can lead to more effective adaptation.

For formal appraisal of options, key factors in choosing an approach are whether the options are all short-term, or also include long-term ones; whether residual impacts can be projected; whether there are risks (or opportunities) due to current climate extremes and variability; and what the relative costs of options are. In general, short-term and lower-cost options, and options that address current risks, provide more room for experimentation and learning – that is, to take adaptation action, monitor the outcome, and make adjustments as needed. This is what is called adaptive management.

If the relative costs of an option are high, and/or if long-term options are involved, experimentation is less desirable. Instead, it would be useful to evaluate the adaptation options upfront, before implementing one, following standard approaches for decision-making under uncertainty such as cost-benefit analysis or cost-effectiveness analysis. (Cost-benefit analysis, as its name suggests, weighs the costs of implementing a measure against its expected benefits. Cost-effectiveness analysis starts from the premise that action – e.g. addressing a drought risk – is desirable, and looks for the most cost-effective, or lowest-cost, way to achieve the desired goal.) For these formal decision-making methods, having probabilistic information about the risks is crucial to calculating expected outcomes.

The farther into the future that a climate risk lies, the greater the uncertainty involved. Not only would the expected costs and benefits have to be calculated for an ever-broader range of climate scenarios, but also for different non-climate variables such as development and policy choices (e.g. how a coastal area is zoned, or whether a hydropower dam is built). Alternative methods have been developed to support decision-making under deep uncertainty. Unlike cost-benefit or cost-effectiveness analyses, which aim to find the optimal solution within a fixed set of parameters, these approaches look for solutions that are robust (don't fail) under many possible future scenarios. Such "robust" decision-making methods can appraise options using the criterion of robustness alone, or both robustness and flexibility.

Planning and implementing adaptation

Once climate impacts and vulnerabilities have been assessed, and adaptation measures to address them have been identified and evaluated to choose the best option, the next step is to make a plan to implement the chosen measures – and then do it. This is a complex and challenging process, and very often, the analytical work is not translated into concrete plans and actions. Key constraints that can arise at this stage include lack of motivation and common purpose; concerns that the desired adaptation measures are not actually feasible; and lack of clarity around objectives or agreement on priorities.

Recognizing these common obstacles, this section focuses not only on the technical tasks of planning and implementing adaptation measures, but also on the work needed to support those efforts: communications, consensus-building, integration with non-climate initiatives (especially development), and capacity-building for key actors and institutions to ensure that they can successfully plan and implement adaptation. A key question to remember throughout the process is "*What are we adapting for?*" (the desired outcomes). For example, if a coastal area is being protected from sea-level rise and storm surges, is the priority to protect buildings, ecosystems or both? And is there a consensus about the desired outcome, or does the agreement stop at "protect the coast", but break down

Farmers tend their early maturing rice varieties in Madagascar ©Katherine Vincent

when it comes to specifics? The scoping phase thus sets the parameters for the work and clarifies what it is intended to achieve and who needs to be involved. Often adaptation is not the only reason for change, and measures may be implemented as part of other initiatives, such as development projects. For example, upgrading a water supply system in a coastal community which currently has no access to fresh water could provide both adaptation and development benefits.

Engagement of stakeholders in creating an adaptation plan – and well before, when identifying and assessing options – means the plan is much more likely to be accepted, especially if the stakeholders are also willing to become advocates or champions of the plan. In designing participatory processes, it is important to define the scope of the issues that stakeholders will be addressing. Stakeholder engagement approaches can vary from fairly passive interactions, where the stakeholders simply provide information, to "self-mobilization", where the stakeholders themselves initiate and design the process. Stakeholders must understand how they are being involved, how the information they provide will be used, and what opportunities they have to influence decisions. When designing the engagement, it is valuable to take into account the stage at which the engagement is occurring in terms of the policy-making process, what decisions have already occurred, and what positions are already fixed.

Adaptation decisions need to be implemented within existing governance and legislative constraints, which will inevitably influence which responses are considered to be feasible. Understanding as much as possible about the context of this wider landscape allows a balance to be struck between ensuring that actions fit within those existing structures, and creating an enabling environment to support appropriate adaptation decision-making in the future. This complexity means it is a greater challenge to ensure that adaptation in one area does not increase vulnerability in another, and that "windows of opportunity" and "win-win" opportunities are maximized. It is by no means a given that the people and institutions charged with implementing an adaptation plan will have the capacity to do so. Thus, it will also be important to identify any capacity gaps and incorporate capacity-building into the adaptation plan.

Capacity involves not only knowledge and skills, but also having the necessary tools and resources, as well as the necessary institutional framework. The best-trained adaptation experts will accomplish little if they must cram their adaptation duties into an already full workload, or they lack crucial software, or money to buy supplies, or the support of their supervisors. Agencies with competing mandates can bring one another to a standstill, and lack of enabling legislation or regulations can keep adaptation measures from being implemented. Thus, there is a broad range of capacity-building work that may need to occur before the actual implementation process.

Monitoring and evaluation

Adaptation can involve a significant investment of resources and effort, and as discussed in previous sections, it is often planned amid uncertainty, with incomplete knowledge, and may require substantial learning, capacity-building and institutional change. All of this makes it crucial to monitor adaptation activities as they are implemented, make adjustments as needed, and evaluate the results at the end.

Monitoring of an adaptation project may have a number of purposes, such as to assess progress in the achievement of stated tasks; to determine whether the tasks are fulfilling the aims of the adaptation initiative; to assess the functioning of the team and of individuals within it; to examine engagement of other people in the process; to gather stakeholders' perspectives on the nature of that engagement (both the process and content); or to understand how well learning is occurring and informing the next steps.

Evaluation goes beyond monitoring in that it includes a value judgement on how an adaptation intervention is performing based on the monitored criteria. As funding for national, sectoral, and project-based adaptation projects has increased, so has the need to understand what makes adaptation actions effective, demonstrate value for money, protect investments, identify best practices, and judge which efforts are suitable for scaling-up. Although initiatives that focus solely on adaptation are still relatively recent, projects in which adaptation is a component have been in place for some time. In many cases, adaptation activities can be evaluated effectively by refining existing monitoring and evaluation (M&E) frameworks rather than building completely new frameworks.

Adaptation initiatives may have features that make them more challenging to evaluate, such as a longer time horizons than is usual for development projects; this means different kinds of indicators, baselines and targets may need to be set up. It is also important to get different perspectives on "success", focusing not only on funders' priorities, but also on the intended "beneficiaries" and their perspectives. Early in the planning stages of an evaluation, it is important to clarify the reasons for undertaking the evaluation and ensure that all participants are in agreement. The two fundamental questions are, "have we done things right?" (that is, the things we said we would do in the adaptation plan) and "were they the right things?" (how relevant were they? will they enable us to be less vulnerable or adapt better?). A third question might be, "how should we measure these things?"

Ideally, evaluations bring in a mixture of different types of information (scientific, political, legal, technical as well as local knowledge). It is useful to provide opportunities to compare these different perspectives – for example, through a science-policy dialogue. Indicators should also be chosen carefully, distinguishing between process and outcome indicators (e.g. number of workshops on heat stroke dangers vs. number of heat-related deaths avoided), including both quantitative and qualitative data, and disaggregating as relevant (e.g. by location, gender, income level or social group). This section also describes commonly used approaches, such as results-based management and logical frameworks – both widely used by funders – and outcome mapping and most significant change, common in development.

Finally, this section emphasizes the value of learning as part of the M&E process. Monitoring and evaluation processes can be designed to enhance learning by encouraging the use of all insights in order to adapt the current plan, improve the design of the next project, or compare with other evaluations in an iterative cycle. Learning needs to be consciously to be built into the process if it is to be effective. This requires thinking through who needs to be learning, how people can provide insight and feedback, what kind of things can be learned (facts, skills, stories) and what level of challenge is available to move people beyond "business as usual". It also requires making "spaces" available for learning and feedback. Lastly, it is important to provide for both fast (short-term) and slow (long-term) learning. For example, it might take 10-15 years to learn that a measure meant to reduce vulnerability to increasing water scarcity (e.g. planting trees) does or does not work well. We need quick ways to check our assumptions about what needs to change and how it will change – e.g. are farmers actually adopting new practices after an intervention, and if not, why not? – while also building our knowledge over time. ■

Section 3: Methods and tools

This section provides in-depth guidance on the approaches discussed in Section 2, as well as additional methods and tools, often with examples from the literature. Rather than try to summarize the entire chapter, which might read like a laundry list, we focus here on providing an overview, a sort of annotated table of contents to highlight materials that might not be easily found through pointers in Section 2.

Participation and engagement

This section builds on ideas introduced throughout Section 1, but goes into much greater depth, discussing the principles behind participatory processes, ethical and social-justice considerations, and the wide range of possible engagement by stakeholders: from one-shot discussions to elicit local knowledge or preferences, to sustained participation, ownership and leadership of adaptation processes. We also discuss what makes a good facilitator – from strong interpersonal skills, to a commitment to ensuring all voices are heard, to awareness of factors that might discourage people from speaking freely.

We then present several tools to help identify the stakeholders who should be engaged, analyse social networks, and understand participation (e.g. "ladders" to show different levels of engagement). Next we describe several methodologies, guidance documents, toolkits and individual tools to help readers work with stakeholders at all stages of the adaptation cycle. Although the approaches we discuss are specifically geared to adaptation, they draw from existing practices and knowledge in development, disaster risk reduction and other fields. We also present tools to help ensure participation of people who are often excluded – such as women, indigenous groups, and people who are not literate – and tools for participatory analysis and conflict resolution, as well as a few useful generic tools (e.g. H diagrams).

Impact analysis

Building on the explanation of the first stage of the adaptation cycle in Section 2, this section describes key tasks in impact analysis and applicable methods, with examples: describing current impacts of climate change; detecting trends via statistical methods; attributing impacts; and modelling future impacts, including how to project future climate change and how to represent adaptation in models.

Next, we provide an overview of vulnerability indication, which starts from the assumption that individual or social capacities and external climate drivers are at least partly responsible for climate change impacts, but their interactions cannot be reliably simulated using computational models. The key question addressed is, which combinations of variables give the most reliable indication of how climate change may affect the study unit? The basic tasks are to select potential indicating variables, based on the literature, and to aggregate the indicating variables based on theoretical and normative arguments. We also highlight concerns that several experts have raised about vulnerability indices.

Another sub-section focuses on different ways to elicit knowledge, including community vulnerability assessments, expert judgement, participatory development, and emerging user-controlled learning tools.

Capacity analysis

This section focuses on methods and tools for assessing the capacity of individuals, communities, systems and institutions to adapt to climate change. Capacity analysis is typically done in the first stage of the adaptation process, identifying adaptation needs, but it is also relevant in appraising adaptation options and planning and implementing adaptation measures. We describe several approaches to capacity analysis, starting with the notion of "adaptation functions" and institutions to support adaptation – based on the Bellagio Framework for assessing countries' adaptive capacity, which identifies planning, management and service delivery functions needed for effective adaptation. We also describe frameworks that focus on characteristics of institutions or organizations that support adaptation, such as learning capacity, ability to understand different perspectives, and fair governance.

We also discuss the links between adaptive capacity and social vulnerability, which can be seen as the "flipside" of adaptive capacity in some respects: for example, people who can read and write may have a greater capacity to adapt than those who are illiterate – and the latter may thus be more vulnerable. Like social vulnerability, adaptive capacity is dynamic, varying across time and space, and shaped by an array of economic, social, cultural, institutional, environmental and other factors. Therefore, like vulnerability assessments, capacity analyses can only reliably tell us about capacity *here and now,* but not necessarily in the future, or under different circumstances. We stress that, although the use of indicators to measure adaptive capacity (and/or social vulnerability) can be problematic, as discussed above, this does not negate the importance of the socio-economic context in assessing adaptive capacity. Instead, we need better analyses and a recognition that adaptive capacity cannot be easily quantified and compared across countries or populations.

Scenario analysis

This section provides an overview of the extensive on the use of data and scenarios in climate impact and vulnerability assessments, focusing on the most useful resources, and highlights important issues to consider when using scenario analysis in the context of adaptation. It also provides a list of data portals that provide global-, national- and regional-level data that can be used in scenario analyses.

We discuss how different kinds of information can be incorporated in such analyses, including climate data; quantitative data about physical, economic, social or technical aspects of the system being studied; and qualitative descriptions of past, present or future conditions (storylines). We also explain different approaches to using scenarios for future climate and for future environmental and societal conditions that may influence vulnerability, impacts and risk management in general. Lastly, we note that using common sets of scenarios can help bring consistency and comparability to climate impact and adaptation assessments.

Behavioural analysis

Behavioural research uses a variety of methods – e.g. laboratory and field experiments, econometric analysis – to try to understand how people make decisions, and how those decisions vary according to contextual factors. In climate change adaptation, impact and vulnerability analysis, behaviour analysis can be used to explain how actors (organizations or individuals) make adaptation decisions – on the assumption that such knowledge is necessary to advance adaptation. For example, understanding the factors that shape household decisions on flood protection can help improve the design of flood risk communication strategies. It can also shed light on the limits to adaptation, leading to more realistic assumptions about autonomous adaptation in climate economics models and adaptation plans.

We focus on three main approaches: one from social psychology, protection motivation theory, which assumes that individuals take action based on their perception of risks and the perceived effectiveness of acting to reduce risks; and two from economics: utility maximization, which assumes that individuals take action to maximize utility, and have complete information and the required analytical abilities; and bounded rationality, which assume that individuals want to maximize utility, but have limited information and/or limited cognitive abilities.

Institutional analysis

Assessments of vulnerability, impacts and adaptation will often seek to understand the institutional context, including political, social and economic factors that structure individual choices. Such methods are broadly categorized as institutional analysis. This section describes three main approaches: governance description, governance design and governance emergence.

Governance description approaches describe the actors and institutions relevant for adaptation, and have been done all around the world in the context of climate change. This type of approach requires no strong theoretical assumptions on the part of the analyst, and contributes to adaptation by providing a more comprehensive description of the policy context in which adaptation takes place. Governance design, meanwhile, addresses the question of how to design effective institutions, on the theoretical assumption that the link between institutions and outcomes can be understood and predicted with some confidence. One governance design approach that has been applied extensively in the adaptation literature is policy analysis, which is used to improve the design of policies, programmes or projects. Finally, governance emergence is approaches strive to understand the existing institutions, particularly addressing which contextual factors give rise to a particular institutional arrangement in a given case. Within this category, a distinction is made between those approaches that assume that it is possible to generalize beyond a single case, and those that do not (such as ethnographic approaches).

Formal decision-making

This section describes and discusses formal decision-making methods, explaining and providing examples of six different approaches. The first is cost-benefit analysis, compares options based on a single metric (net cost or benefit), calculated as the difference between the present value of cost and present value of benefits for each, and picks the option with the highest net benefits or benefit cost ratio. Cost-effectiveness analysis, meanwhile, compares options based on both their costs and a different metric describing a desired outcome (e.g. number of endangered species saved), and picks the option with the highest cost-effectiveness ratio.

Sand banks are used to stabilise the river bank and reduce flood risk in southern Malawi ©Katherine Vincent

Multi-criteria analysis applies multiple metrics in the comparison, computes a weighted sum for each option, and picks the one with the highest score.

We also discuss robust decision-making, which is particularly useful when making decisions amid uncertainty (see Section 2 summary), and multi-shot robust appraisal, which is useful when the set of options includes options with long investment horizons, or when a decision is considering adaptation to mid- to long-term hazards, and when the options considered are flexible. In such cases, flexible options may be favoured over non-flexible ones, and decisions are delayed to keep future options open. Adaptation "tipping points" may be identified beyond which some strategies are no longer effective, and other options need to be considered. Finally, we discuss adaptive management, another method for decision-making under uncertainty. Adaptive management allows for the updating of actions on the basis of new information as it becomes available. In this sense, adaptive management is an ex-post evaluation of options based on the preferences of the decision-maker. Adaptive management requires the availability of new information on the effectiveness of an adaptation action, and therefore is closely related to monitoring and evaluating, and to learning.

Valuation methods

This section focuses on an important task that is essential to many kinds of formal decision-making: computing a monetary value to an option on the basis of its non-monetary outcome attributes. Valuation is necessary in situations in which monetary values of outcomes are considered important, and it is also important in impact analysis, in order to identify adaptation needs.

The point of departure for valuation is those goods that people buy and sell on the market, such as bread, butter or bicycles. Their value can be established by observing the average prices that people pay for them. As prices change over time, a base year can be established, and a correction can be made for inflation of values obtained in the past or estimated for the future. From the simple case, there are several characteristics of outcomes that can make it more difficult to assign monetary values. We discuss different approaches applicable to situations where non-market outcomes are involved, where there are indirect outcomes, where there are inter-temporal outcomes, or where outcomes are uncertain, and we note important considerations, such as the implications of different discount rates.

Finally, we discuss criticism of the valuation tasks and methods we have described, which are largely based on the neoclassical economics approaches of welfare economics. Some critics have focused on the unrealistic assumptions made about actors' choice processes, which can ignore well-known cognitive biases. Others have criticized valuation methods for enabling trade-offs to be made between outcomes should be seen as incommensurable, such as assigning a monetary value to human suffering.

Tools for adaptation planning and implementation

This section begins by highlighting the importance of understanding the context in which adaptation is to take place – societal priorities, economic interests, governance structures, etc. – and tailoring adaptation actions to that context. We also discuss different guiding principles that have been proposed for effective adaptation planning and implementation, such as the need to be participatory and inclusive, to recognize both local and scientific knowledge, and to encourage stakeholders to make their own choices and take the lead in adaptation.

We then present an array of resources and tools to support adaptation planning and implementation, including both generic, widely applicable materials, and tools designed specifically for local and regional-level planning, for specific sectors, and for businesses and organizations. We also briefly describe several techniques that have been successfully used in adaptation and other settings, such as participatory mapping, "mental model" approaches, and Soft Systems Technology.

Methods for monitoring and evaluating adaptation

This section begins with an overview of the different reasons for doing monitoring and evaluation (M&E), and the potential benefits of doing it well – from the learning opportunities, to the transparency and accountability that they can provide to both funders and intended beneficiaries. We note that although adaptation practitioners, funders and researchers have now been designing, analysing and testing M&E frameworks for several years, this is still a relatively new field for climate adaptation, and there are still many challenges to address, such as how to account for adaptation benefits that occur over a long time-scale.

We provide an overview of M&E methods, which range from fairly theoretical and technical frameworks, often developed in academia, to practical, step-by-step guides geared to people working on community-based adaptation and disaster risk reduction. And we identify several common traits of effective M&E systems, such as starting with a clear, agreed-upon understanding of what constitutes success, and how to measure it; tracking progress over the course of the project, rather than just looking at the end result; considering not just *what* is done or achieved, but *how* it is done – the quality of the process as well as the content; and recognizing that not everything can be measured, and thus including qualitative assessments as well as quantitative ones.

We describe three useful online resources, summarize an array of critical reviews of adaptation M&E to date, discuss two frameworks that provide step-by-step guidance for adaptation M&E, and briefly list several other commonly used evaluation methods and tools.

Tools for learning and reflection

This section examines different perspectives on learning in adaptation, and emphasizes the importance of structuring adaptation activities in ways that promote learning and reflection. Learning to learn, we argue – from our own experiences, and from others' – is crucial to successful adaptation, and helping people become better learners and critical thinkers is an important aspect of building adaptive capacity. Doing this well requires understanding *what needs to be learned, by whom,* and *how*.

We also discuss emotional and relational aspects of learning, and how people can, with support, evolve as learners from depending on others to "hand down the truth" to becoming aware of multiple perspectives and having the confidence to form and express their own ideas. This kind of evolution is an important aspect of building adaptive capacity and encouraging autonomous adaptation; in the long run, the people exposed to climate hazards cannot depend entirely on others' help and expertise to avoid the worst impacts. Closely linked to this discussion is the concept of adaptation as social learning – learning on a larger scale than just individuals or groups, up to a societal scale, as a result of social interactions

Flooding, Heidelberg, Germany © Flickr/Sylvia Wrigley and processes. Through social learning, successful adaptation strategies and lessons from individual projects and actions become part of the collective knowledge base, building adaptive capacity across entire organizations, communities or sectors.

The section ends with a listing of several tools and resources to support learning and reflection, as well as cross-references to relevant resources discussed in previous sections of the guidance. ■

Section 4: Example cases

In this section, we provide three case studies of how the characteristics of an adaptation situation can be mapped to specific tasks to be addressed, and to specific approaches. Each case study begins with a narrative description of the situation, which describes the adapting actors, the climate hazards and the geographic location. Next, the key characteristics of the situation are analysed in order to identify critical tasks. Finally, a schematic diagram is presented which illustrates the sequence of questions to be addressed within a given case.

We describe two adaptation research cases: the first focused on dwindling water resources in the upper and middle Guadiana river basin, in Spain, and the second on drought impacts and neglected agricultural irrigation infrastructure in central Serbia. We also describe one policy case, examining the implications of climate change for ground-level ozone pollution in the UK, where ozone is already a public health concern, especially during heat waves. ■

The armoured coast on the village of Beesands, in Start Bay, UK. © Flickr/Slapton Ley Field Center

1 Introduction

1.1 Purpose of this guidance and how to read it

This document provides methodological guidance on assessing climate change vulnerability, impacts and adaptation as well as on implementing, monitoring and evaluating adaptation. Unlike many previously published documents and tools, which focus on specific approaches, this guidance covers a wide range of approaches, integrating them into a coherent framework. We thereby emphasize the diversity of adaptation challenges that exist, as well as the variety of approaches and methods needed to adjust to or cope with the effects of climate change.

A feature of this guidance is that it identifies the principal approaches and methods for addressing different kinds of adaptation challenges. Selecting appropriate methods for climate risk assessment and adaptation requires a series of methodological choices, and this guidance presents criteria and decision trees to assist the reader through those choices. Note that the decision trees provide guidance through the selection of methods, and not through the adaptation decision themselves. Once the appropriate methods have been identified, we explain how to apply them.

We organize the methodological choices according to five general stages of what we call the adaptation learning cycle, which are 1) identifying adaptation needs, 2) identifying adaptation options, 3) appraising adaptation options, 4) planning and implementing adaptation, and 5) monitoring and evaluation. This is an idealized model of adapting to climate change; "real-world" adaptation processes may not be linear, and in fact, may require refinement through iteration. This guidance therefore provides multiple entry points, highlighted in boxes throughout the document, to allow readers to enter (and re-enter) at various stages or substages of the process.

We should stress that we only consider methods for assessing impacts, vulnerability and capacity insofar as they are embedded into the wider picture of advancing adaptation. Assessments for other purposes, such as setting mitigation targets, are not discussed here.

1.1.1 What this document is not

This is guidance material, not a guideline. Assessing vulnerability and impacts and implementing adaptation are complex processes, and many of the tasks involved need to be carried out by experts. There is no "one size fits all" approach, and this document cannot cover the myriad issues that may arise for any given context. The decision trees we present are meant to be indicative – they do not prescribe specific methods as the only valid ones. The aim of the document is to provide an overview of the widely diverse activities that make up climate risk assessment and adaptation, and a coherent and integrated structure for addressing them.

While some aspects of climate risk assessment and adaptation are specific to sectors, regions and hazards, this document does not provide sector- or region-specific information. The current state of knowledge for specific regions, sectors and issues is extensively discussed by the Intergovernmental Panel on Climate Change (IPCC) in its *Fourth Assessment Report* (IPCC 2007a), and updated information will be available in March in the *Fifth Assessment Report*. This document instead focuses on generic methodological guidance applicable across sectors, regions and hazards.

1.1.2 How does this differ from previous guidance?

This guidance brings together adaptation insights generated from very different perspectives into one coherent framework. Many methods are available, often focused on particular aspects of climate risk assessment and adaptation, but there is little guidance on which method is appropriate in a given situation, or how to use different methods in a complementary way. The IPCC technical guidelines (Carter et al. 1994) focus primarily on impacts, risk management frameworks focus on (formal) decision-making, and community-based and ecosystem-based guidelines focus on building adaptive capacity. The decision trees in this guidance integrate these different approaches.

Recent literature has emphasized the need to both recognize and overcome barriers to adaptation (Adger et al. 2009; Moser and Ekstrom 2010). This document offers guidance on how to identify barriers to action, how to conduct research to better understand those barriers, and how to select and apply methods to overcome them.

1.1.3 Structure and content of this guidance

Section 1 introduces the basic structure and terminology used in the guidance, including how to frame the adaptation process and how to differentiate adaptation challenges in terms of the type of situation, the climate change impact, the actors involved, and the adaptation options available.

Section 2 describes the process of assessing impacts and vulnerability, as well as planning, implementing and monitoring adaptation. It provides guidance on which approaches and methods are applicable when confronted with a particular adaptation challenge. This is done in the form of decision trees, which guide the user in identifying appropriate methods based on relevant empirical, theoretical and normative criteria related to local circumstances.

Section 3 provides guidance on appropriate methods and tools for addressing these tasks, along with some examples.

Section 4 presents case studies from research and policy to illustrate the approach of this guidance to characterizing adaptation challenges and identifying salient methods and tools.

1.1.4 Who should read this?

Generally, this document is targeted at professionals such as researchers, consultants, policy analysts and sectoral planners who have some prior knowledge on climate risk assessment and adaptation. Some of the material is technical and requires some relevant experience. The guidance should also be of use to those leading or initiating planned and collective adaptation, such as community-based organizations or NGOs.

1.1.5 Where should one start reading?

This document provides multiple entry points, to allow readers to go directly to the material that meets their immediate needs. Suggested entry points are marked by boxes at the beginning of the subsections.

If you are interested in guidance on how to approach climate risk assessment and adaptation practice in general, you should read this introductory section to understand the basic concepts. Next, or if you don't need an introduction, you can proceed to Section 2, which is structured around the five stages of the adaptation cycle. Each stage is a potential entry point for readers.

If you are interested in the technical details of a particular method or tool, you can jump directly into the respective subsections of Section 3. The links between the identification of a task in Section 2 and the application of a method in Section 3 are made explicit in the decision trees, so it is not necessary to read the sections sequentially. Section 4 presents the case study examples and provides further links to the relevant sections describing the methods that have been applied in the cases. ■

1.2 Mapping adaptation challenges to salient approaches

The main objective of this guidance is to help analysts choose approaches that are salient for addressing specific ***adaptation situations*** – challenges that actors face in connection with expected, perceived or experienced climate change impacts (Hinkel and Bisaro 2013b). When climate change affects coupled ecological (or natural) and social (or human) systems, actors have to find ways to adapt, and in the process interact with one another at various levels of decision-making. For example, climate change may reduce snowfall in mountain regions. For ski resort owners, the adaptation challenge is then to try to understand the extent of the snowfall decline, the implications for their business, and the costs and benefits of different options for meeting immediate and long-term goals.

We use the term ***salient*** as defined by Cash et al. (2003): relevant to the needs of decision-makers. Many approaches might reveal interesting insights, but not all of those insights would be useful to the actors trying to address the adaptation challenge at hand. Our focus is on approaches that have the potential to advance adaptation practice on the ground. In this context, we do not consider an approach to be salient if it leads to maladaptation – adaptation choices and measures that increase climate risks (Barnett and O'Neill 2010). While this guidance does not explicitly address maladaptation, the literature on maladaptation has informed its development, as it raises the important point that actions that are effective in the short term may not be in the long term.

The choice of salient approaches is based on a number of criteria, starting with ***empirical criteria.*** These are criteria that describe characteristics of the adaptation situation and thus the basic conditions that must be met by the chosen approach or method. For example, an institutional analysis might be useful to a policy-maker looking to identify policy measures to influence others' adaptation actions. A planner evaluating potential infrastructure investments, on the other hand, might find a cost-benefit analysis more useful. There might also be situations in which both of these methods are applicable. We discuss these empirical criteria in more detail in the next subsection.

Empirical criteria are important, but they are not the only relevant criteria in choosing an approach. Methods may also differ with respect to their underlying theoretical assumptions, which may reflect the assumptions of the scientific discipline, school of thought or computational model on which they are based. Thus, ***theoretical criteria*** also inform the choice of approach. For example, to analyse and predict how adaptation actors might make decisions, an analyst could apply methods based on socio-psychological theory, which links cognitive variables to the behaviour of an adapting actor. Alternatively, a method from economics employing assumptions of utility maximization could be applied to the same task. A further example would be an analyst's choice between applying an impact model in which adaptation occurs, or one in which no adaptation occurs. That choice is not based on the adaptation situation itself, but rather on a judgement about what assumptions are likely to lead to useful insights.

In both research and decision-making, the choice of approaches is also strongly influenced by ***normative criteria***. The range of options that are considered acceptable is defined by values and priorities: for example, whether a coastal zone threatened by sea-level rise can be abandoned or must somehow be protected, or whether an endangered species must be saved or can be allowed to go extinct. This guidance cannot solve this sort of dilemma, but it can help to make explicit some of the criteria that should be considered in climate risk assessment and adaptation, and outline the fact that normative choices must be made by readers selecting and applying the methods contained in this guidance.

Finally, there are ***pragmatic criteria*** associated with the analyst carrying out the work. The scope of the assessment or the terms of reference for adaptation work often constrain the approaches considered to be relevant. Many of the methods require expert knowledge, and the skills and expertise of the analyst are thus relevant for choosing appropriate methods. So are the resources available; some of the computational and empirical methods in particular require substantial data, time, personnel and technical resources. This might be relevant in terms of considering the costs of generating new information, versus the disadvantages of acting on incomplete information. These are fundamental decision-making problems, and we do not address these kinds of choices. Pragmatic criteria have not been used in building the decision trees, which recommend the best available approaches from climate risk assessment research and adaptation practice. However, the information we provide about the different methods and tools may help readers make their own pragmatic choices.

1.3 Empirical criteria for choosing salient approaches

1.3.1 Stages of the adaptation process

The top empirical criterion for choosing a salient approach is the stage of the adaptation process at which an actor needs to tackle a particular adaptation problem. There is wide agreement that adaptation in an iterative learning process involving a number of stages, from the definition of the adaptation challenge, to monitoring and evaluating adaptation progress. For two prominent examples, see the climate adaptation framework of the UK Climate Impacts Programme (Willows and Connell 2003) and the Adaptation Support Tool of the European Commission and the European Environment Agency (EC and EEA 2013). Here we name the stages as follows:

1. **Identifying adaptation needs:** The goal at this stage is to gain more knowledge about the risks and opportunities faced in the adaptation challenge. What impacts may be expected under climate change? What are actors' vulnerabilities and capacities? Are vulnerable actors aware of potential threats? What major decisions need to be addressed?

2. **Identifying adaptation options:** How can the specific risks and opportunities that were identified be addressed? There may be several options available to achieve the desired goals.

3. **Appraising adaptation options:** The goal at this stage is to weigh the pros and cons of the different options and identify those that best fit the adaptation actors' objectives.

4. **Planning and implementing adaptation actions:** Once an option has been chosen, implementation can begin. The focus here is on practical issues, such as budgeting, assigning responsibilities, setting up institutional frameworks, and taking action.

5. **Monitoring and evaluation of adaptation.** As measures are implemented, the process is monitored and evaluated to ensure it goes as planned, identify any problems, document the outcomes achieved, change course as needed, and draw lessons from the experience.

These stages provide the primary **entry points** for choosing salient approaches in this guidance (Figure 1.3.1). For example, an analyst who is confronted with a challenge of developing a cross-sectoral adaptation plan would enter adaptation at the stage of "identifying adaptation needs", while

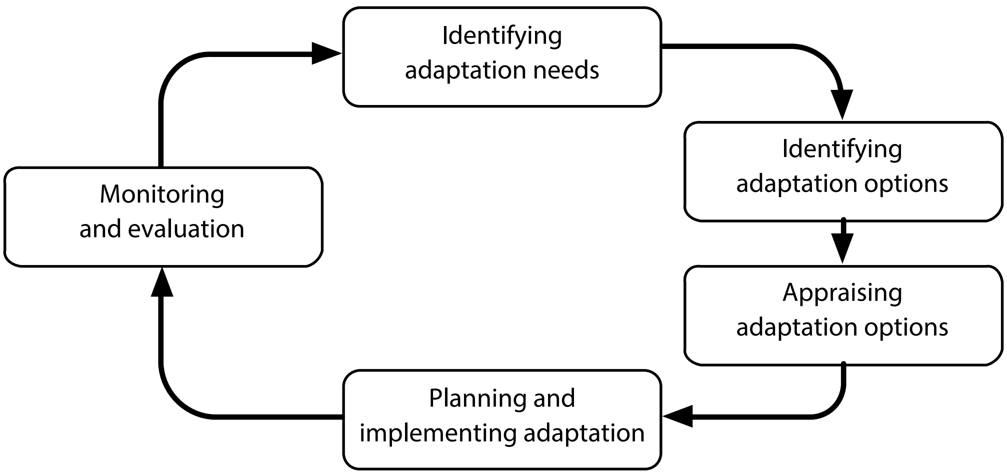

FIGURE 1.3.1 **The adaptation learning cycle.**

an analyst who is confronted with a particular decision, such as whether to raise a dike to reduce flood risks, would enter at the stage "appraising adaptation options".

1.3.2 Types of adaptation situations

The second empirical criterion we use for distinguishing adaptation challenges is actor configuration (Hinkel and Bisaro 2013b), with four basic types of adaptation situations:

1. Private individual;
2. Private collective;
3. Public influencing individual action; and
4. Public influencing collective action.

Private individual situations are those in which persons act in their own interest when they perceive a threat from climate change or foresee a benefit from this action. Examples would be farmers adapting their cropping patterns, or coastal dwellers flood-proofing their homes.

Private collective situations are those in which groups of people take action together in their own interest. Collective action means that there is interdependence between the adapting actors, in the sense that the actions of one actor will affect the others. Typical examples involve common-pool resource use, such as when farmers use groundwater from a common aquifer for irrigation. The use of water by one farmer limits its use for others. Another example of this situation would be coastal residents wanting to protect themselves from sea-level rise: barriers built by individual homeowners could increase the flood risk for their neighbours, or they could all work together to restore protective mangroves or dunes.

Public situations are those in which a public actor takes action with a fiduciary duty to act in the public interest. Public actors include local authorities, government ministries, public water boards, etc. – anyone acting on behalf of the citizenry. Public adaptation situations may be further distinguished into **public individual situations**, where the public actor seeks to influence the actions of individuals, and **public collective situations**, where the public actor coordinates or seeks to influence collective action.

A public actor may take physical action – that is, act upon the physical environment where vulnerable individuals are situated. An example would be to build a dike to protect people exposed to flooding. A public actor may also take influencing action – to encourage vulnerable actors to adapt. This may entail providing information, such as when governments sponsor campaigns to raise the awareness of people settling in high-risk areas such as floodplains or steep hills prone to landslides. Public actors may also provide economic incentives – to reduce the cost of adaptive measures, or make it expensive not to adapt. Finally, the public actor may enact laws or regulations, such as new zoning rules, building standards or insurance coverage requirements.

1.3.3 Other empirical criteria

Our guidance considers three other sets of empirical criteria as well. The first relates to characteristics of the climate risks (or opportunities) involved, as shown in Table 1.3.1.

Another set of empirical criteria relates to the vulnerable or affected actors. When seeking to influence vulnerable actors, it is important to understand how they perceive the impacts of climate change and what their concerns, interests and capacities are (Bisaro and Hinkel, 2013). Table 1.3.2 summarizes some of the relevant criteria and their implications.

A final set of empirical criteria relates to the available adaptation options, as shown in Table 1.3.3. ■

TABLE 1.3.1 **Characteristics of the climate risks/opportunities being addressed.**

Empirical criteria	Description	Value	Indication on salient approaches
Current variability	Are risks or opportunities due to current climate variability?	Yes/no (extreme weather events, e.g., may be due to current variability, whereas slow-onset climate changes are not)	If risks/opportunities are at least partly due to current climate variability, vulnerability to current conditions needs to be addressed as well as the need to adapt to changes in the climate.
Observed trend	Has a past trend been observed?	Unknown, not knowable, clear direction, no direction	If a past trend has been observed, it may be easier to motivate the affected actors to adapt. If the trend is unknown or shows no clear direction, vulnerability and capacity indication may be appropriate.
Future impacts	Given a scenario, can the impacts (or outcomes) be computed?	Yes/no	If future impacts (or outcomes) can be computed, this should offer a firmer basis for applying quantitative decision- making methods on future outcomes.

TABLE 1.3.2 **Characteristics of the affected actors.**

Empirical criteria	Description	Values	Indication on salient approaches
Awareness of risks of current climate variability and ongoing climate change	How well do actors understand the climate risks that they face (e.g. from floods, coastal storms, extreme heat)?	High/low	If low, measures to communicate current risks and raise awareness of adaptation needs are indicated.
Potential adaptive capacity	How well equipped are actors to adapt, in terms of financial, human, and social capital?	High/low	If low, measures to build adaptive capacity may be required; social vulnerability analysis may also be useful.
Actual or expected adaptation	To what extent are private actors actually adapting, or expected to adapt in the future?	High/low	If low despite high adaptive capacity, may want to conduct institutional or behavioural analysis to identify cognitive and institutional barriers. Incentives may also be identified to encourage adaptation.

TABLE 1.3.3 **Characteristics of the adaptation options.**

Empirical criteria	Description	Values	Indication on salient approaches
Relative costs	Investment costs relative to actors' annual income and capital stock	High/low	If costs are high, the ability to experiment and learn may be reduced.
Investment horizon	Time interval between when the investment is made, and when the resulting benefits are expected – as well as the duration of those benefits	Short/long	If short, data on current climate variability and climate trends may be sufficient; if long, projections of future climate change impacts are highly desirable.
Flexibility	An option is flexible if it allows for switching to other options that might be preferable in the future once more is known about the changing climate.	Yes/no	If options are flexible, then flexibility should be considered in decisions, and multiple-shot decision-making frameworks should be considered, e.g. adaptation pathways.
Conflict	Degree to which individual preferences and social welfare are in conflict.	High/low	If high, then institutional analysis may be necessary.

1.4 Decision trees for choosing approaches

This guidance presents the relevant criteria for choosing approaches for an adaptation challenge in the form of **decision trees**, in which **decision nodes** on empirical, theoretical and normative criteria lead to different approaches. The analyst enters a decision tree via an **entry point**'s decision node. Some approaches are intermediate tasks that lead to subsequent decision nodes within the same decision tree. Other tasks are **exit points** that lead to the next stage in the overall adaptation cycle.

The guidance document is structured as represented in Figure 1.4.1: Section 2 provides guidance on choosing the appropriate approach based on the adaptation challenge, and Section 3 provides more specific guidance on the approaches as well as available methods and tools.

The decision trees are accompanied by an explanatory text that walks the reader through each node and its implications for identifying salient approaches.

Importantly, there is no predefined sequence of approaches. Approaches are identified and methods are applied iteratively. Based on the current knowledge of the adaptation challenge, an initial approach is selected and applied, and new insights are gained. This, in turn, may lead to the formulation of a new adaptation challenge (see Figure 1.4.1).

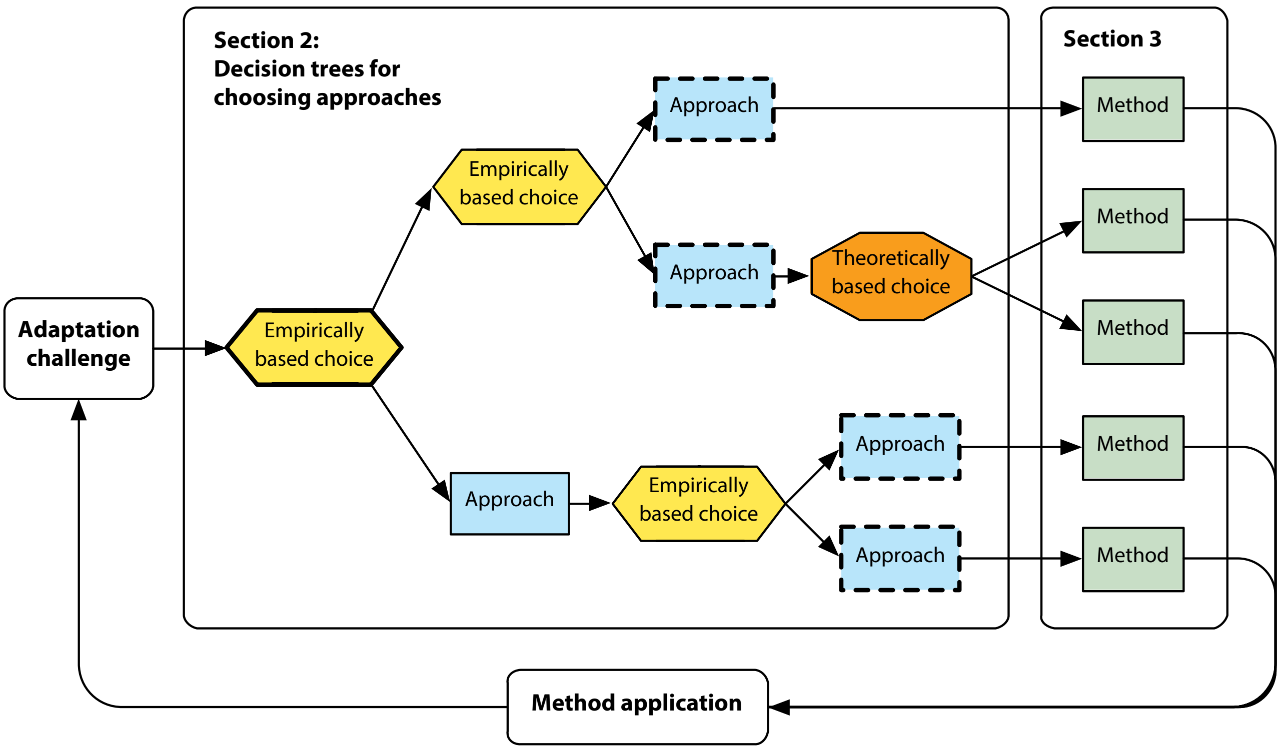

FIGURE 1.4.1 **Exemplary decision tree and its iterative application for choosing approaches based on the current adaptation challenge. Decision nodes on empirical criteria are represented by yellow hexagons; decision nodes on theoretical criteria are represented by orange octagons. The salient approaches are represented by blue rectangles. The entry point to a decision tree is a decision node with bold borders. Exit points are approaches that lead to the next stage in the overall adaptation cycle. They are represented with dashed bold borders.**

1.5 The role of stakeholders

Stakeholder participation is important at all stages of the adaptation learning cycle, and should cover the full range of affected groups, including women and marginalized populations. This is particularly the case for collective adaptation situations, to understand and take steps towards harmonizing the diverse and potentially conflicting perspectives of different actors. Stakeholders can play a range of roles in the adaptation cycle. In assessing vulnerabilities and impacts, they may provide access to a broader knowledge base, which in turn improves problem definition and strengthens the analysis. When identifying and appraising adaptation options, the stakeholders can have a key role in making preferences explicit, providing input for valuation techniques, and maybe choosing a measure through dialogue or negotiation. Stakeholder participation may also be important in evaluating and learning following the implementation of adaptation options. Thus, participatory methods may be appropriate in addressing many of the tasks identified in Section 2, and several are discussed in Section 3.

Focus group of women discussing their vulnerability to climate change in Nampula province, Mozambique © Katharine Vincent

Facing melting glaciers, Peru ©Flickr/Oxfam International, Zbigniew J. Tyrlik

2 Choosing approaches for addressing climate change adaptation

This section leads you through the process of thinking about the adaptation challenges faced and the approaches and methods available to address them. It includes five sub-sections, one for each stage of the adaptation learning cycle. The sub-sections are further broken down into more specific tasks that may be relevant depending on the specific adaptation situation.

Note that the structure of Section 2 differs from that of Section 3, because Section 2 is organized according to adaptation challenges or tasks, while Section 3 is organized by method types. While in some cases there may be overlap, there is no one-to-one correspondence: a single task may be accomplished by several different methods, and a method may be applicable across several adaptation tasks, or even across several stages of the adaptation process. Section 2 as a whole can be seen as a decision tree to guide you through the process of addressing adaptation and choosing relevant methods.

The first decision is at which stage to enter the adaptation learning cycle. This leads to the corresponding sections 2.1, 2.2, 2.3, 2.4 and 2.5 (see Figure 2.1). Within these sections, more specific entry points and decision trees are given, leading to the tasks to be addressed and the methods applicable. When a method has been identified, a link is given to a more comprehensive description of methods and tools in Section 3. See also Section 4 for examples of how the methods have been applied in cases from research, policy and practice.

For example, imagine that you are a coastal manager concerned about sea-level rise. You do not know how much the water will rise, or what the consequences might be, so you enter the adaptation learning cycle at the first stage: identifying adaptation needs (Section 2.1). Once you have identified the type of methods appropriate to your situation with the help of decision trees – e.g. impact projection – you would then move to Section 3 to explore impact projection methods in detail; in Section 4, you find an example of how a method of interest has been applied. Alternatively, if you already had credible and comprehensive sea-level rise projections, a clear understanding of your vulnerabilities, and some ideas for how to address them, you might enter the learning cycle at the stage of "appraising adaptation options" (Section 2.3), to read about different approaches you could take to judging the relative merits of, say, building dikes, re-zoning coastal areas, or restoring mangroves.

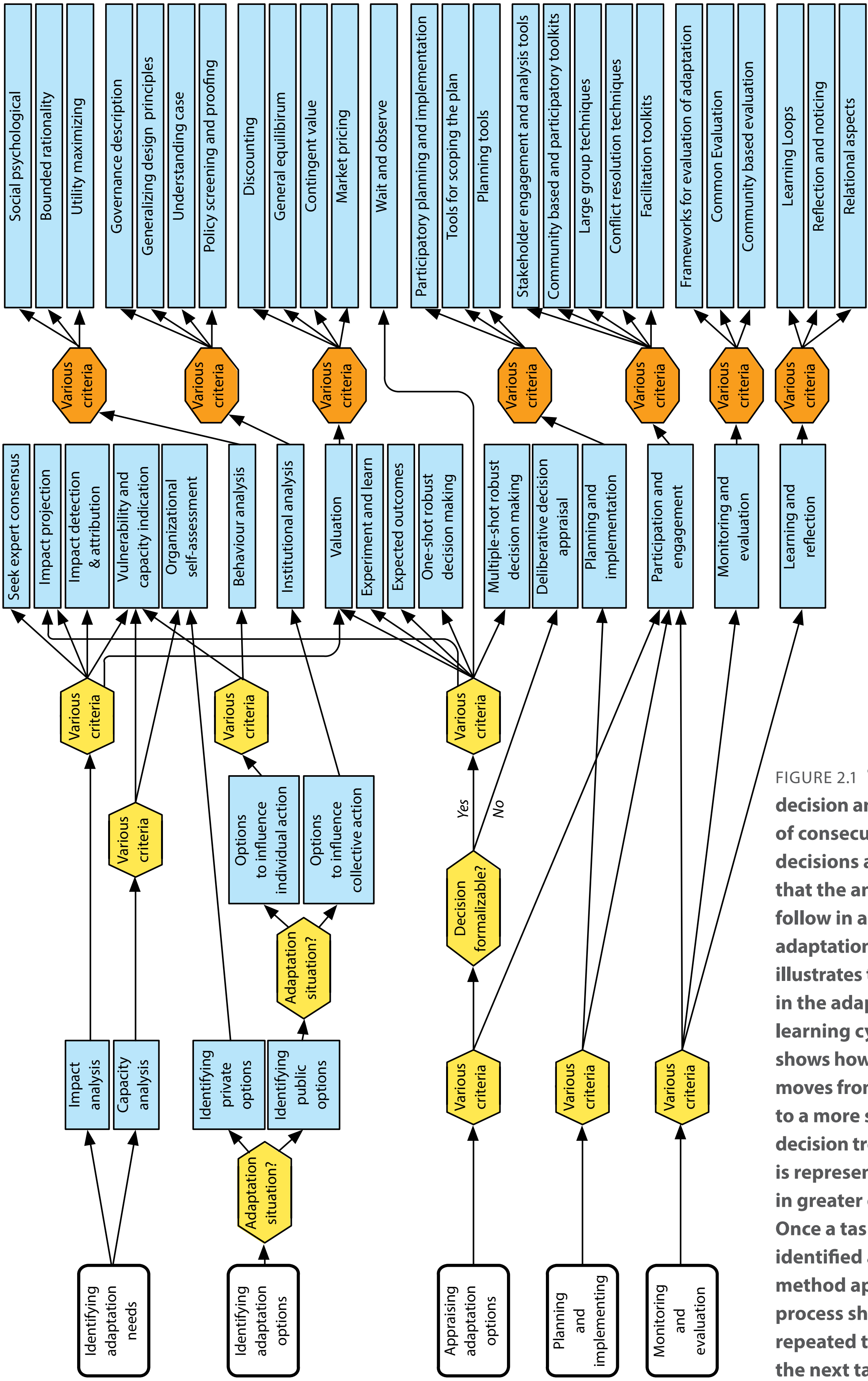

FIGURE 2.1 **Topmost decision and overview of consecutive decisions and tasks that the analyst may follow in addressing adaptation. This figure illustrates the 5 stages in the adaptation learning cycle, and shows how the analyst moves from one stage to a more specific decision tree. Section 2 is represented here in greater detail. Once a task has been identified and a method applied, the process should be repeated to identify the next task.**

Once you have decided at which stage to enter the adaptation learning cycle, further decisions on suitable methods must be taken. A key criterion will be the type of adaptation situation faced. Figure 2.1 gives an overview of approaches applicable at different stages of the adaptation process and for different adaptation situations. In the first stage there is a fair amount of overlap: similar approaches are applicable across all situations in identifying adaptation needs, with some differences in assessing capacity. In later stages, the approaches differ more significantly, as very different sets of actors, potential adaptation measures, and implementation mechanisms are involved.

We should note that although private individuals might learn from this guidance and find some aspects useful in assessing their own adaptation needs, opportunities and options, most of the approaches discussed here are geared to private collective and public adaptation situations. In all of those situations, stakeholder participation is important at all stages. Participatory processes can reveal different perspectives and competing preferences amongst actors, and facilitate mutual understanding, negotiation and cooperation. Many of the tasks discussed in Section 2 can be addressed in participatory manner; several methods for doing so are described in Section 3. ■

2.1 Identifying adaptation needs

Entry point

Adaptation situation:

- Climate change is a concern, but its potential impacts – and specific vulnerabilities to be addressed – are not well understood.

You want to:

- Identify adaptation needs

2.1.1 Overview

Entering at the first stage of the adaptation learning cycle is appropriate if adaptation needs have not yet been identified. Thus, the tasks are to gather information about current and potential climate change impacts and vulnerabilities, as well as potential opportunities. This is a critical stage, as it will guide all subsequent work. More than one approach may be needed to gather all the relevant knowledge.

Before we go deeper, we should warn that the term "vulnerability" is the subject of intense debates among experts in this field, with several competing definitions; "vulnerability assessment" has been used to refer to anything from projecting climate change impacts to carrying out an institutional analysis. Here we use the term in a very broad way, as the Intergovernmental Panel on Climate Change did in its Special Report on extreme events and disaster risk (SREX): "the propensity or predisposition to be adversely affected" (IPCC 2012). Note that this definition differs from the widely used one in the IPCC's *Fourth Assessment Report* (IPCC 2007a), which defines vulnerability as a function of exposure, sensitivity and adaptive capacity; SREX treats vulnerability as an intrinsic quality, separate from the hazard to which someone is vulnerable. We do not delve into that distinction here, however, but rather focus on the different tasks that users of this guidance might engage in, and refer to methods accordingly. We describe methods that model climate change impacts as “impact analysis”, and methods that analyse the institutional context of vulnerability – including political, social and economic factors – as “institutional analysis” (Hinkel and Bisaro 2013a). The latter include methods for assessing “social vulnerability”, considering rights, entitlements and power in the analysis (e.g. Bohle et al. 1994; Ribot et al. 2005). Finally, we use the term “indication” to describe methods that use indicators (individually or in indices) to measure climate impacts, adaptive capacity, or both.

2.1.1.1 Two aspects: impacts and capacity

Identifying adaptation needs involves two equally important and complementary sub-tasks:

1. Analysing observed or expected **impacts** of climate change (with and without adaptation).

2. Analysing the potential **capacity** to prevent, moderate or adapt to these impacts.

Early work on adaptation focused on the first sub-task. More recently, the adaptation literature has emphasized capacity analysis just as much. This is due to the realization that in many situations, what prevents adaptation action is a lack of capacity,

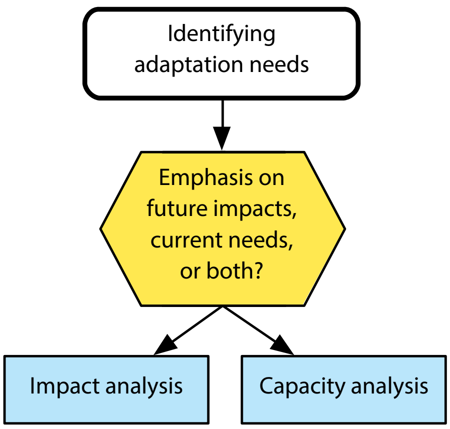

FIGURE 2.1.1 **Approaches to identifying vulnerability.**

often in the form of cognitive and institutional barriers, rather than a lack of knowledge of future climate impacts (Adger et al. 2009; Moser and Ekstrom 2010).

In most adaptation situations, both types of analysis are likely to be relevant. Arguably, if it is known at the outset that socio-economic and institutional factors play a significant role in shaping the magnitude of the risks and opportunities in a given adaptation situation, then capacity analysis will be more important (Hinkel and Bisaro 2013a). For example, the comparative health risk assessment (Ezzati et al. 2004) led by the World Health Organization (WHO) has warned that diarrhoea-related mortality is expected to increase due to climate change. In this case, the critical factor leading to diarrhoea-related mortality is lack of access to sanitation and clean drinking water, which makes people very vulnerable to water-borne diseases. Thus, in order to reduce those climate-related risks, we need to understand how to improve access to sanitation and safe drinking water.

Resource constraints may also make it necessary to prioritize one type of analysis over the other. Generally, impact analysis is more resource-intensive, in terms of cost, time and technical expertise required, while capacity analysis can be carried out under tighter constraints. Further, when uncertainties about future climate change are very substantial, the knowledge produced by impact analysis may not justify the resources required; there may also not be enough data to support a useful analysis. Finally, while participatory processes are useful in impact analyses (to complement climate data with direct observations, and to provide context), they are often essential in capacity analyses – both for the knowledge they provide, and to build a sense of ownership amongst stakeholders, which can increase the chances of success in the implementation stage.

2.1.2 Choosing approaches to impact analysis

Entry point

Adaptation situation:
- Climate change is a concern, but its potential impacts – and specific vulnerabilities to be addressed – are not well understood.
- Knowledge on impacts is considered to be critical in shaping adaptation needs.

You want to:
- Identify adaptation needs
- Understand the potential impact of climate change

Impacts analysis methods focus on gathering information on current and future biophysical and socio-economic impacts in order to identify adaptation needs. A variety of approaches are relevant; Figure 2.1.2 presents the decision tree for choosing amongst them. The respective approaches are described in more detail below, in particular in Tables 2.1.1 and 2.1.2.

DECISION NODE: Are studies on future impacts available?
The entry point to consider is whether studies of future impacts relevant for your location and/or sector have been carried out and are readily available.

DECISION NODE: Are the available studies comprehensive and credible?
If impact studies are available, the next question is whether these studies are credible and have comprehensively explored the full range of uncertainty. Impact projection is only useful for adaptation if a representative range of uncertainties in terms of climate and socio-economic scenarios is explored, because analyses based on only a limited range of scenarios may not produce reliable results. Ideally, it would even be desirable to use a range of impact models for these projections as impact models themselves may entail large uncertainties. In practice, however, impact models are only available for some sectors, such as agriculture, forestry and water, and rarely do resources allow for several models to be applied for the same impact (Hofmann et al. 2011).

Further criteria apply to the credibility of the impact models. Are the available models well calibrated on a robust empirical basis? Impact models themselves are uncertain, and thus ideally impact projection should also make use of several impact models in order to characterize uncertainty. These issues are discussed in greater depth in Section 3.2.2.

If the existing studies are not credible and/or comprehensive, it may be useful to conduct further impact analysis.

DECISION NODE: Are the results of these studies ambiguous regarding impacts?
When a significant number of studies have been undertaken, incorporating the range of possible scenarios, you must consider whether the results of these studies are ambiguous, with different studies showing different and possibly conflicting results. Ambiguity in impact projections can result from disagreement, or competing scientific claims, that may arise in regard to impact models and assumptions they employ. In these cases, it may be advisable to seek to build consensus amongst experts using approaches such as the Delphi method (see **www.rand.org/pubs/tools/expertlens.html**; also Doria et al. 2009).

When this ambiguity is not present, or once it has been addressed through consulting domain experts, you may move on to the next stage and consider identifying and choosing adaptation measures and options.

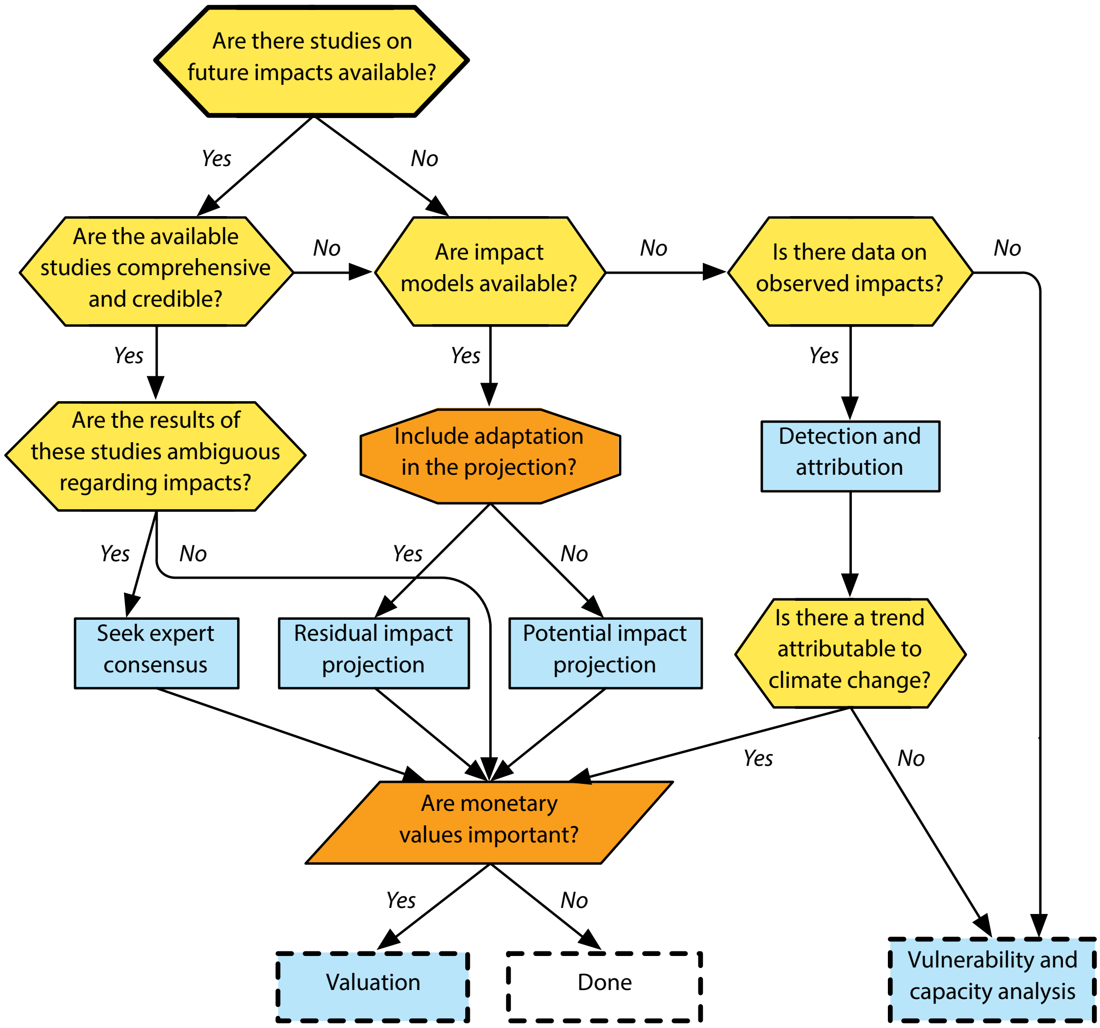

FIGURE 2.1.2 **Choosing approaches for impact analysis.**

DECISION NODE: Are impact models available?
If credible studies on future impacts are not readily available, the next relevant decision node concerns whether there are impact models available for exploring the given adaptation challenge. When impact models are available, impact projection may be carried out. When no impact models are available, then impact analysis should consider existing data on impacts and their attribution to climate and social factors (see below).

DECISION NODE: Should adaptation be included in the projection?
When impact models are available, it is then important to decide whether to choose methods that project *potential impacts,* which are those that may occur without considering adaptation (IPCC 2007a), in contrast to methods that project *residual impacts,* which include adaptation. Generally it is desirable to include adaptation in impact projections because this gives a more realistic picture on adaptation needs and opportunities.

For example, the IPCC's *Fourth Assessment Report* finds that "many millions more people are projected to be flooded every year due to sea-level rise by the 2080s" (IPCC 2007b). This is, however, a rather unrealistic picture because it assumes that people will continue to live in coastal zones despite frequent flooding or even permanent inundation (Hinkel 2012). See Table 2.1.2 for a description and some examples.

DECISION NODE: Are monetary values involved and not known?

Whether it is necessary to address valuation of impacts depends on whether monetary values of outcomes are considered important, and whether monetary values are already well known. Market prices may be sufficient for valuation of outcomes; however, when they are not, due to, for example, a lack of markets or intertemporal considerations, then various valuation methods can be applied (see Section 3.8). Whether valuation methods are applied is a normative choice to be made by the analyst and depends on the context in which impact analysis occurs.

DECISION NODE: Can a trend be detected and attributed to climate change?

In the case that impact models are not available, future impacts cannot be projected, and analysis needs to focus on current impacts. If there is data available on current and historical impacts, then the analyst can dig deeper looking for trends in the data (Section 3.2.1.1), and attributing these trends to anthropogenic climate change or to other drivers (Section 3.2.1.2). Trend detection may involve both socio-economic and biophysical systems, as is the case with detecting trends in damages from tropical storms. Detected trends in impacts can be attributed to climate change or other, often socio-economic, drivers either through process-based models or by building statistical models of the relationship between observed impacts and a number of explanatory variables. This is discussed in detail in Section 3.2.

Approaches using statistical methods for attributing observed harm to socio-economic drivers are sometimes also called vulnerability or adaptive capacity indicators in the literature (e.g. Yohe and Tol 2002). We give these approaches instead the more precise label of impact attribution approaches in order to avoid confusion. We reserve the term vulnerability indicator for approaches that are applied without using data on observed impacts

TABLE 2.1.1 **Impact-analytical methods.**

Method type	Trend detection	Impact attribution	Vulnerability indication
Task	Trend detection in time series data.	Explaining observed changes in study unit through (combination of) variables.	Indicating how climate change may impact study unit based on (combination of) variables.
Data availability	Time-series data is available on the study unit.	Data on explanatory variables is available. Data on observed impacts on the study unit is available.	Data on indicating variables is available. Data on observed impacts is NOT available. Future impacts cannot be reliably simulated using computational models.
Theoretical assumptions	Trend in data can be detected.	Observed impacts can be explained through climate or socio-economic variables.	Future impacts can be predicted based on current state.
Steps taken	1. Selection of variables of interest. 2. Application of statistical methods.	1. Selection of potential explanatory variables based on literature and theory. 2. Application of statistical methods.	1. Selection of potential indicating variables based on the literature. 2. Aggregation of indicating variables based on normative or theoretical arguments (Hinkel 2011).
Results	Statistically significant trend found (or not found) in the data.	Statistical model explaining observed impacts.	A function that maps the current state of the entity to a measure of possible future impacts. The measure is often called adaptive capacity.

TABLE 2.1.1 ***continued***

Method type	Trend detection	Impact attribution	Vulnerability indication
Example cases	Emanuel (2005) develops an index of accumulated annual power-dissipation from tropical storms in five ocean basins. The index is based on measures of wind speed and precipitation in the storms. Using statistical methods, an upward trend in the index is observed over the period since the 1970s. Pielke et al. (2008) find no trend in annual hurricane damage in the U.S. normalized for inflation, population and wealth.	Checkley et al. (2000), for example, explain changes in daily hospital admissions in Lima through the stimuli variables temperature, humidity and rainfall. Singh et al. (2001) explain observed incidences of diarrhoea in Fiji based on variations in temperature and rainfall. Tol and Yohe (2007) address the question of whether national-level socio-economic variables can explain observed impact data found in the EM-DAT database. An initial list of 34 variables was selected based on the IPCC's eight determinants of adaptive capacity. Six alternative indicators such as number of people affected by natural disasters, infant mortality and life expectancy were selected for which data was available in the EM-DAT database. 24 of the 34 indicating variables are found to be statistically not significant. Amongst the statistical significant ones, different ones are found significant for different hazards. They conclude that there are no universal explanations; mechanisms that cause impacts vary from case to case and from hazard to hazard.	Hahn et al. (2009) develop a Livelihood Vulnerability Index based on surveying 220 households in Mozambique. The indicating variables describing aspects such as demographics, social networks, resource availability and past exposure to climate variability were selected based on the literature and then aggregated using equal weights.
Issues involved	See Section 3.2.1	A general issue for the complex social-ecological systems considered in climate vulnerability and impacts assessment is that the amount of possible explanatory variables is very large and not conducive to building statistical models. Second, most impact data has only begun to be collected with respect to slow-onset changes; most impact data is on extreme events.	See Section 2.1.3

(Hinkel 2011). Thus, the difference between attribution and indication methods is that the former require data on observed impacts, while the latter are only applied in the absence of such data (ibid.).

2.1.2.1 Impacts, capacity and vulnerability indication

When no impact model is available, no trend is discernible in the data or the trend cannot be attributed to climate change, then the identification of adaptation needs and opportunities must rely exclusively on indication methods (see also Sections 2.1.3 and 3.2). These methods include impact indication, which involves indicators of climate impacts; capacity indication, which involves indicators of adaptive capacity; and vulnerability indication, which involves both kinds of indicators. Impact indicators usually relate to current climate and climate variability variables such as monthly average temperature or the average number of flood events. Impact indicators are rarely employed alone, however, but rather combined with capacity indicators to form vulnerability indices. These will be discussed in the next subsection.

TABLE 2.1.2 **Projecting climate change impacts with or without adaptation.**

Method Type	**Impact Projection**	
Task	Project future impacts of climate change.	
Subtype	**Potential Impact Projection (PIP)**	**Residual Impact Projection (RIP)**
Characteristics of adaptation situation	Interaction between the drivers and the study unit can be formally represented as a computational model.	
Theoretical assumptions	People affected do not adapt.	People affected adapt. Adaptation can be formally represented by a computational model.
Steps taken	1. Selection of climate and socio-economic scenarios; 2. Computation of the potential impacts of those scenarios; 3. Evaluation of impacts using impact indicators.	1. Selection of climate and socio-economic scenarios; 2. Selection of adaptation options and strategies; 3. Computation of the impacts of the scenarios and the adaptation strategies; 4. Evaluation of impacts using impact indicators.
Results achieved	A list of propositions that map each scenario to an impact. Each proposition is interpreted as follows: "When the world evolves according to scenario S1 and people don't adapt, the impact will be I1".	A list of propositions that map each scenario to a residual impact. Each proposition is interpreted: "When the world evolves according to scenario S1 and one adapts according to strategy A1, the impact on the vulnerable system will be I1."
Example cases	Dasgupta et al. (2007) gauge the impacts of sea-level rise on developing countries. Impacts are projected for sea-level rise scenarios of 1 to 5 metres by overlaying data on land, population, agriculture, urban extent, wetlands and GDP with the inundation zones of the sea-level rise scenarios. They find that tens of millions of people will be displaced and economic damages will be severe, but limited to a few countries.	Hinkel et al. (2010) address the question of what will be both the potential and the residual impacts of sea-level rise on coastal countries of the EU-27. The authors use the DIVA model to project the impacts of various sea-level rise and socio-economic scenarios on the countries first without any adaptation (potential impacts) and then with an adaptation strategy (residual impacts) that raises dikes to protect against coastal flooding and nourishes beaches to protect against coastal erosion. It is found that while the potential impacts are substantial, adaptation reduces these impacts by one or two orders of magnitude.
Issues involved	Likely to overstate impacts, as at least some adaptation is likely to occur, especially in the face of major impacts (e.g. coastal residents will move after repeated floods, not wait until total, permanent inundation).	It is challenging to develop realistic models of adaptation. The assumptions made in the model (e.g. dumb, typical, smart and clairvoyant farmer) will significantly shape the results.

2.1.3 Choosing approaches to capacity analysis

Entry point

Adaptation situation:

- Climate change is a concern, but its potential impacts – and specific vulnerabilities to be addressed – are not well understood.
- Social, economic and institutional capacity are considered to be critical in shaping adaptation needs.

You want to:

- Identify adaptation needs
- Understand which social, economic and institutional factors shaping vulnerability and adaptive capacity are relevant

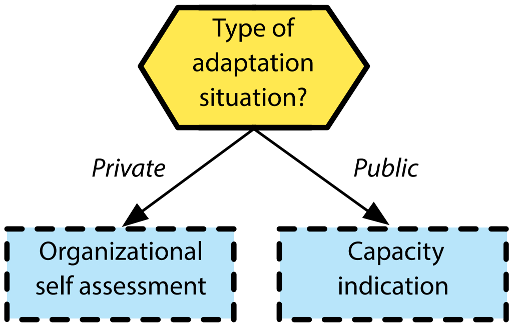

FIGURE 2.1.3 **Choosing approaches for assessing potential capacity.**

Adaptive capacity is a broad concept that refers to the availability of all kinds of resources – such as natural, financial, cognitive, social, and institutional capital that may be mobilized for adapting to climate change. See, for example, the discussion of these resources in the sustainable livelihood framework (Carswell et al. 1997). As a consequence, a wide variety of methods for assessing capacity can be found in the literature. The applicability of these methods depends on the type of situation (Figure 2.1.2).

Public adaptation situations

In public situations, a public actor may wish to understand the adaptive capacity of private actors in order to influence their actions at later stages in the adaptation process. Towards this end, capacity indicators or indices are used. These approaches attempt to "indicate" possible future impacts based on data collected on the current state of the exposed individuals, groups of people, communities or countries. In the literature, these approaches are also called social vulnerability indices. Different types of variables are used for this.

The main group of variables used in adaptive capacity and social vulnerability indication approaches relate to the generic and *potential capacity* of social groups to adapt and includes variables at a micro-analytical level and at a macro-analytical level. The former focus on individuals or households, and analyse the resources available to individuals. The latter, the macro-analytical level approaches, generally focus on aggregate characteristics of social systems, such as, for example, GDP, education levels, age structure, information management (McGray et al. 2007) or polycentric decision-making contexts (Pahl-Wostl et al. 2007). Adaptive capacity indicators may also include variables that refer to the current climate as well as experienced disaster damage/losses. See Section 3.3 for a more comprehensive treatment of these approaches.

Generally, adaptive capacity and social vulnerability indication methods face the challenge that the aggregation of indicating variables into a vulnerability index can hardly be supported by theory, nor can the results be validated empirically (Hinkel 2011). Due to the lack of theory, some approaches seek to validate through data generated in interviews and focus groups against the "narratives" of vulnerability present in the literature (e.g. Mustafa et al. 2011). Other approaches use expert judgement, but different experts usually rank dimensions differently (Brooks and Adger 2005). See Table 2.1.1 for a summary and examples.

It is thus important to note that adaptive capacity indicators only provide a rough, high-level and rapid assessment of the potential and generic capacity of actors threatened by climate change. Whether this potential capacity is realized in the context of a specific climate threat depends on many contextual institutional and cognitive factors. As public actors are concerned with influencing action of private actors, they may generally be interested in further exploring these factors by applying methods of behavioural and institutional analysis in order to understand and predict how the actors they aim to influence will act given a particular public adaptation option. These methods are only applicable once an adaptation problem or decision has been identified, however, as only with respect to a specific adaptation decision can the relevant institutions and cognitive factors be identified. These methods will thus be treated in Section 2.2 on identifying measures. Methods that aim at building adaptive capacity refer to implementation and are therefore treated in Section 2.4.

Private adaptation situations

In collective private adaptation situations, where firms, or community groups adapt in their own interest, organizational and procedural aspects of adaptive capacity are most relevant. Towards this end, organizational self-assessment methods are applicable.

2.2 Identifying adaptation options

2.2.1 Overview

Entry point

Adaptation situation:

- A specific adaptation problem or decision has been identified.

This is what you want to do:

- Identify adaptation options.

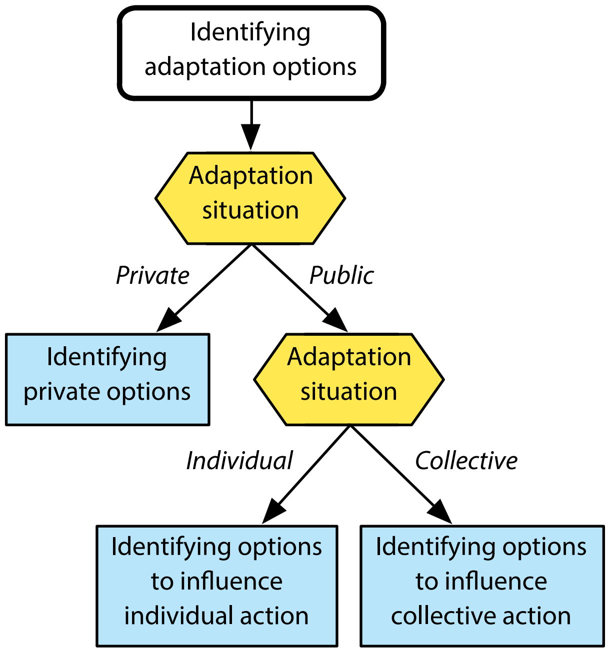

FIGURE 2.2.1 **Choosing approaches for identifying adaptation options.**

Once specific adaptation needs have been identified, the next step is to identify potential ways to address them (measures, strategies or actions). For example, a climate impacts and vulnerability analysis might have found that due to sea-level rise and changing weather patterns, coastal communities will be exposed to major floods during storm surges. The task would then be to identify ways to address that risk. We refer to these as *adaptation* *options* – different pathways that can be taken. For example, for a municipality, protecting the coast might involve building new infrastructure, such as a sea-wall, or working to restore natural barriers such as dunes and mangroves – both of which could be done simultaneously. Individual homeowners might consider raising or fortifying their houses, or getting better insurance. The public sector might consider financial incentives to encourage individuals to pursue those measures, or if it considers retreat a better option, it might provide incentives to leave, or change zoning laws to prevent further development.

Methods to identify adaptation options are often not systematically applied, and mix inputs from analysts, who model different options, and stakeholders, who identify options already in use to handle current climate variability (Carter and Mäkinen 2011). A full discussion of these methods can be found in Section 3. Appraising and choosing options involves decision-making methods and is addressed in Section 2.3.

This section describes methods for both public and private actors to identify adaptation options, drawing on approaches from the fields of organizational learning, decision analysis, policy analysis, and institutional and behavioural analysis.

The nature of this task is different for private and public actors, and thus we cover appropriate methods for each in separate subsections. Private actors act in their own interest, and can focus narrowly on the adaptation options available to them (see Section 2.2.2). Public actors, on the other hand, are mandated to act in the public interest and have jurisdictional power to influence the behaviour of others. In identifying adaptation options, a public actor thus needs to consider a much wider array of measures and criteria, such as distributional effects and potential conflicts that may arise (Sections 2.2.3 and 2.2.5). As a consequence, a different set of tasks are applicable. As public adaptation situations are more complex and require influencing the behaviour of others, research methods – particularly from behavioural and institutional research – can play an important role.

Some methods for identifying adaptation options are relevant to both public and private adaptation situations. For example, often a starting point is to look at existing strategies to address similar hazards due to current climate variability – for example, how farmers have traditionally dealt with water scarcity, or how people cope with regular seasonal floods. These responses may be inventoried and analysed in conjunction with key stakeholders in a given sector or region. However, the resulting list of options may not suffice when the climate is changing in ways that go well beyond local experience. Thus, additional measures may have to be identified through expert judgement (UNDP-UNEP Poverty-Environment Initiative 2011) or by considering theoretically appropriate options (Ebi and Burton 2008). Experiments and research and development may also lead to the identification of adaptation measures, such as new crop varieties or design technologies.

In situations involving collective adaptation, identifying options can be much more complex. Options that are theoretically possible – say, choosing not to further develop a high-risk coastal zone – might not be feasible without first building consensus, and that requires great leadership and skill. At the same time, actors' awareness of the limits of their authority or influence might lead them to not even consider potential measures that would be beyond their immediate control. Many things can affect this: different missions, levels of power and authority, political interests, funding and so on. Finally, as mentioned earlier, actors must have sufficient knowledge, awareness, skill and financial resources to be able to carry out the methods associated with each task. These are barriers related to pragmatic criteria for identifying tasks and selecting methods and are not incorporated into the decision trees because they arise in specific contexts. Therefore, it is important to be aware of these potential barriers, at each stage of the process.

2.2.2 Identifying private adaptation options

Entry point

Adaptation situation:
- A specific adaptation problem has been identified.
- You are a private actor (or you carry out an assessment on behalf of a private actor).

This is what you want to do:
- Identify private adaptation options.

Individual private actors act in their own interest, and thus the identification of adaptation options is a more narrowly defined task. For collective private actors, however, such as community-based organizations or private companies, some additional considerations may arise: might different members of the group have different priorities, interests or adaptive capacity? Several approaches can be taken to address these issues. For example, an organization may choose to apply capacity self-assessment methods as part of the process of identifying adaptation measures (Section 3.3.2). Other useful methods for identifying adaptation options in collective private situations include brainstorming, consultation exercises, focus groups, checklists, screening, free-form gaming, and policy exercises (Carter and Mäkinen 2011).

2.2.3 Identifying public options for influencing individual action

DECISION NODE: Potential capacity?
Assessing the capacity of private actors includes two aspects. The first is the actor's **potential capacity:** the resources, including material resources, skills and networks or social capital, available to the private actor. If potential capacity is unknown, methods may be applied to describe resources available to the affected actor, such as the sustainable livelihoods framework (Scoones 1998) and the IPCC adaptive capacity framework (see Section 2.1). Assessing the potential capacity thus refers to assessing the resources available to an actor in an objective sense.

When actors have low capacity, they are unlikely to adapt on their own. They may not even know how they could adapt, or have any viable options. In these situations, the priority for public actors is to find ways to increase those private actors' adaptive capacity – by providing information and training, infrastructure, financial assistance, or other support. For example, they may provide economic incentives or training, or they may consider measures to regulate adaptation, for example, by legislating building codes in coastal zone or establishing parks for natural resource conservation. Further, potential capacity may be increased by physical measures such as infrastructure provision. Which type of measure a public actor might consider is determined by the relative costs of the measure; tasks and methods for making these decisions are considered in Section 2.3.

DECISION NODE: Are private actors adapting?
If the potential capacity of private actors is high, the next question is, are they in fact adapting? This second aspect of capacity is what we call **actual capacity**. Actual capacity includes the capacity of the actor to go through the whole adaptation learning cycle – that is, the capacity to assess their adaptation needs, to identify adaptation measures, to appraise options, and to implement, monitor, evaluate and learn. Actual capacity is thus different from the potential capacity in the sense that actors might have potential capacity, in terms of financial resources and skills, but still not act. For

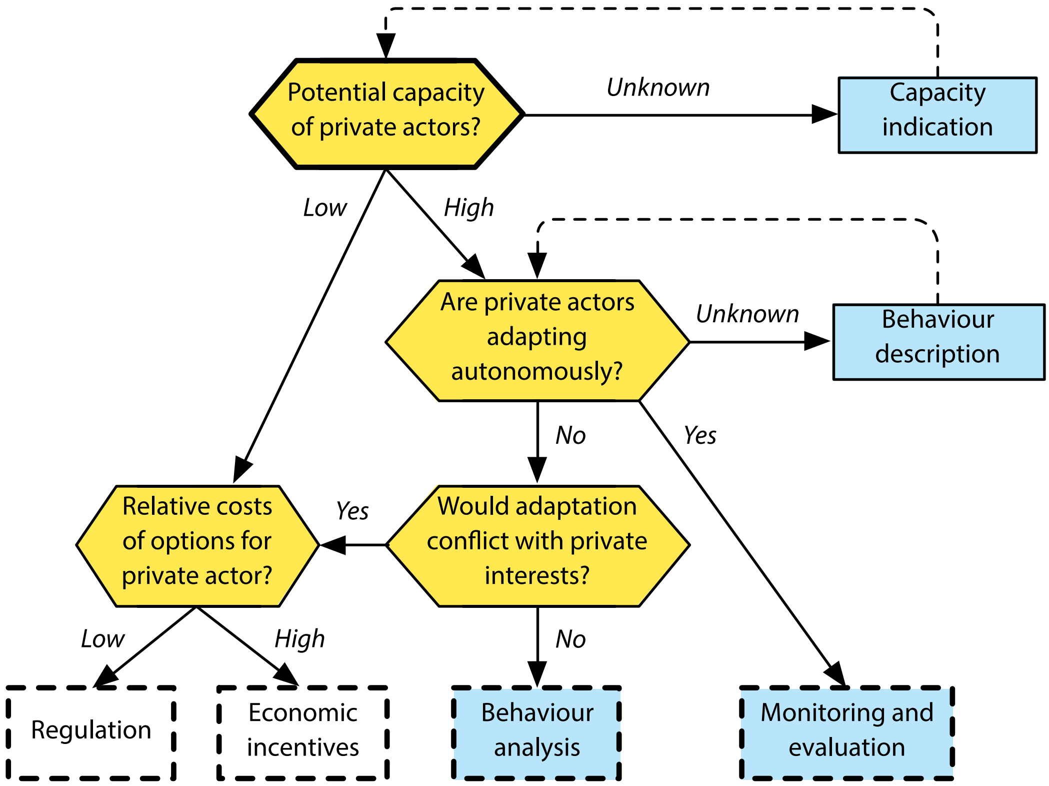

FIGURE 2.2.2 **Choosing approaches to support a public actor influencing individual adaptation.**

example, elderly people threatened by heat waves in a developed country may have the potential capacity to adapt by installing an air conditioner, or even just drinking more water (see Table 2.2.1). However, their actual capacity may be much lower, because of cognitive barriers, or other reasons.

Actual capacity thus includes institutional and cognitive factors that enable and constrain potential capacity. These are called **barriers to adaptation** (e.g. Moser and Ekstrom 2010). At the individual level, these barriers to a great extent involve an actor's own perceived ability to act effectively. People may misinterpret information about climate change, be distracted by other priorities or by distance to the issue, have too little time to think about the risk, or have a mental/cultural frame of reference which blocks out the risk or the need to adapt to it – such as a belief that whatever happens is God's will, and trying to stop it is futile (Moser and Ekstrom 2010; Berkhout et al. 2006). One approach that can be used to examine such barriers is Protection Motivation Theory (Rogers 1983; applied to climate risks by Grothmann and Patt 2005). This literature suggests that it is not sufficient to focus on actors' potential capacity, as this potential is often not realized (Adger et al. 2007). It is therefore desirable to understand barriers to adaptation action early in the process, well before implementation, and hence to focus on what we call here actual capacity. Even then, further barriers will still likely emerge during implementation; these are discussed in Section 2.4.

At both the individual and collective levels, institutional factors – from social norms, to the effectiveness of governance systems – may also create barriers to adaptation. Moser and Ekstrom (2010) note that information about vulnerability and impacts may not be adequately communicated, or may not reach individuals, if it does not reach the appropriate governance networks, or if those networks are dysfunctional. Analysis of governance and institutional arrangements is thus a critical task in this situation, as it aims to understand barriers to actual capacity. By better understanding the barriers, measures to overcome them can be selected as part of the adaptation plan.

If private actors are, in fact adapting as needed, then the public actor does not need to take influencing action and can directly consider monitoring and evaluating adaptation (Section 2.5).

DECISION NODE: Would adaptation conflict with private interests?

If private actors are not adapting although they have the resources – that is, the potential capacity – to do so, this is a clear indication that cognitive and institutional barriers are present. The subsequent decision node for the public actor is to consider whether adaptation would conflict with private interests.

If adaptation conflicts with private interests, then identifying relevant adaptation measures to influence private action must consider the relative costs of action. This informs the choice of type of policy instruments, which can be appraised through various methods (Section 2.3).

Conversely, if adaptation does not conflict with private interest, behavioural analysis should be undertaken to understand why adaptation is not taking place, and identify the relevant cognitive and institutional barriers. Analysis here addresses whether inaction is due to a lack of information, or to more complex barriers internal to the individual (cognitive) or in the governance system (institutional), which also includes slower changing institutions related to culture and social norms (Moser and Ekstrom 2010). In the former case, it may be assumed that awareness-raising may be sufficient, while in the latter case, risk communication supported by behavioural or institutional analysis may be necessary.

The latter illustrates a challenge in choosing an approach to examine barriers to adaptation. This choice depends to a significant degree on the circumstances and the resources available. Undertaking behavioural analysis, for example, to understand cognitive barriers might require careful study over several years, while the next impact event can be expected much sooner. In this case, it might be more appropriate to launch an awareness-raising campaign, perhaps through television advertisements, even without a full understanding of the cognitive barriers that may be present, and learn more by monitoring and evaluating the effectiveness of the measure.

TABLE 2.2.1 **Salient approaches for identifying public adaptation options for influencing individual action. "N/A" means these criteria are not relevant for the choice of the approach.**

Potential capacity?	Are actors adapting?	Conflict with private interest?	Indication on salient approach	Example
Low	N/A	N/A	Practice: economic incentives or regulation	Public actor wanting to influence smallholder farmers faced with increasing droughts needing increased farm inputs, including drought-resistant crops
High	Yes	N/A	Monitor and evaluate	Public actor wanting to influence people living in a floodplain to take protective measures, and actors are already adapting
High	No	Yes	Practice: economic incentives or regulation	Public actor wanting to influence farmers to keep migration corridors open in order to allow species to migrate and thus maintain biodiversity
High	No	No	Behaviour analysis: what constrains individual action?	Public actor wanting to influence people living in a floodplain to take protective measures, which they are not currently doing

2.2.4 Choosing approaches to behaviour analysis

Entry point

Adaptation situation:

- A specific adaptation problem or decision has been identified.
- You are a public actor (or you carry out an assessment on behalf of a public actor) and want to influence the adaptation of private actors in your jurisdiction.

This is what you want to do:

- Understand what drives and hinders individual behaviour or make predictions thereof.

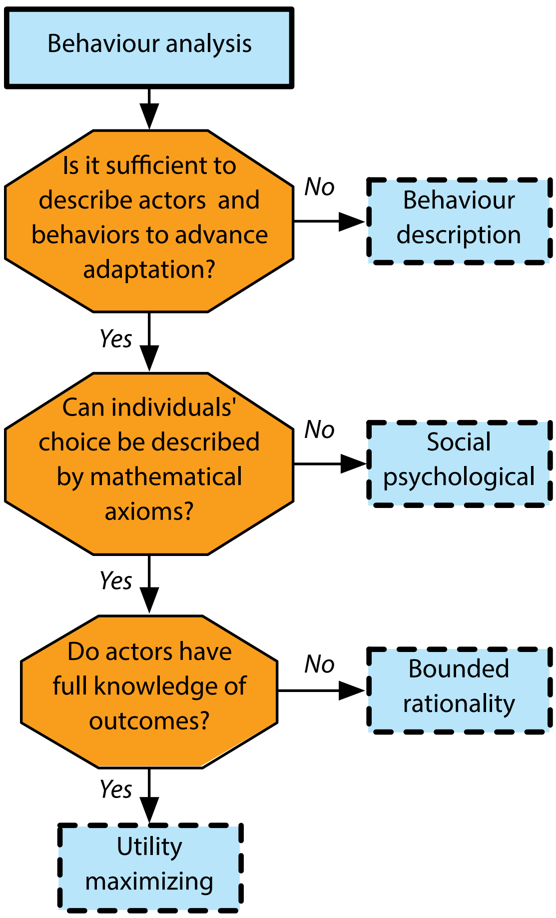

FIGURE 2.2.3 **Choosing salient approaches for behaviour analysis.**

Behavioural research is carried out using a variety of methods, e.g. laboratory experiment, field experiment, econometric analysis, etc., in order to understand how actors (organizations or individuals) make decisions, and how those decisions vary according to contextual factors. The insights derived from such applications can then be drawn upon to explain decisions in other situations, e.g. why individuals might purchase lottery tickets when they know it's almost certainly a waste of money. In climate change adaptation, the application of these methods is based on the assumption that knowledge of what drives individual decision-making is necessary in order to advance adaptation. For example, understanding factors explaining household decisions on flood risk reduction can help improve the design of flood risk communication strategies. The application of these methods is discussed in Section 3.5; here we develop criteria for identifying the critical tasks and selecting methods of behavioural analysis.

It may be noted that behavioural analysis tasks and methods are closely related to the decision-analytical methods described in Section 2.3, as they may employ similar assumptions about actors' choice processes. However, these types of methods can be differentiated fundamentally from one another on the basis of their goals. Behaviour analytical tasks and methods are descriptive – that is, they seek to identify (empirical or theoretical) models that "realistically" describe observed behaviour. Conversely, decision-analytical tasks and methods are prescriptive – that is, they seek to identify measures that are optimal under some decision criteria, irrespective of whether this "optimal" behaviour can be observed in practice.

Following the classification of Cooke et al. (2009), we differentiate at the highest level between methods based on assumptions about individual choice processes which can be described by mathematical axioms regarding outcome ordering, and methods based on social psychological theory which do not employ such rigorous restrictions on preferences over outcomes.

DECISION NODE: Are preferences described by mathematical (rational choice) axioms?

The first decision encountered in selecting an appropriate method of behavioural analysis involves the theoretical assumptions employed. Approaches based on **utility maximization** explain and predict behaviour based on axiomatic mathematical models which assume that rational individuals maximize utility. The classical assumptions of rational choice are that given a choice set, preferences are complete, transitive and continuous. This is a vast literature dating back more than a century to the foundations of modern economic thought and utilitarianism (e.g. Mill 1863). As it is beyond the scope of this guidance to discuss this vast literature, we limit ourselves to a couple of approaches relevant for adaptation. If you believe that actor's choice processes can be appropriately described through the axioms of rational choice, you may wish to use one of these approaches.

On the other hand, approaches based on **social psychological** theory explain and predict behaviour through empirically based statistical models using cognitive variables such as motivations and barriers for action. A prominent theory which underlies these approaches is Protection Motivation Theory, described briefly in Section 2.2.3, which posits that actors take action based on four factors: the perceived severity of a threatening event, the perceived probability of the occurrence, the efficacy of the recommended preventive behaviour, and the perceived self-efficacy (Rogers 1983). In the domain of adaptation, Grothmann and Patt (2005) draw on this theory to explain the adaptive behaviour in case studies in Germany and Zimbabwe, and find it explains adaptive actions better than traditional micro-economic models of decision-making.

It is worth noting that although this decision node offers a choice of theoretical assumptions, behaviours around climate risks and adaptation which appear intuitively irrational might be more fruitfully examined through the methods of social psychology. For example, Dow et al. (2013) note that risk has both a material dimension, and a socially constructed and culturally defined one, and the combination of the two can make the same event characteristics and probabilities "appear very risky and intolerable for one group and as tolerable and manageable by another". Meaning and interpretation are often important in understanding and explaining behaviour, particularly outside of a market setting, and social psychological approaches explicitly address these aspects.

DECISION NODE: Do actors have complete knowledge and cognitive abilities?

Rational choice or maximization approaches can be further distinguished according to whether they assume that individuals are fully rational, having the ability to compare a full set of options, and those that assume only bounded rationality. Fully rational means that agents are perfect optimizers, in the sense that they have complete information and are able to calculate outcomes for all contingencies, and optimize utility (Cooke et al. 2009). While utility maximization approaches are used widely, they have been criticized for making unrealistic assumptions. Knowledge is often not freely available, and the limitations of human cognitive capacities are well-documented (van den Bergh and Gowdy 2003).

Bounded rationality relaxes the assumptions of utility maximization, and aims to predict behaviour based on heuristics or rules of thumb, which are simple rules that achieve an approximately optimal outcome (Kahneman et al. 1982). One such rule is that people will consider available options, and choose the first one that is satisfactory (Simon 1956). This so-called "satisficing" stands in contrast to “maximizing” in that it involves defining a set of minimum criteria and accepting any choice that meets them, rather than weighing all possible options to find the best one. (For example, in purchasing a car, a satisficer might set a price range, a minimum fuel economy, and an array of desired features, and buy the first car that meets those criteria. A maximizer would evaluate all cars that meet those criteria, and then choose the most desirable.) Closely linked to bounded rationality is the concept of adaptive heuristics: people develop and use mental shortcuts to identify acceptable options quickly, with a minimal amount of necessary information (Payne et al. 1993).

2.2.5 Identifying public options for influencing collective adaptation

If interdependence does exist between private actors, a collective action situation is at hand and a different set of decision nodes becomes relevant for the public actor to consider.

In many collective situations, interdependence gives rise to conflicts between the individual preferences of private actors and social welfare. Examples of such interdependence are:

- Environmental pollution: If an actor pollutes the environment and does not suffer from the pollution herself, then it is not rational for the private actor to stop polluting.
- Over-exploitation of a common pool resource: For scarce resources which any actor can access and use, it is not rational from the perspective of one single actor to preserve the resource. From the social welfare perspective, however, it may be. An example of such a situation would be a common groundwater stock that is declining under climate change and is used by a group of farmers to irrigate their fields.
- Under-provisioning of a public good and free-riding: For actors that consume a freely available public good, it is not individually rational to contribute to the maintenance or the provisioning of the public good. An example of such a situation is a community of private actors facing increasing risks of flooding but not contributing to the maintenance of the dike that protects them.

In order to identify appropriate policy measures, one needs to understand the nature of these interdependences and conflicts.

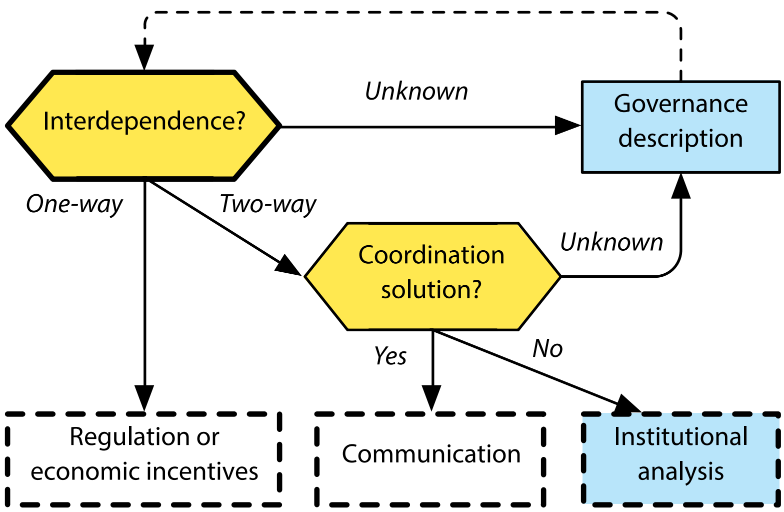

FIGURE 2.2.4 **Choosing approaches to support a public actor influencing collective adaptation.**

DECISION NODE: Interdependence?

The first decision node concerns what type of interdependence is present. One-way interdependence means that the action of one actor influences another actor, but not vice versa. In the economics literature, this is called a unilateral externality (Dombrowsky 2007). Examples of such challenges include pollution problems and upstream-downstream situations in shared river basins. Prominent examples of one-way interdependence in adaptation include the provisioning of urban flood risk reduction by private upstream farmers, and the establishment and maintenance of biodiversity migration corridors by private farmers (Bisaro and Hinkel 2013). The design and appraisal of these options may be addressed through methods for formal appraisal of options (see Section 2.3).

When interdependence is one-way, the public actor needs to find a normative agreement between the interests of the upstream and downstream actors and may achieve this through regulation and economic incentives. When interdependence is two-way, the decision node concerns whether a coordination solution is available. If it is unknown which type of interdependence exists, the relevant task is a description of governance arrangements, which involves identifying relevant actors and their preferences (see Section 3.6).

DECISION NODE: Is a coordination solution available?

When interdependence is two-way, the decision node concerns whether a coordination solution is available. A coordination solution is one in which all actors are satisfied with a given course of action, and no trade-offs or conflicts of interests are present. If it is unknown whether such a solution exists, the indicated task is governance description, which involves understanding the interests, preferences and networks of relevant actors.

When a coordination solution is available, communication, awareness-raising or information-sharing amongst the private actors is required in order to promote coordination and facilitate adaptation. For example, in shared transboundary river basins, there may be sufficient water to fulfil demand, provided that water is extracted at different times in a coordinated manner. It may be sufficient for actors to share information about when they will extract the resource, in order to avoid shortages at any given time, while still providing enough water to cover all of the individual actors' demands.

When no coordination solution is available, we have what we call a *social dilemma*. This means that there is a conflict between the common good and individual private interests, and some or all private actors involved will need to compromise. One prominent type of such a challenge is the over-exploitation of a common pool resource, such as when a common groundwater stock that is declining under climate change is used by a group of farmers to irrigate their fields (Varela-Ortega et al. 2013). Another prominent type of social dilemma is the private provisioning of public goods. Take, for example, a community of private actors facing increasing risks of flooding and needing to collaborate to maintain the dike that protects them. In these cases, internal solutions are not very likely, but they are still possible, and understanding the nature of these conflicts and identifying policy measures requires in-depth institutional analysis (see Section 2.2.6). There are no panaceas to policy design for social dilemmas; all instruments or mixes thereof may be applicable. The success of policy measures in a given case depends upon many case-specific factors, and it is difficult to generalize from one case to another. Furthermore, in some cases, policy intervention might even be counterproductive, which underlines the importance of contextual knowledge provided by institutional analysis (Ostrom 2005).

TABLE 2.2.2 **Salient approaches for identifying public adaptation options for influencing collective action.**

Type of interdependence	Coordination solution?	Indication on salient approach	Example
Two-way	Yes	Communication	Public actor wanting to influence coordinated use of a shared river basin.
One-way	No	Regulation or economic incentives	Public actor wanting to influence farmers to provide land for migration corridor maintenance for key biodiversity species.
Two-way	No	Institutional analysis	Public actor wanting to influence farmers using a shared and already scarce groundwater resource that is declining under climate change.

Figures 2.2.3 and 2.2.4 above show decision trees for selecting the tasks to be carried out for public actors influencing individual and collective adaptation respectively. Table 2.2.2 further illustrates the choice of tasks and methods based on the criteria interdependence and coordination, and provides examples.

2.2.6 Choosing approaches to institutional analysis

Entry point

Adaptation situation:

- A specific adaptation problem or decision has been identified.
- You are a public actor (or you carry out an assessment on behalf of a public actor) and want to influence the adaptation of private actors in your jurisdiction.

This is what you want to do:

- Understand the institutions that drive and hinder behaviour or make predictions thereof.

Generally, institutional analysis tasks and methods are appropriate in situations in which there are many actors facing many different interconnected decisions. Institutional analysis aims to understand how institutions emerge from the actions of individuals and groups, and predict the effect of institutions on behaviour and outcomes. Institutions are understood as the "rules of the game" (North 1990) or "the prescriptions that humans use to organize all forms of repetitive and structured interactions" (Ostrom 2005, p.3). Understood in this broad sense, institutions include both informal norms, customs and shared strategies, as well as formal laws, policies and policy regimes. Data used in institutional analysis is collected through a variety of methods, e.g. interviews, surveys, document analysis, field observations and field experiments. Insights gained in institutional analysis may then be employed to explain the emergence of institutions in other contexts, or to craft effective policies, for example, for sustainable management of natural resources. We present criteria for identifying critical institutional analysis tasks and methods in Figure 2.2.5. These methods are discussed in more detail in Section 3.6.

DECISION NODE: Is it sufficient to describe actors and institutions to advance adaptation?

Figure 2.2.5 presents a decision tree for identifying institutional analysis tasks. Similar to other fields in social science, theoretical assumptions form the top-level criteria for identifying tasks and selecting methods, as these determine what kind of questions may be addressed. If it is assumed that a description of relevant actors and institutions will significantly advance adaptation, then governance description must be addressed (see Section 3.6).

DECISION NODE: Can outcomes of institutional arrangements be predicted?

Going beyond the purely descriptive approach, a distinction can be made between methods that assume that outcomes of institutional arrangements can be predicted, and those that assume it is not possible.

If it is assumed that, due to complexity in the social system, for example, outcomes of institutional arrangements cannot be predicted, the appropriate task is to explain governance emergence.

Governance emergence approaches are based on the theoretical assumption that it is inherently difficult to predict outcomes of institutional arrangements because of the complexity in action-outcome linkages and the importance of contextual factors (Ostrom 2005; 2007; 2009; Huitema et al. 2009). These methods are based on in-depth description of the many factors, material, ideational and historical, which lead to the emergence of institutions. It logically follows from this assumption that designing institutions or policies in order to achieve a policy goal (e.g. reduced climate vulnerability) cannot be meaningfully addressed before governance emergence has been explained. Governance emergence approaches, therefore, strive to understand the existing institutions, particularly addressing which contextual factors give rise to a particular institutional arrangement in a given case. While these approaches can be further differentiated based the subsequent decision node in Figure 2.2.5, understanding and explaining the emergence of institutions is a broad field, and these decision nodes provide only some high-level entry points (see Section 3.6 for discussion and examples).

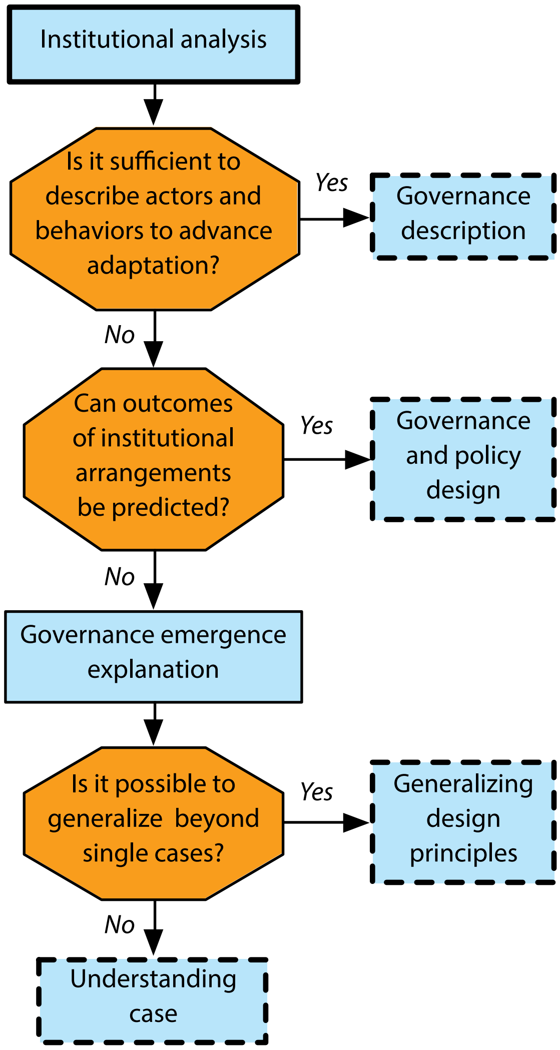

FIGURE 2.2.5 **Choosing salient approaches for institutional analysis.**

On the other hand, if the assumption is made that governance and policy outcomes can be predicted, then the task of governance (or policy) design may be addressed. Governance design approaches assume that it is possible to predict outcomes of institutional arrangements with some confidence, and on this basis they address the question of how to design effective policies and institutions. Because adaptation concerns many different policy domains, the task of adaptation policy design may be to "mainstream" the consideration of climate change risks into existing sectoral policies (see Section 3.6). Mainstreaming approaches can be further differentiated on the basis of whether climate is already considered in a given policy. If climate has not been considered, then policy screening (or portfolio screening) aimed at analysis of whether potential climate impacts threaten existing policies is appropriate (Klein et al. 2007). On the other hand, "climate-proofing" is appropriate to design policies in which climate impacts has been identified as a risk. This involves addressing relevant risks early in the policy formulation process, to identify any obvious effects on other sectors or objectives. The practice of proofing policies is well-established in other sectors, such as health, and rural development (Urwin and Jordan 2008).

DECISION NODE: Governance emergence explanation – can a generalization be made?
Within governance emergence approaches, a distinction is made between approaches that assume it is possible to generalize beyond a single case, and those that do not, such as anthropological and ethnographic approaches. Among the approaches that assume generalization is possible, several from new institutional economics have made significant and extensive contributions to the natural resource and water management literature (e.g. Ostrom 2005; Hagedorn et al. 2002; Bougherara et al. 2009). While the above-mentioned assumption of complexity limits the generalizable conclusions from any particular study about which institutions lead to which outcomes, the accumulation of evidence has led to conclusions about general characteristics of social-ecological systems that can be related to desirable outcomes. A description of these methods, with examples, is provided in Section 3.6.

2.3 Appraising adaptation options

Entry point

Adaptation situation:

- A specific adaptation problem or decision has been identified.
- A set of adaptation options has been identified.

This is what you want to do

- You want to appraise the options and choose the best.

2.3.1 Overview

Entering the adaptation learning cycle at this stage requires that an adaptation problem and options for addressing it have been identified. Now, the task is to appraise those options. There is a wealth of methods that can be applied towards this end, from the fields of organizational learning, decision analysis, policy analysis, and institutional and behavioural analysis. This section guides the reader though selecting an appropriate approach.

The crucial methodological choice faced at this stage is whether to apply a formal approach, a deliberative/participatory approach (Renn 2008), a combination of both, or none – and make a decision based on intuition (Figure 2.3.1). Formal decision appraisal methods are based on formalizing the decision and then applying mathematical reasoning to indicate which options *should* be chosen. Examples of such methods are multi-criteria analysis, cost-benefit analysis or robust decision-making. In contrast, deliberative approaches appraise options by eliciting information from the actors involved and harmonizing their preferences. Intuitive decision-making relies on cognitive processes that have been developed through a great deal of experience and learning.

DECISION NODE: What type of adaptation situation is at hand?
A first decision node to consider is whether the adaptation situation is individual or collective because collective adaptations are often characterized by the various stakeholders involved having different preferences on outcomes, while for individual adaptation this is, of course, not the case.

In private individual adaptation situations, actors need to decide whether to formalize the decision-making process or to decide intuitively. A formal approach has many advantages, as research has found many persistent biases in individuals' decision-making including overestimating the value of low-probability, high-impact events (Tversky and Kahneman 1983; Weber and Hilton 1990), strong aversion to potential losses (Kahneman and Tversky 1979), and problems discounting future events (Laibson 1997; Frederick et al. 2002; Karp 2005). On the other hand, research in psychology has shown that people's informal decision-making may be remarkably effective, and in the presence of *limited or highly ambiguous information,* even consistently lead to better results than formal methods (Gigerenzer 2000). This is particularly true in settings where an individual has had *extensive experience* with similar decisions, and the decision provides *immediate feedback* and thus an opportunity for learning (Kahneman et al. 1982).

DECISION NODE: Are there conflicting private interests?
For situations that involve several actors, the analyst must consider whether these actors have *conflicting interests* on goals, decisions to be taken, and outcomes. The inability to agree upon these can become a significant barrier to selecting adaptation options (Moser and Ekstrom 2010). In such cases, deliberative or participatory approaches may be applied to build consensus among stakeholders. These include methods for addressing collaborative goal-setting, and consensus-building.

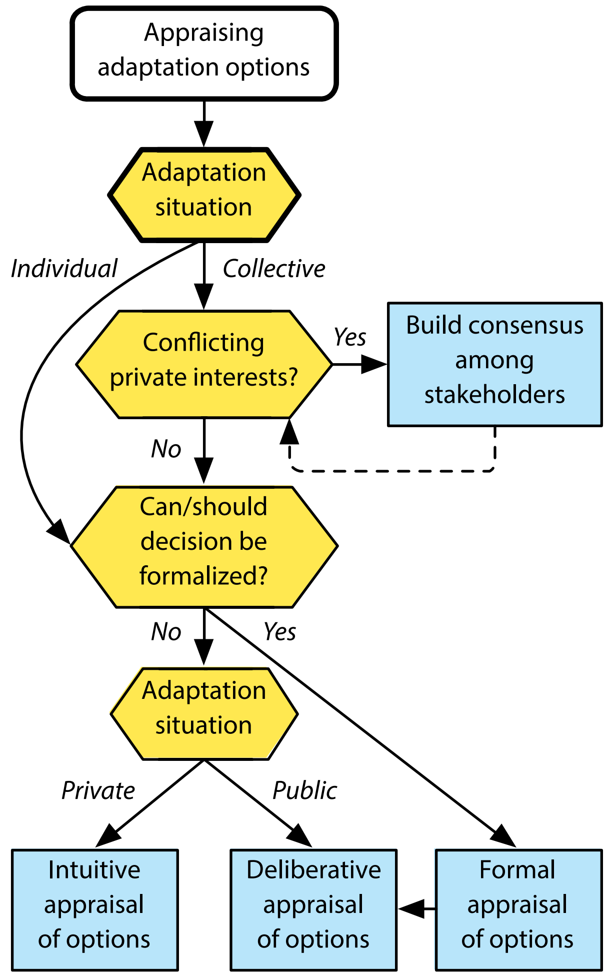

FIGURE 2.3.1 **Overview decision tree for appraising adaptation options.**

A citizen jury, for example, is a method for obtaining informed citizen input into policy decisions (Crosby 1995). Citizen juries can strengthen the democratic process and at the same time contribute to informed decision-making (Raadgever and Mostert 2010). In other settings, participatory rural appraisal (Chambers 1994) may enable community development decisions to be made on the basis of a shared understanding and harmonized interests. These methods are discussed in Section 3.1.6.

DECISION NODE: Can/should decisions be formalized?
Once preferences have been harmonized, the next consideration is whether to apply formal approaches, deliberative approaches, or both.

There are a number of criteria that are relevant here – but it is important to note that these are not definitive, and often both deliberative and formal methods may be equally relevant within a given adaptation decision.

In order for formalization to be appropriate, a decision must be well-defined. A decision is well-defined and can be formalized under the following conditions:

- A decision among a set of options has been identified. Notably, the identification of this set is not addressed by decision-analytical methods.
- Outcomes of implementing options are known – that is, they have been computed using either methods of risk assessment for present climate extreme event risks or residual impact projection methods for future climate (both slow onset and extreme-event). In the former case, outcomes may be expressed either probabilistically (with a likelihood of occurrence) or via scenarios (without a likelihood of occurrence). In the latter case, outcomes may only be represented via scenarios, as probabilities cannot be associated to different pathways of socio-economic development and associated emissions, which drive climate change and its impacts.
- Outcomes are characterized by one or several attributes (also called metrics, criteria, values), where at least one attribute describes the costs of planning and implementing an option.

A baseline, which is a "do nothing" option against which the values of the attributes can be established. Formal decision-making methods are often prescribed by the policy or legal context. Table 2.3.1 summarizes additional criteria to consider in choosing whether to apply a formal decision-making method, related to the feasibility and cost of formalizing a decision. Formalizing a decision requires being able to translate the "real-world" complexity into the canonical form that formal methods rely on: one decision among a set of options, with each option characterized by a set of attributes (also called metrics, criteria, values). The attributes describe both the costs of implementing an option as well as the costs and benefits of the outcomes of implementing options. For decisions that are not *well-defined* and are *interconnected* to other decisions this might be difficult to do, or the *costs of information-gathering and -processing* might be prohibitively high. It may then be appropriate to make individual decisions informally on the basis of intuition.

TABLE 2.3.1 **Criteria relevant to selecting formal or informal methods for appraising options.**

Empirical criteria	Formal appraisal	Intuitive/ deliberative appraisal
Ambiguity on options, outcomes and baselines)	Low	High
Interconnectedness of decisions	Low	High
Information gathering and processing costs	Low	High
Importance of money in decision	High	Low
Experience on similar decisions with immediate feedback.	Low	High

2.3.2 Choosing approaches for informal (deliberative or intuitive) appraisal of options

Entry point

Adaptation situation:
- A specific adaptation problem or decision has been identified.
- A set of adaptation options has been identified.
- It has been determined that the decision on which option to pursue should not be formalized.

This is what you want to do:
- Choose an adaptation option using informal (deliberative or intuitive) methods.

Only a limited set of adaptation decisions can be formalized due to, among other factors, the intensive time, resource and capacity requirements of formal decision-making methods. Further, for many decisions, informal decision appraisal may be preferable – and, as discussed above, may lead to better results than formal methods.

For individual decisions, there is good evidence that when information is limited or ambiguous, some informal patterns consistently lead to better decisions than the attempt to apply more formal methods (Gigerenzer 2000). When individual decisions are complex, and the costs of information-gathering and processing become prohibitively high, it may be appropriate to make individual decisions informally on the basis of heuristics. Heuristics, and informal individual decision-making in general, are most effective in settings where an individual has had extensive experience with similar decisions, and the decision provides immediate feedback, and thus an opportunity for learning.

For collective decision appraisal, informal methods may take a more deliberative form. For example, consensus-based decision-making involves discussing the options within the group to familiarize everyone with the issues and build a shared understanding and a sense of shared control over the decision – which, in turn, can lead to more effective adaptation (Minkler and Wallerstein 2010). In-person interaction is also valuable because body language, for example, can play an important role in communication and help produce better outcomes (Kahneman et al. 1982). Sections 3.1.3 and 3.9.3 describe a variety of methods for collaborative goal-setting, which cannot be addressed by formal methods.

2.3.3 Choosing approaches for formal appraisal of options

Entry point

Adaptation situation:
- A specific adaptation decision has been identified.
- A set of adaptation options has been identified.
- It has been determined that the decision on which option to pursue should be formalized.

This is what you want to do:
- Choose an adaptation option using a formal method.

There are multiple formal methods for appraising adaptation options; Figure 2.3.2 presents a decision tree to help guide the choice of such a method for a given adaptation situations. The factors relevant for this decision tree are characteristics of the set of available adaptation options and the type of knowledge available on the hazard, impacts and outcomes of options.

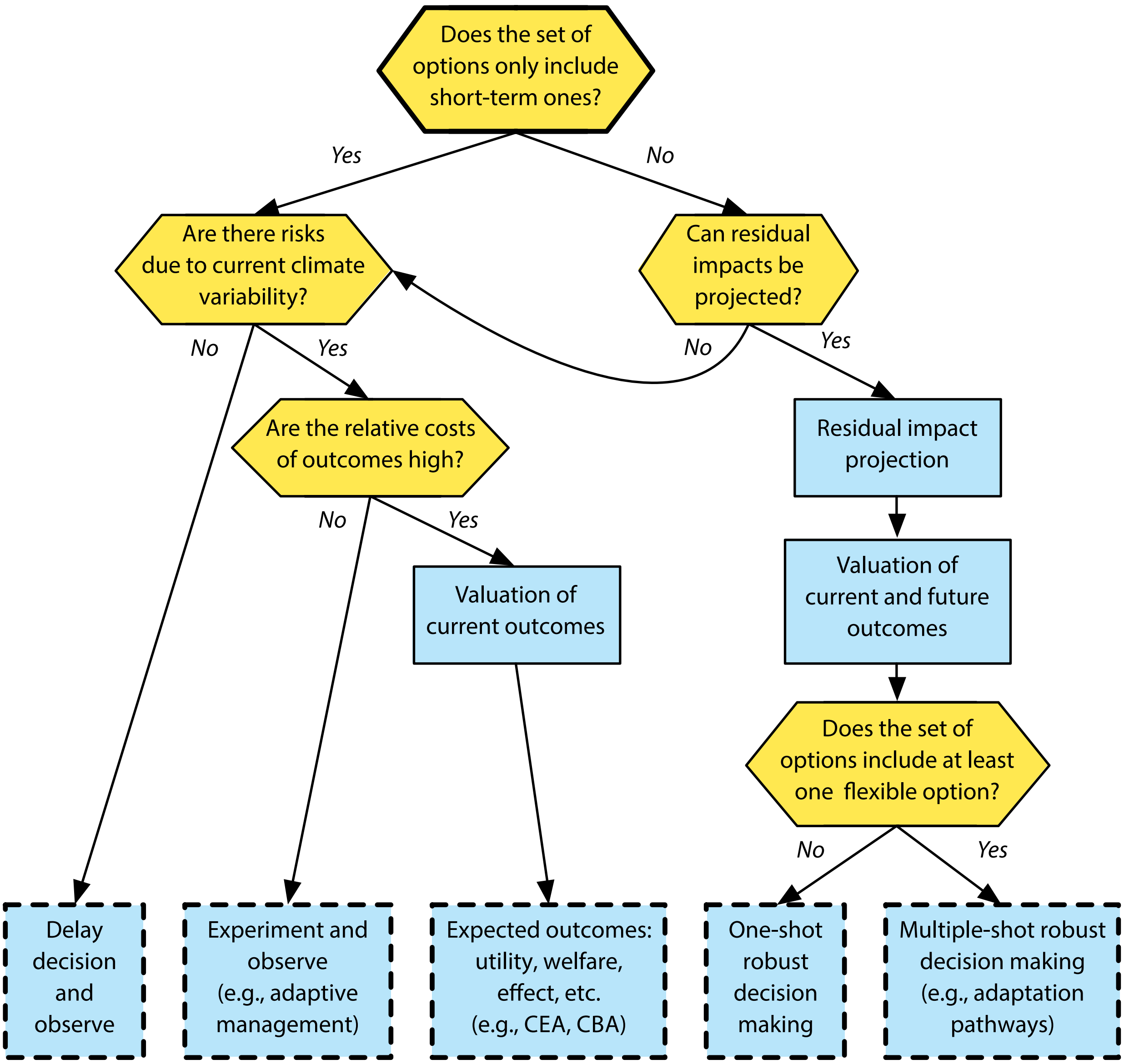

FIGURE 2.3.2 **Choosing approaches for formal appraisal of options. Note that CBA refers to cost-benefit analysis, and CEA to cost-effectiveness analysis. These are described further in Section 3.7.**

As this decision tree is complex, the three most important decision nodes are discussed together at the beginning of this section. These three nodes determine whether decisions are short-term, long-term or should be postponed. The decision nodes for identifying critical tasks and methods are then described in more detail below. Table 2.3.2 provides some examples of paths through the decision tree. The different methods are presented and discussed in more detail in Section 3.7.

Short-term or long-term decisions or delaying decisions

The applicability of formal decision-making approaches depends on whether a decision is to be based on the current or future situation. The following three decision nodes are relevant for deciding this, as represented in Figure 2.3.2:

1. *Does the set of options only include short-term ones?* A *short-term* option is one with a short lead time (the time from implementation to effects) and a short lifetime (how long the measures are effective). For example, building a dike is a long-term option, while planting a drought-resistant crop variety is a short-term option.

2. *Can residual impacts be projected?* This requires the availability of credible impact models that consider adaptation, which is generally only the case for some sectors.

3. *Are risks (and opportunities) currently present due to climate extremes and variability?* Such risks may be related to extreme events such as storms, floods or heat waves, or to longer-period climate variability such as decade-scale El Niño–Southern Oscillation (ENSO).

Figure 2.3.2 presents a decision tree combining these three characteristics of decisions. The decision tree shows that for some decisions it is best to postpone and observe, for others it is best to apply a decision-making method to only current risks, and, for a third class of decisions, it is best to decide based on long-term future risks as well.

Figure 2.3.2 illustrates that adaptation decisions should consider the future situation when long-term options are involved (1) and residual impacts can be projected for these (2). When it is not the case that both of these occur, then deciding based on the current situation is sufficient. Take, for example, a farmer facing drought impacts (current variability) with a decision on changing crop types to more drought-resistant strains (short-term options); she should decide based on current variability. If long-term options are involved (1), but residual impacts cannot be projected (2) due to the unavailability of impact models, then decisions can, similarly, only be based on the current situation. If there are no current risks (3), then the decision can be delayed. Below each decision node is described in more detail.

DECISION NODE: Does the set of options include only short-term ones?

Long-term options need to be evaluated in the context of how conditions may change in the future, and thus require more sophisticated levels of analysis, including projecting future impacts. Short-term options, on the other hand, can be evaluated in the current context if the risk is immediate, or else the decision can be postponed to see how conditions change.

For example, consider a farmer facing increasing drought risk. If the only available adaptation options are switching to more drought-resistant crop varieties, or adding more organic material to the soil, the choices would all be short-term, as planting has to be done every year. Then the question becomes: Does she need to adapt right away, because droughts are already a problem, or can she wait to see what happens within a few years? In contrast, if another option would be to install an irrigation system – a long-term investment with potential long-term benefits – the farmer would want to consider future conditions before making a decision.

DECISION NODE: Are there risks (or opportunities) due to current climate variability?

As noted in the example above, if the adaptation options being considered are all short-term, the next decision node involves determining whether the risks to be addressed also exist in the short term, or are only expected in the future. (There may also be opportunities due to climate change, which can be evaluated in the same way.) If the risks exist in the short term, the decision can be based on current conditions.

If only future risks are being considered, and all options are short-term, then the best course of action may be to postpone the decision and observe. This is because there would be no benefit to implementing the short-term options right away, and the risks are likely to be better understood in the future. A "wait and observe" approach might also be best for longer-term options if impacts cannot be reliably projected. Uncertainty would then be too high to justify action right away, since the risks are likely to be better understood in the future.

DECISION NODE: What are the relative costs of options?

When deciding based on the current situation only, the next decision node involves the *costs of an option* (including opportunity costs). If the costs are low, then it is possible to experiment – that is, to take adaptation action, monitor the outcome, and make adjustments as needed. The

TABLE 2.3.2 **Selecting an appropriate decision-making method.**

Are there risks due to current climate variability?	Does the set of options include only short-term/ flexible options?	Given a scenario, can the outcome of a given option be calculated?	Relative costs of options	Example	Next task indicated
Yes	Yes	—	High	Subsistence agriculture threatened by drought; options include switching to more drought-resistant varieties	Cost-benefit analysis, cost effectiveness analysis, multi-criteria analysis
Yes	Yes	—	Low	Agriculture threatened by droughts; One of option is to manage demand through water market credits	Adaptive management
Yes	No	—	High	Forestry is threatened by forest fires; options include emergency response measures or planting different tree species; coasts threatened by sea-level rise and storm surges; options include to protect the coast, retreat, or spread risk (through insurance)	Robust decision-making on current and future outcomes
Yes	No	No	—	A household is threatened by river flooding	Cost-benefit analysis, cost-effectiveness analysis or multi-criteria analysis on current outcomes
No	No	Yes		Biodiversity is threatened as species habitats shift and migration is impaired by a lack of corridors; options include maintaining habitat corridors, agri-environmental schemes, creating a national park	Robust decision-making on future options; flexibility should be included in the analysis.
No	No	Yes	High	Agriculture is threatened by drought; the option being considered is to improve irrigation; ski-lift operators are threatened by decreasing snowfall; options include artificial snow-making, building summer tourism, or giving up	Robust decision-making on current and future outcomes
No	No	No	Not known	Coastal fisheries affected by migration of fish stocks	As the direction of the trend in risks is not clear, additional adaptation action may not be required

above-mentioned farmer might try a few different kinds of new seeds, for example, or several new soil moisture conservation techniques, until she finds the ones that work best for her needs. This is what is called adaptive management (Holling 1978; Walters 1986), an approach that has been used extensively in ecosystem management (e.g. Walters 1997).

If the relative costs of an option are high, experimentation is less desirable. Instead, it would be useful to evaluate the adaptation options upfront, before implementing one, following standard approaches for decision-making under uncertainty such as cost-benefit analysis or cost-effectiveness analysis. (Cost-benefit analysis, as its name suggests, weighs the costs of implementing a measure against its expected benefits. Cost-effectiveness analysis starts from the premise that action – e.g. addressing a drought risk – is desirable, and looks for the most cost-effective, or lowest-cost, way to achieve the desired goal.) For these formal decision-making methods, having probabilistic information about the risks is crucial to calculating expected outcomes. See Section 3.7 for a discussion of these methods.

DECISION NODE: Given a scenario, can residual impacts be computed?

As noted above, when the adaptation options being considered include at least one long-term option, it becomes important to consider future conditions. In those contexts, the next relevant decision node concerns whether reliable impact studies or models are available to calculate the residual impacts of climate change after implementing an adaptation option.

If residual impacts can be computed, scenario-based projections of future impacts (see Section 3.4) and valuation (see Section 3.8) can be carried out to calculate those impacts for each option under consideration.

If residual impacts cannot be computed, the task to address depends on whether the climate risks to be addressed are already present, or whether they are only projected for the future. If the risks already exist, the decision can be made based on current conditions, as described in the preceding section. If only future risks are being addressed, the best course of action may once again be to postpone the decision and observe.

Dried corn fields, Missouri © Flickr/Jane Shotaku

DECISION NODE: Does the set of options include at least one flexible option?

The farther into the future that a climate risk lies, the greater the uncertainty involved, which makes it increasingly difficult to apply methods such as cost-benefit or cost-effectiveness analysis. Not only would the expected costs and benefits have to be calculated for an ever-broader range of climate scenarios, but also for different non-climate variables such as development and policy choices (e.g. how a coastal area is zoned, or whether a hydropower dam is built). And while it may be possible to quantify the probability of a current extreme event risk, that is not really possible for long-term, multi-variable scenarios (Lempert and Schlesinger 2001; Hallegatte 2009).

Alternative methods have been developed to support decision-making in such situations, under deep uncertainty. Unlike cost-benefit or cost-effectiveness analyses, which aim to find the optimal solution within a fixed set of parameters (e.g. there's an 80% chance of a storm surge, which will cause X amount of damages), these approaches look for solutions that are robust (don't fail) under a variety of possible future scenarios. Thus, they are often referred to as "robust" decision-making methods (e.g. Lempert and Schlesinger 2001; Lempert and Collins 2007), although a clear-cut terminology has not (yet) been established. These approaches may include participatory processes; here, however, we only discuss the formal appraisal stages of the methods.

Robust decision-making methods can appraise options using the criterion of robustness alone, or both robustness and flexibility. An option is *flexible* if it allows to switch to other options that might be preferable in the future once more is known about the changing climate. For example, in an aquifer under increasing water scarcity, an adaptation option of demand management through water pricing is a flexible option, as this option can be abandoned and greater storage capacity infrastructure can be built at any point in the future. Building a reservoir would be a less flexible option, because it would require large upfront investment costs that would not go away if the reservoir didn't end up being needed.

The choice of which of the two approaches to use thus depends on whether one of the options being considered is a flexible one.

When none of the options is flexible, then formal appraisal methods can focus on the criterion of *robustness,* and a one-shot robust decision-making method is appropriate. An option is robust if it is effective over the full range or a large share of scenarios (Lempert and Schlesinger 2001; Lempert and Collins 2007). See Wilby and Dessai (2010) for an application to water management in the UK and Lempert et al. (2012) for an application to infrastructure investment decisions at the Port of Los Angeles in the context of future sea-level rise.

When at least one option is flexible, the criterion of flexibility should also be considered, and decision-makers may want to favour flexible options over non flexible ones, so they can better adjust to changing conditions in the future (Hallegatte 2009). The adaptation pathways method, for example, does so by characterizing options in terms of two attributes: i) adaptation turning points, which are points beyond which options are no longer effective (Kwadijk et al. 2010), and ii) what alternatives are available once a turning point has been reached (Haasnoot et al. 2012). Importantly, the exact time when a turning point is reached does not matter; it is rather the flexibility of having alternatives options available. Prominent applications of this approach include the Thames Estuary 2100 Plan (Lowe et al. 2009; Penning-Rowsell et al. 2013), the Dutch Delta Programme (Kabat et al. 2009) and the work of the New York City Panel on Climate Change (Rosenzweig et al. 2011).

Table 2.3.2 supplements the analysis provided in the decision tree in Figure 2.3.2 by presenting these characteristics and their indication on the critical task through several examples. Formal decision-making methods and examples are described in Section 3.7.

CASE STUDY *Costs of sea-level rise for Boston under three adaptation options*

Another way of appraising adaptation options is to look at the difference in projected costs based on various scenarios of adaptation. Climate's Long Term Impacts on Metro Boston (CLIMB) is a multi-sector assessment of how climate change will affect key socio-economic activities, based on estimates of the costs of potential impacts.

The three adaptation options are:

- "Ride It Out" – assumes that no adaptive steps will be taken to reduce the impacts of climate change, and that facilities or systems damaged by climate change are abandoned or rebuilt in a similar configuration. This is the most expensive scenario.
- "Build Your Way Out" – assumes that limited structural measures are taken to reduce climate-related damages: reinforcing sea-walls, for example, or arranging for water-sharing from different jurisdictions to deal with water shortages.
- "Green" – assumes proactive implementation of innovative policies and technologies to prepare for and counteract adverse climate impacts. These might include flood-proofing to reduce damage from sea-level rise or intense storms, as well as other measures such as tree-planting and high-albedo roofs to reduce unsustainable energy demand on hot days.

In the CLIMB report, the approach was fully developed for coastal flooding, a major hazard for coastal Boston. The table below summarizes the findings. In terms of appraising adaptation options, this table shows that Build Your Way Out is the most cost-effective, followed by Green, with Ride It Out resulting in the greatest level of costs under both climate scenarios.

Climate Event	Scenario	Residential Costs*	Commercial / Industrial Costs	Emergency Response Costs	Adaptation Costs	Total
Moderate sea-level rise One event (flood)	"Ride It Out"	3,563	13,525	2,905	0	19,993
	"Build Your Way Out"	1,091	3,984	863	3,462	9,400
	"Green"	756	2,697	587	1,766	5,806
One metre sea-level rise Three events	"Ride It Out"	16,140	64,250	13,666	0	94,056
	"Build Your Way Out"	1,820	6,703	1,449	3,462	13,434
	"Green"	3,272	12,760	2,726	6,798	25,556

Source: Kirshen et al. (2008). All costs are in millions of dollars.

2.4 Planning and implementing adaptation

Entry Point

Adaptation situation:
- A specific adaptation problem or decision has been identified.
- Adaptation options have been identified and appraised, and an option has been chosen.

This is what you want to do:
Design a plan of action to address the adaptation problem and implement the chosen option, and to monitor and evaluate the effectiveness of that option in reducing climate risks.

2.4.1 Getting started

This section focuses on the fourth stage of the adaptation cycle. Once climate impacts and vulnerabilities have been assessed (Section 2.1), and adaptation measures to address them have been identified (Section 2.2) and evaluated to choose the best option (Section 2.3), the next step is to make a plan to implement the chosen measures – and then do it. This is a complex and challenging process, and very often, the analytical work is not translated into concrete plans and actions (see Moser and Ekstrom 2010; Preston and Stafford-Smith 2009; Burton 2002). Key constraints that can arise at this stage include:

- lack of motivation and common purpose;
- concerns that the desired adaptation measures are not actually feasible; and
- lack of clarity around objectives or agreement on priorities.

The implementation of adaptation measures can also be hindered by a lack of accountability or responsibility on the part of the relevant actors; cognitive biases, conflicting priorities or lack of will; and lack of social and political acceptance.

Recognizing these common obstacles, this section focuses not only on the technical tasks of planning and implementing adaptation measures, but also on the work needed to support those efforts: communications, consensus-building, integration with non-climate initiatives (especially development), and capacity-building for key actors and institutions to ensure that they can successfully plan and implement adaptation. In this context, it is important to note that given the wide variety of situations in which adaptation takes place, there is no fail-safe, "correct" formula for designing an adaptation implementation plan; the accompanying checklists provide guidance on how to sort through different issues that may arise.

One important thing to remember is that often adaptation is not the only reason for change, and adaptation measures are implemented as part of other initiatives. In many cases it may be hard to differentiate adaptation actions from those focused on development goals such as improving livelihoods, especially at the local level. For example, upgrading a water supply system in a coastal community which currently has no access to fresh water could provide both adaptation and development benefits. Given the extent to which vulnerability to climate change is driven by socio-economic factors (see Section 2.1), it stands to reason that activities that contribute to community resilience (improving human health and well-being, economic conditions, education, and societies) would also build adaptive capacity.

Much existing guidance on adaptation planning focuses primarily on methods and tools, but especially in projects where the aim is to get stakeholder engagement, ownership and outcomes that build capacity to deal with climate change, agreeing on underlying principles and designing an open and inclusive process is as important as choosing specific tools. This part of the guidance aims to address both issues. The underlying motivations for the work that emerged in the scoping phases of the adaptation process should be revisited at this stage to bring in new people and reflect on how well they have been addressed in the option identification and appraisal stage. This is also an opportunity to think about what might be considered as a "success", in terms of implementation, by developing shared principles and clarifying objectives. This will help in designing the details of the process, what types of tools should be used, and how the work can most effectively be monitored and evaluated (see Section 2.5).

Figure 2.4.1 illustrates the various questions that should be considered when planning and implementing adaptation, considering, in the first instance, what is going to be implemented and how much agreement there is about it. The figure provides guidance on possible tools which can be applied to answer each question. The tools are explained in further detail in the related sections and in Chapter 3, as indicated below.

Few adaptation processes to date have reached the implementing, monitoring and evaluating stages (Moser and Ekstrom 2010), mainly because climate adaptation has emerged as a concern relatively recently and partly due to the difficulty in overcoming barriers in the previous stages. However, Moser and Ekstrom (2010) write:

> Moving from option selection to implementation also is influenced in important ways by the governance and larger social context, in part through its impact on the actor's perception, freedom, and capacity to do so, in part through its impact on the available resources, authorization, permits, political climate, or social norms. (p.4)

As shown in Figure 2.4.1, in order to implement an adaptation plan effectively and efficiently, it is important to reflect on issues of intent, feasibility, purpose, principles, priorities and clarity of objectives. The past practices of the implementer and the degree to which the system of concern will be changed can also be barriers. Some options are inherently more likely to be accepted than others; these include options that are perceived to be flexible and even reversible, and so-called "no-regrets" options – those that will lead to benefits even if climate impacts are not as expected.

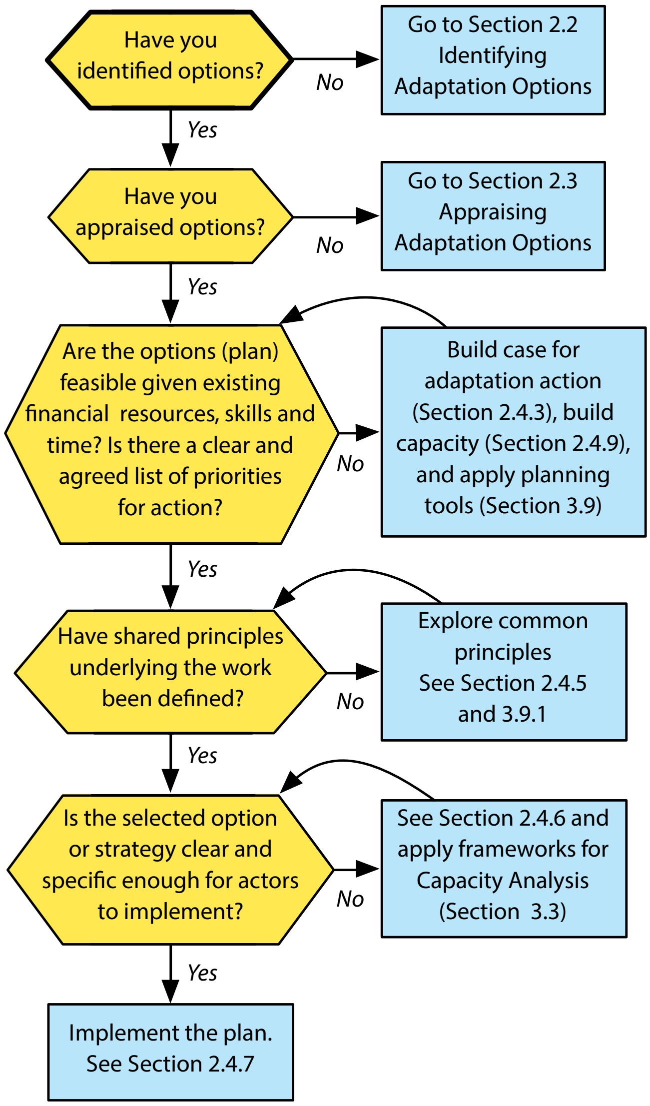

FIGURE 2.4.1 **Decision tree for agreement on what is to be implemented with respect to motivation, feasibility and priorities.**

Further, it can be difficult to accurately evaluate what constitutes a "successful" outcome if there is no agreement on appropriate indicators of progress or success, or if relevant data, methods and expertise are missing. A lack of agreement on indicators may be particularly problematic for management – an approach in which adaptation measures are adjusted as new information or conditions emerge. Thus, it is important to establish a consensus upfront on what is to be achieved, what is to be measured in terms of progress (see Sections 2.5.5 and 3.10), and what is to change if adaptation is deemed "successful" (see also Section 2.5 on monitoring and evaluation).

2.4.2 Stakeholder engagement

As emphasized in Section 1, stakeholder engagement is essential throughout the adaptation process. At this stage we are concerned with reaching agreement on objectives, responsibilities and accountability for implementation of the adaptation plan. Well-facilitated stakeholder engagement can encourage creativity and new thinking, build trust and cooperation, and gather crucial feedback to ensure that the adaptation activities chosen make sense on the ground. Engagement of stakeholders in creating an adaptation plan – and well before, when identifying and assessing options (Sections 2.2 and 2.3) – means the plan is much likelier to be accepted, especially if the stakeholders are also willing to become advocates or champions of the plan. By giving stakeholders a chance to explore the gap between current reality and a shared vision for the future, participatory processes also encourage shared responsibility for implementation. Participatory tools aim to build a strong sense of ownership and commitment to the resulting plan, and can also help stakeholders resolve issues that had previously been difficult to address.

In designing participatory processes, it is important to define the scope of the issues that stakeholders will be addressing. Stakeholder engagement approaches can vary from fairly passive interactions, where the stakeholders simply provide information, to "self-mobilization", where the stakeholders themselves initiate and design the process. Stakeholders must understand how they are being involved, how the information they provide will be used, and what opportunities they have to influence decisions. When designing the engagement, it is valuable to take into account the stage at which the engagement is occurring in terms of the policy-making process, what decisions have already occurred, and what positions are already fixed. It may be that a particular engagement activity, though very participatory in itself, is not effective or satisfactory for the participants because the scope is too constrained and there is no opportunity for developing creative solutions.

2.4.2.1 Facilitation and conflict resolution

Good facilitation can significantly add to the effectiveness of the process, the quality of the engagement and learning that takes place, and how much ownership over the outcomes is developed. Well-facilitated processes build capacity with the stakeholders and in the communities where the work is taking place, enabling them to respond effectively to change in the future. Poor facilitation, meanwhile, can lead to inadequate connections with stakeholders and the larger communities and groups involved, potentially leading to anger and mistrust and damaging the potential for future collaboration. The effect and legacy of any adaptation intervention is likely to be limited and short-term if people feel they have not been treated well in the process or their voices have not been heard. See Section 3.1 for facilitation tools and a more in-depth discussion of these issues.

Facilitation can also improve teamwork by improving communication among team members, which, in turn, improves the quality and creativity of the work. Benson (2001) writes that good team performance results from the interplay of three sets of needs and behaviours that all need to work well. Facilitators can inquire about each area to support the functioning of the team:

- Helping the group achieve the task. Here questions might be: How are we getting on with the task? What is going well? What blocks are there? What strategies do we have to overcome them?
- Individuals within the team. Here questions might be: Where do I fit in this? Are my needs being met? Am I being stretched? Am I learning?
- Maintenance of the team as a whole. Here questions might be: How is the team communicating? What is going well, and what could improve?

Good teamwork is important in all projects, of course, but supporting these three aspects of effective teams can be particularly useful when working in adaptation, where the challenge may seem daunting and some aspects of the work may seem unclear.

Finally, conflict resolution tools can be used by facilitators to reframe how an issue is presented, create opportunities for dialogue, and encourage engagement even where actors are in dispute. Issues of power, access to resource, and control over the process can hinder trust-building and effective learning, and instead reproduce (or even reinforce) previously held, unhelpful perceptions of other actors. In such situations, people can feel that there is no point in engaging. Conflict resolution tools can help all sides address such issues openly by investing in building relationships and breaking down preconceptions. This highlights the need for "co-production" of knowledge through collaborative learning approaches.

For guidance on conflict resolution tools, see Section 3.1.7. For guidance on large-group and whole-system techniques, see Section 3.1.6.

2.4.2.2 Incorporating stakeholder input

Participatory processes do not end when the conversation is over. Stakeholders may provide a great deal of input – perhaps in a very unstructured form – and how that input is processed and incorporated into the adaptation plan may greatly affect the outcome. Reflection on material generated through a participatory process allows for patterns to be identified and issues prioritized. The people who undertake the analysis have a great deal of influence over outcomes from a process, including any recommendations made. If they process the material remotely, with no further contact with the stakeholders who provided it, it is easy to misunderstand meanings. A community map may not make much sense to someone who does not know the local area or local words and symbols used. An outsider trying to make sense of it may thus miss important aspects and make wrong judgements about what is important to local people.

Undertaking the process of reflection and analysis with those who generated it, with stakeholders (or within a community), not only considerably increases the quality of the data, ideas and solutions that come out of the process, but also enables those who participated to gain confidence in their ability to represent their views to others. By delving deeper into the causes of the problems and understanding more about why these issues are important and the reasons behind them, it becomes possible to identify realistic and relevant solutions. For more information on participatory analysis tools, see Section 3.1.5.

2.4.3 Building the case for adaptation action

To the extent that stakeholders have been engaged in the adaptation process so far, there should be a collective understanding of why adaptation is needed, and why a particular approach should be taken. However, not everyone who might play a role in adaptation will have been involved in the process. At this stage, it is important to make the case for adaptation action to others who are vital to the process – e.g. those at the operational level or who control budgets – to persuade them to engage with the work (or not obstruct it) and provide the needed resources. This is relevant at both a local and national level.

To be persuasive, messages have to:

- Clearly explain the climate risks to be addressed, supported by evidence and how they are likely to affect the situation of interest.
- Explain why a specific adaptation option or set of measures was chosen, and how they complement other initiatives.
- If relevant, highlight the advantages of taking action early rather than responding as impacts become visible.
- Where relevant, make links to and draw on past experience of existing weather-related changes in the given situation.

Further useful guidance on building a case for adaptation can be found in UKCIP's Adaptation Wizard (UKCIP n.d.) as well as in the resources in Section 3.1.3.

A number of authors (Burton 2002; Preston and Stafford-Smith 2009) refer to the "adaptation bottleneck" which happens when decision-makers have reached a high level of awareness of climate change in the general sense, and understand the case for adaptation, but have not yet translated it into strategy and operations. This is where it becomes important to create opportunities to show how adaptation can be grounded in the work at hand, focusing on real decisions that are being made. This involves not only decisions about climate change, but also about major investments and policy decisions with long-term implications and the potential for maladaptation.

2.4.4 Acknowledging what makes information 'usable'

In adaptation, the challenge is often not that climate information is missing, but that there are no opportunities to ground such information and make it meaningful for a particular situation. In fact information "overload" may be more of a problem, and there is a need for ways to filter what is available and facilitate the transfer of information into knowledge. This could be through boundary organizations or "infomediaries" who can translate the raw data or general information and make it accessible and relevant to different groups. This can be done by creating "headline messages", for example, that explain climatic trends in terms relevant to the particular group: "*A rise in extreme precipitation will bring more landslides and road collapses, greatly increasing road maintenance costs.*" Boundary organizations can also provide safe spaces to explore the implications of the information and share experiences.

Haas (2004) discusses what makes up "usable knowledge" in a policy context – in short, "accurate information that is of use to politicians and policy-makers" and identifies several criteria in the literature and in prominent research organizations' own definitions:

- Legitimacy: Were processes designed to reduce bias? Do participants accept the knowledge?
- Credibility: Do participants believe the information is true?

- Effectiveness: Does it have the capacity to influence questions of concern?
- Adequacy: Does it include all the relevant information and facts? Can it mobilize adequate political support for an agreement? Can it generate solutions that help solve the problems and solutions that can be implemented?
- Salience: Is it timely and usable in our processes?
- Value: Does it contribute to understanding?

Notably – and consistent with the discussion above – Haas (2004) emphasizes that usable knowledge also needs to incorporate effective mechanisms for transmitting knowledge to the policy world, with an awareness of different actors' roles in the context of social learning and policy-making.

2.4.5 Defining the nature and scope of the work

Adaptation to climate change can be framed in a number of fundamentally different ways, and this basic framing will shape how the issue is perceived – which is why the same basic evidence can lead people to different conclusions on how to respond (Dow et al. 2013). This may be influenced by past experiences managing change, perceptions of and approaches to risk, what is believed to be motivating action, who else is involved, and how the process is facilitated. O'Brien et al. (2007) emphasize that power relations play a significant role in the planning process, and implicit ways of framing adaptation – e.g. as a technological problem, a vulnerability problem or a learning process – "allow certain questions to be asked while others get silenced". They also shape the resulting implementation plan.

In this context, the question "*What are we adapting for?*" (the desired outcomes) is as significant, if not more, as the question "*What are we adapting to?*" (the climate impacts and vulnerabilities that have been identified). For example, if a coastal area is being protected from sea-level rise and storm surges, is the priority to protect valuable properties and commercial activity, or to protect ecosystems – or are both seen as crucial? And is there a consensus about the desired outcome, or does the agreement stop at "protect the coast", but break down when it comes to specifics? As Brown et al. (2011) write: "A lack of clarity of the desired outcomes can present as much of a barrier to adaptation as uncertainty about the nature of future climate hazards" (p.11).

The scoping phase thus sets the parameters for the work and clarifies what it is intended to achieve. This is the stage when some of the most important decisions in adaptation planning are made, such as defining the key questions to be addressed, negotiating the boundaries of the work and the appropriate depth of the analysis, considering who needs to be involved and in what ways, and reflecting on potential solutions and approaches to achieve them. Evidence from practice suggests that often very little time is spent on scoping adaptation work, and this may result in ambiguity over the purpose of the work and conflicts when different assumptions surface during the work.

Effective scoping requires methods that enable people to be open about their underlying values, needs and motivations and requires trust and skilled facilitation, especially where resources are scarce or disputed. It is also important to understand the larger context for the work. Deciding what needs to be included in the work and what lies outside it has implications for who needs to be involved, what support they might need to fully participate, and what skills and resources are needed to provide such support. There is, of course, a need to be realistic about what support is available and what can be achieved given limited resources. Some tools and examples that can help to scope the work are given in Section 3.9.2.

2.4.5.1 Developing guiding principles

A related task at this stage is to define key guiding principles for the process. For example, one such principle might be: "Avoid actions that foreclose or limit future adaptations or restrict the adaptive actions of others." No single set of principles can be defined for all adaptation situations, as they are necessarily context-specific and will change depending on the scale, scope and level of depth the work is hoping to attain. The process of articulating and agreeing on guiding principles is undertaken with key actors and provides an opportunity to discuss different and shared values, experience and motivations for participating – a valuable grounding for the work. The principles can then be used to guide the design of the process, for example, how stakeholders need to be brought in to the process, what the definition of a successful outcome might be, and what indicators might be used in the monitoring and evaluation processes. For a more in-depth discussion of these issues, see Section 3.9.1.

2.4.6 Incremental or transformational change?

In adapting, different levels of engagement are possible. Pelling (2011) describes three visions of adaptation: resilience (maintaining the system's structure and functions in the face of climate impacts), transition (incremental social change and exercising of existing rights) and transformation (new rights claims and changes in political regimes). Adaptation, he argues, can focus too narrowly on avoiding climate change impacts without addressing the fundamental drivers of vulnerability. Section 2.1 discusses these issues at some length; here we will focus on the fact that even in choosing to address those drivers, there are further choices about the extent of the desired changes and the pace at which they should occur.

Similar distinctions are made in the literature on resilience, learning and organizational change, with different possible levels of response depending on the situation and the assumptions being questioned. Along with Pelling (2011), this section draws on insights from Bateson (1972), Argyris and Schön (1978) and Senge et al. (2005) to explain the different levels of learning. This is crucial to understanding processes of transformation in individuals, groups, organizations and systems.

2.4.6.1 Incremental change, or Pelling's 'resilient' adaptation

This refers to solving problems or improving skills in a "business-as-usual" mode, without examining or challenging underlying beliefs and assumptions – for example, through a change in the technology or management practice used. Much work on adaptation addresses only this incremental change, or what Pelling (2011) calls "resilience", seeking only changes that allow existing practices and functions to persist and not challenging the status quo or addressing power inequalities. Such changes may increase efficiency, but do not fundamentally question the assumptions underlying the activity or purpose of the organization or wider system. This may be fine for many situations, but might lead to inadequate or unsustainable solutions. For example, addressing food insecurity risks among subsistence farmers by introducing them to drought-resistant crops might make them more resilient to drought, but will not change the fact that subsistence farmers are always one failed harvest away from hunger, and need opportunities to diversify their livelihoods and earn cash.

2.4.6.2 Reframing, or Pelling's 'transitional' adaptation

This level of change requires revising activities and questioning current perspectives or frames of reference, and thus usually leads to *doing something different* or *in a different way*. This level of adaptation can occur when people are more open to change, increasing the potential scope of adaptation from just "tweaking" technologies and management practices within existing processes, to questioning the adequacy of the processes or governance structure themselves. This entails asking questions such as: What's going on here? What patterns can we see? How do our actions – and those of others – affect the system? Transitional adaptation, according to Pelling (2011), focuses on the governance regime "through acts that seek to assert full rights and responsibilities rather than make changes in the regime itself".

2.4.6.3 'Transformational' adaptation

This is doing new things and working in a radically different way. Reflecting on the assumptions that make up the current regime context has the potential to create shifts in the way that people within that regime see the world. All existing patterns and systems may thus come into question, allowing gradual or sudden changes to occur. Transformation can occur by creating a shift in the context within which the organization (or system) operates. Transformational adaptation responses fundamentally reassess the way a system operates, with the potential to reform the overarching regimes within which a particular system operates, challenging the status quo, cultural norms and existing power structures (Pelling 2011). Note that different definitions of what constitutes "transformative" adaptation exist; this is explored further in Kates et al. (2012).

2.4.7 Implementing the adaptation plan

Once you have designed the plan, there are several further criteria to consider in order to ensure the plan will be implemented in an efficient, effective and inclusive way. Many of these criteria relate to *who* will implement different aspects of the plan.

It is also important to have a sense of the stages of an adaptation process, while at the same time ensuring that the plan is flexible enough to cope with "messiness" and "surprise" as they arise. Adaptation is not a linear process, although it is often presented in that way for the sake of simplicity. In practice adaptation occurs iteratively and with unanticipated elements that challenge the inevitably partial and inadequate framing. These provide opportunities to challenge assumptions about how change happens and learn from the unforeseen consequences of interventions (Moser and Ekstrom 2010).

A good collaborative adaptation process is composed of cycles of learning that deepen and focus the inquiry into what will support effective adaptation in a given context. Seeing adaptation as a learning process allows openness to not knowing precisely what will emerge. Understanding will develop during the process, particularly if opportunities for reflecting, reassessing and refocusing are built in. Much of the most useful learning and connections between individuals happens through informal processes in "shadow spaces" (Pelling and High 2005) that provide opportunities for people to connect with peers in their own and other organizations and build informal links in order to learn from one another. For guidance on tools for learning and reflection, see Section 3.11.

2.4.8 Embedding the adaptation plan into the context

As discussed in Section 2.3, the characteristics of climate change, in particular the long time scales, uncertainty, complexity, and potential for significant consequence, mean that it would be impossible to collect enough information with sufficient certainty to be able to make "perfect" adaptation decisions. Furthermore, as circumstances change (new information, new technologies, etc.), what seemed optimal before may no longer be. Clearly, adaptation decisions need to be implemented within existing governance and legislative constraints, which will inevitably influence which responses are considered to be feasible. Understanding as much as possible about the context of this wider landscape allows a balance to be struck between ensuring that actions fit within those existing structures, and creating an enabling environment to support appropriate adaptation decision-making in the future. This complexity means it is a greater challenge to ensure that adaptation in one area does not increase vulnerability in another, and that "windows of opportunity" and "win-win" opportunities are maximized.

There are several useful questions to ask when working to embed an adaptation plan into existing processes. It is important to understand cross-sectoral impacts, for example – how will the adaptation measures affect vulnerability in other sectors or areas? See Sections 3.1.2, 3.1.3 and 3.1.5 for tools that can help with these challenges. It is also crucial to understand how the adaptation plan fits with existing processes and identify possible "windows of opportunity" – for example, if there's a major overhaul of agricultural policy being done, that might be a good time to directly address climate change impacts on local agriculture and embed adaptation measures in the plan. The same applies to potential "win-win" opportunities, such as increasing the use of passive cooling in buildings (an energy-saving way to cope with hotter summers) or combining urban flood protection measures with new green space (City of Copenhagen 2011).

2.4.9 Building capacity

It is by no means a given that the people and institutions charged with implementing an adaptation plan will have the capacity to do so. Capacity gaps may have been identified at the outset, during the capacity assessment (Section 2.1), or they may have become evident while appraising adaptation options (Section 2.3) or developing the adaptation plan. At this point, before diving into the implementation, it is crucial to address those gaps. If, for some reason, the capacities of key actors relative to their roles in adaptation have not been assessed, that process needs to occur now; Figure 2.4.2 outlines key questions to ask in such an analysis.

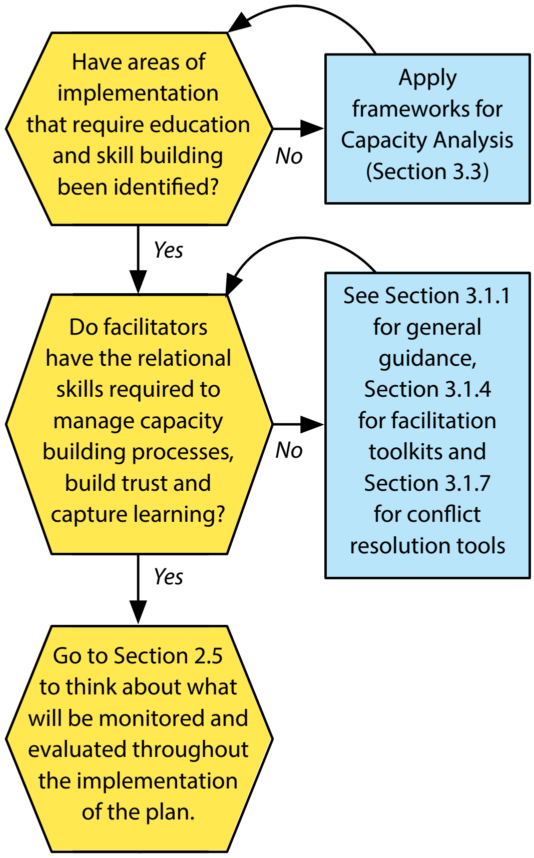

FIGURE 2.4.2 **Checklist for capacity-building for sustainable adaptation.**

Capacity involves not only knowledge and skills, but having the necessary tools and resources, as well as the necessary institutional framework. The best-trained adaptation experts will accomplish little if they must cram their adaptation duties into an already full workload, or they lack crucial software, or money to buy supplies, or the support of their supervisors. Agencies with competing mandates can bring one another to a standstill, and lack of enabling legislation or regulations can keep adaptation measures from being implemented. Thus, there is a broad range of capacity-building that may need to occur before the actual implementation process.

2.5 Monitoring and evaluation

Entry point

Adaptation situation:
- Adaptation actions are being or have been implemented.

This is what you want to do:
- Monitor the progress of the actions, and ensure they are proceeding as planned.
- Evaluate any outputs and outcomes, and draw lessons to improve ongoing activities and inform future efforts.

2.5.1 Monitoring

Adaptation can involve a significant investment of resources and effort, and as discussed in previous sections, it is often planned amid uncertainty, with incomplete knowledge, and may require substantial learning, capacity-building and institutional change. All of this makes it crucial to monitor adaptation activities as they are implemented, and make adjustments as needed. Provisions for monitoring should be included in the adaptation plan (see Section 2.4), but if they were not, a monitoring plan should be developed as early as possible in the implementation process.

Monitoring of an adaptation project may have a number of purposes, such as:
- To assess progress in the achievement of stated tasks;
- To determine whether the tasks are fulfilling the aims of the adaptation initiative;
- To assess the functioning of the team and of individuals within it;
- To examine engagement of other people in the process;
- To gather stakeholders' perspectives on the nature of that engagement (both the process and content);
- To understand how well learning is being captured and brought into the process to inform next steps.

Regular, ongoing checking of different aspects of the project is important to keep the project on track and capture surprise or unanticipated changes as they arise. Danny Burns, in his account of running systemic action research approaches, suggests asking the following questions at each new stage of a process (Burns 2007):
- How is it going? Are there issues arising that need our attention?
- Are we still on track with our underlying (research) purposes?
- Do our purposes need to alter?
- What new questions do we need to ask?
- What new inquiries do we need to open up?
- What new data do we need to collect?
- What new action do we need to take?
- What practices and methods do we need to use at this stage?
- What outputs or feedback do we need at this stage (if any)?

No sophisticated tools or methods are required to do this, although some of the visual tools described in Sections 3.1.3.6 and 3.1.5 may help in drawing out more tacit knowledge, sharing understanding and prioritizing areas for further inquiry.

2.5.2 Evaluation

Evaluation goes beyond monitoring in that it includes a value judgement on how an adaptation intervention is performing based on the monitored criteria. As funding for national, sectoral, and project-based adaptation projects has increased, so has the need to understand what makes adaptation actions effective, demonstrate value for money, protect investments, identify best practices, and judge which efforts are suitable for scaling-up. Although initiatives that focus solely on adaptation are still relatively recent, projects in which adaptation is a component have been in place for some time. In many cases, adaptation activities can be evaluated effectively by refining existing monitoring and evaluation (M&E) frameworks rather than building completely new frameworks. Lessons can also be drawn from evaluations being done in other areas. Horton et al. (2003) suggest that six activities are essential in preparing for an evaluation for capacity development:

- Clarify why and for whom the evaluation is being done;
- Involve intended users throughout the evaluation process;
- Cultivate the necessary support for the evaluation;
- Mobilize adequate resources to carry out the evaluation;
- Discuss possible results of the evaluation;
- Agree on basic principles to guide the evaluation.

However, adaptation initiatives may have features that make them more challenging to evaluate, such as a longer time horizons than is usual for development projects; this means different kinds of indicators, baselines and targets may need to be set up. In recent years, guidance for M&E specifically in the context of adaptation has begun to emerge. In late 2008, the World Resources Institute convened a technical workshop in Bellagio, Italy, to identify a shared set of critical adaptation functions. This was motivated by the recognition of the need for shared approaches despite the huge range of ways in which climate impacts might affect different societies, and the equally wide range of adaptation strategies and measures that might need to be developed. The resulting Bellagio Framework (McGray et al. 2009) was produced to identify strengths and gaps in adaptation capacities in a given country, prioritize actions and encourage investment, and serve as a reference point to assess progress on adaptation. This would require a set of metrics of progress to determine how performance on achieving the adaptation functions was changing over time.

At a national level, in 2010 the UK Department for Environment, Food and Rural Affairs (Defra) published a proposed approach for measuring adaptation to climate change. As well as achieving maximum value for the money, this work was motivated by the recognition climate change "will have an effect on the most crucial areas of our society – public health, energy supply, water supply, transport etc. – [so] we need to be sure that the action we are taking to prepare is having the desired effect" (DEFRA 2010, p.3). The proposed approach recommends developing a set of indicators that could be used to provide regular "snapshots" of the progress of the UK's adaptation efforts and gauge the effectiveness of the actions taken so far.

Recent work describes broad early lessons on the use of M&E specifically for adaptation (Spearman and McGray 2011):

- Defining adaptation success requires consideration of the context in which adaptation activities occur;
- A diversity of inputs – including information and participants – contributes to successful adaptation M&E systems;
- Tracking assumptions is an important component of M&E systems for adaptation, in order to contend with the uncertainties associated with climate change.

The rest of this section goes some way to expanding on these key lessons. Figure 2.5.1 provides a decision tree to help guide the process of designing an M&E plan for adaptation projects. As mentioned earlier, a number of barriers (Moser and Ekstrom 2010) may exist at this and previous stages; some of these are captured by decision trees or within each entry point in this guidance.

2.5.3 *Defining the purpose of and principles underlying the evaluation*

Early on in the planning stages of an evaluation, it is important to clarify the reasons for undertaking the evaluation and ensure that all participants are in agreement. Lack of discussion about this can result in confusion when deciding what indicators to collect, what kind of data are relevant, what methods and expertise are needed, and what could be considered as "successful" adaptation. The two fundamental questions are, "have we done things right?" (that is, the things we said we would do in the adaptation plan) and "were they the right things?" (how relevant were they? will they enable us to be less vulnerable or adapt better?). A third question might be, "how should we measure these things?"

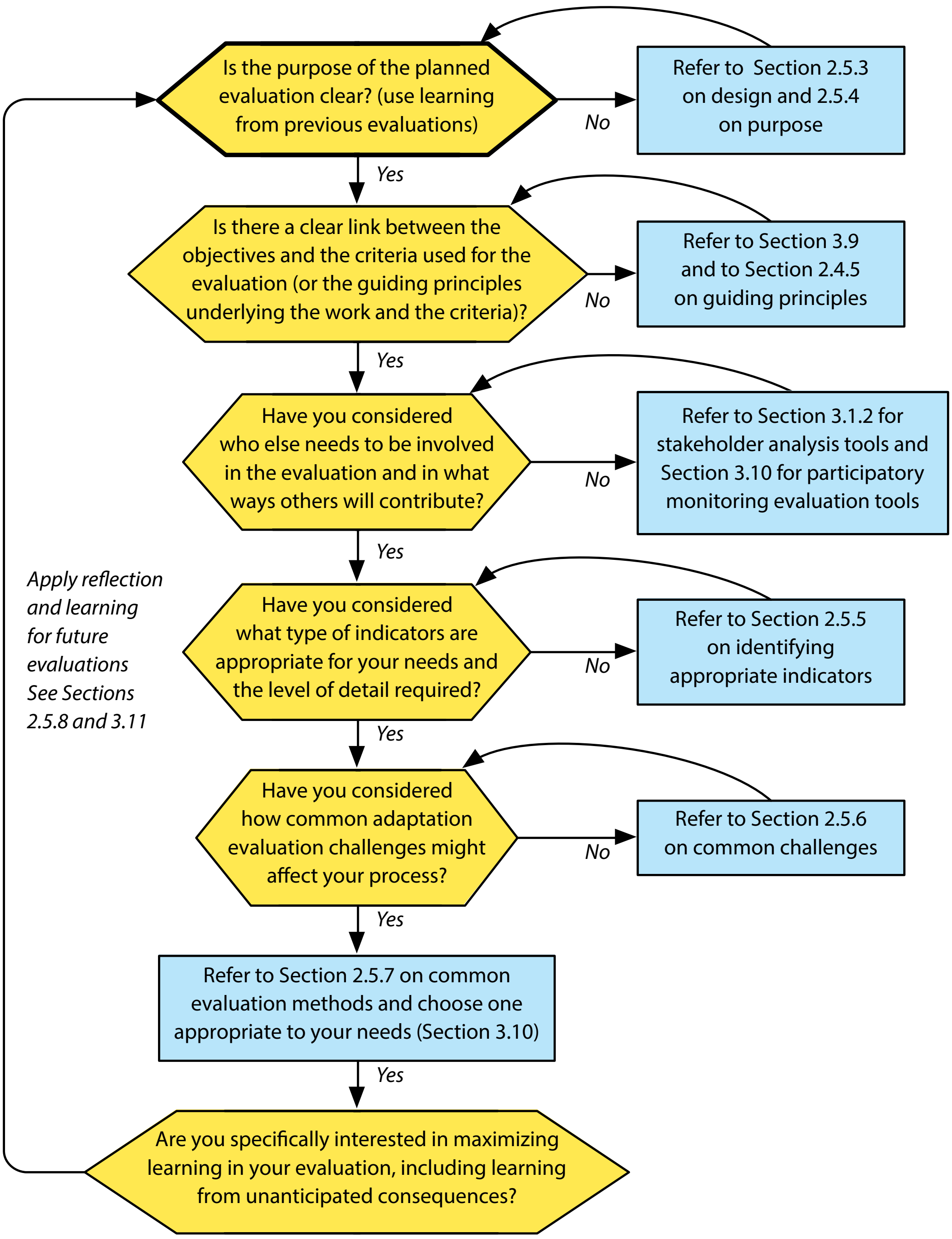

FIGURE 2.5.1 **Guidance for the process of monitoring and evaluation.**

Ideally, evaluations bring in a mixture of different types of information (scientific, political, legal, technical as well as local knowledge). It is useful to provide opportunities to compare these different perspectives – for example, through a science-policy dialogue. Aspects essential for creating sustainable solutions may not be adequately captured through local indicators, and scientific indicators could be used to provide a fuller picture. Having a wider understanding of the whole system can help in identifying points of leverage for catalysing change; informing decision-making in the change process; informing facilitation strategies of research teams, and supporting evidence-based policy-making.

2.5.3.1 Reasons for evaluating adaptation projects

An evaluation may have more than one purpose, and it is important for everyone involved to understand which purposes an evaluation is meant to serve. UKCIP's ADAPTMe Guidance (Pringle 2011) identifies the following possible purposes for M&E in adaptation:

To evaluate effectiveness: Often evaluations are used to determine whether an intervention has achieved the intended outputs and outcomes, which must be clearly specified at the start. Understanding effectiveness is particularly valuable in adaptation because we are still learning what are the most effective interventions, under what circumstances, and why. It is also important to consider whether the measures taken were truly needed and appropriate: for example, could they actually result in maladaptation?

To assess efficiency: Evaluators may want to determine whether an intervention was efficient in terms of the costs, benefits and risks involved and the timeliness of actions. This may require economic evaluation techniques where the costs and benefits are calculated in financial terms.

To understand equity: The impacts of climate change will be experienced unevenly, both spatially and temporally, and affect some individuals and communities more than others due to their differing vulnerability. Thus equity and justice are important factors to consider when evaluating adaptation interventions. This may raise questions about the effects of the project on different social groups (distributional justice) and their ability to engage in (procedural justice) and benefit from the intervention; whether the intervention has targeted the "right" people; and whether certain groups are exposed to disproportionate risks, bear additional costs or otherwise be negatively affected by the intervention.

To provide accountability: There may be a contractual or procedural requirement to undertake an evaluation to ensure that commitments, expectations, and standards are met. This is especially true where public money has been invested in adaptation, and evidence is needed to illustrate the achievements and challenges of the project. Accountability may overlap with efficacy and efficiency considerations – for example, to account for an investment in terms of its costs and benefits.

To assess outcomes: An evaluation may seek to provide an understanding of the outcomes and impacts of an intervention. This can be challenging, as it may not always be clear to what extent outcomes are attributable to the intervention, rather than to other factors. In adaptation projects in particular, a common challenge is that the outcomes may not be seen until long after the intervention is over. A project to introduce drought-resistant crop varieties, for example, might be able to show that X number of hectares are now planted with such crops, but the benefits (or lack thereof) won't be seen until the next drought. This is even more the case if the adaptive measures are meant to address longer-term climatic changes. In addition, it is difficult to take credit for avoided negative outcomes – for example, that no cholera outbreaks occurred due to sanitation improvements – precisely because nothing happened. The assessment of outcomes tends to be associated with summative evaluation approaches and the use of impact indicators.

To improve learning: Learning should permeate all evaluations, but the reality is that the investment in learning can vary considerably between evaluations. This can be the result of a tension between learning ("what happened and why?") and accountability ("have we done what we said we would?") and the limitations placed upon monitoring and evaluation processes. Recognizing these tensions and identifying who should be learning what, when and how, can help achieve learning objectives. Learning can occur in different spaces, within and between organizations, communities and sectors. Given the complex nature of adaptation, we should look to combine our own learning objectives with broader societal learning about adaptation. While some information may be commercially sensitive, much of the time sharing knowledge and experience of adaptation makes sound business sense, helping to make future adaptation interventions more efficient and cost-effective.

To improve future interventions: The purpose of an evaluation may be to strengthen future activities and interventions either at the end of a project (to inform future projects) or mid-way through an ongoing project. This would suggest a strong focus on learning in the design of the evaluation and, where appropriate, use of the formative methodology. Given that we are at an early stage in adapting to climate change, this should be a strong consideration for all evaluation processes.

To compare with other evaluations: You may wish to compare the experiences, results and other learning from different evaluations to understand how the impact of a specific type of adaptation intervention has varied in different locations or communities, and what factors might underlie the differences – or to compare the implementation and outputs of one adaptation option with those of another.

The choice of the purpose or purposes of an M&E framework will have an obvious influence on the type of indicators to be developed, the type of data to be collected, the level of detail required, etc. That, in turn, will dictate the level of complexity of the evaluation process, with implications for available resources, manpower requirements and time needed to collect the data. For example, Defra (2010) suggests that obtaining a snapshot of the adaptation status of the UK could consist of collecting and interpreting data for four components:

1. **Level of embedding:** The degree to which climate risk management is embedded in mainstream risk management and decision-making processes across society (including the policies, programmes and systems of government).

2. **Adaptive capacity:** The ability of a system to adjust to climate change (including climate variability and extremes) to moderate potential damages, take advantage of opportunities, or cope with the consequences. Note, within the skills, knowledge and understanding (e.g. of interdependencies) required for adaptive capacity are the capability to track and provide projections of climate and weather events: the existence and quality of monitoring/warning systems that indicate when a climate event and/or their effects is likely to take place, is taking place or has taken place, as well as providing timely warning of when significant climate sensitive thresholds are being approached.

3. **Effectiveness of actions:** The relative effectiveness of past/current adaptive actions and options in terms of sustainably reducing the rate and magnitude of the impacts and enhancing adaptive capacity and resilience.

4. **Degree of flexibility preserved:** The degree of flexibility preserved or promoted in society's systems by maintaining or increasing flexibility and future options for evolution through adaptive actions taken.

While it is important to design an evaluation process that is comprehensive and focused on the key areas of interest, there will always be a balance between types of data that would be ideal to collect for a given purpose and what is pragmatically possible, given data availability and availability of resources.

In addition to clarifying the purpose of the evaluation, it may also be useful to articulate principles underlying the work. Spearman and McGray (2011) suggest that three principles underpin effective M&E systems for adaptation interventions: design for learning; manage for results; and maintain flexibility in the face of uncertainty. They emphasize the need to carefully articulate adaptation objectives when undertaking an evaluation, to clarify the basis for project design, and make transparent assumptions regarding, for example, the climatic, social and economic factors that may influence the project's ability to help vulnerable people thrive in a changing climate. Once this has been clarified and agreed, it is then possible to go on to select indicators and build information systems that are able to track adaptation success.

2.5.4 Designing monitoring and evaluation processes

Spearman and McGray (2011) distinguish between three types of adaptation efforts: community-based adaptation, programme- and project-based adaptation, and national policy initiatives. Each type has evolved to meet specific needs, and each requires an M&E system that is tailored to meet those needs. Examples of evaluation design and planning processes are provided in Section 3.9.

It is important to remember that adaptation activities occur within a broader context, so in many cases, rather than create separate M&E frameworks, the task will be to integrate climate change vulnerability and adaptation into existing frameworks. For example, rather than create a new system to monitor climate-related health issues, one might add adaptation indicators to public health surveys that are already in use. In addition, adaptation-specific M&E frameworks can be strengthened by capturing longitudinal data from monitoring structures in various government agencies and across sectors.

There is a clear need to be getting different perspectives on "success" in an adaptation evaluation. Funders may see the project as suiting their needs, but the intended "beneficiaries" might see no positive change. This requires methods that can effectively bring in different perspectives. A number of resources are available that address this; they are discussed in Sections 3.9.3 and 3.9.5.

Below we describe different approaches for designing M&E processes in developing and developed countries.

2.5.4.1 Developing countries

Spearman and McGray (2011) propose a six-step process to develop adaptation-relevant M&E systems in developing countries. For each step, they identify design and implementation questions for practitioners to address, and they provide example indicators along three key dimensions of adaptation: adaptive capacity, adaptation actions, and sustained development in a changing climate. Below we describe those steps in the context of the previous sections' guidance.

Step 1 – Describe the adaptation context: It is essential for practitioners to understand the climate and non-climate factors and populations that will affect and be affected by the interventions they plan. This information can be drawn from vulnerability and/or climate risk assessments done at the outset (see Section 2.1) as well as from additional research and participatory processes during the appraisal of adaptation options (see Section 2.3) and the development of the adaptation plan (see Section 2.4). Additional data may be gathered to better understand the context.

Step 2 – Identify the contribution to adaptation: As discussed in Section 2.4, a key aspect of adaptation planning is to set specific goals, linked to specific activities. Spearman and McGray (2011) propose three categories of activities based on their potential contributions to the adaptation process: adaptive capacity, adaptation actions, and sustained development in a changing climate. Funders and their partners can use this framework to, among other things, define high-level goals or outcomes. Practitioners can use it to characterize types of lessons learned from the M&E systems of various adaptation interventions.

Step 3 – Form an adaptation hypothesis: To test the validity of a location-specific approach to adaptation, practitioners can formulate an adaptation hypothesis for each major expected outcome. For example, crop diversification might be a strategy for a farming village to manage increasing climate variability. The hypothesis might be that the use of a particular seed blend will reduce crop sensitivity to extreme temperatures and drought, thereby improving average yield and overall average food security. The intervention results would show whether the tested approach yielded the quality or degree of intended behavioural or environmental changes.

Step 4 – Create an adaptation theory of change: In light of the many uncertainties surrounding adaptation interventions, a theory of change is a helpful tool for practitioners to illustrate the relationship between an intervention's components, expected results, and assumptions about factors that can enable or inhibit the likelihood of achieving success. Practitioners can use a theory of change to identify and correct false assumptions, integrate new information into a strategy, or pinpoint the reasons for achievements or failures.

Step 5 – Choose indicators and set a baseline: Choosing appropriate indicators for adaptation requires rooting an intervention's goals within its specific climate change and development context. Practitioners can use the three adaptation dimensions. Spearman and McGray (2011) offer two sets of example indicators within each dimension: "assets" and "institutional functions" for adaptive capacity; "climate hazards" or "vulnerability drivers" for adaptation actions, and "ecosystem services" and "livelihoods" for sustaining development in a changing climate.

Step 6 – Use the adaptation M&E system: This step in Spearman and McGray (2011)'s guidance explains how to use the M&E system for various purposes. Adaptation-relevant M&E systems can be used by practitioners to demonstrate the relative contribution of interventions to the adaptation process and answer evaluation questions related to, for example, performance, efficiency and effectiveness. The differences between activity and outcome monitoring are highlighted, as well as the importance of results-based management, flexibility, and learning, including through regular feedback loops and engagement with partners.

2.5.4.2 Developed countries

At the project or programme level, UKCIP's AdaptME toolkit (Pringle 2011) offers ways to think through some of the factors that can make an evaluation of adaptation activities inherently challenging, and assist in designing a robust evaluation. Specifically, the toolkit offers help on:

- Refining the evaluation purpose and objectives;
- Reflecting on what is being evaluated and the logic behind this;
- Understanding how specific traits of climate adaptation can make evaluation challenging, and how to overcome these challenges;
- Drawing out, understanding and re-evaluating assumptions;
- Considering how progress and performance might be best measured and evaluated;
- Identifying examples, good practice and techniques which may help to ensure an evaluation is robust in the context of climate change;
- Prioritizing evaluation activities, recognizing that evaluations need to be proportionate to the investment and are resource-limited.

2.5.5 Identifying appropriate indicators

The ability to track progress on adaptation and learn lessons relies on the selection of indicators that are capable of isolating and representing the essential changes sought. Going through the process of defining indicators may also help in clarifying different perspectives on the desired outcomes and in setting realistic expectations, and they may also help to achieve consensus. On the other hand, there are many potential pitfalls in the use of indicators. It is easy to pick misleading or inappropriate indicators, the data may be unreliable, and a great deal of context may be lost, creating a false sense that climate risks are fully quantified and understood.

Flood evacuation road in India © Flickr/European Commission DG ECHO

The United Nations Development Programme's M&E guidance (UNDP 2002) notes that cost, complexity and/or the timing of data collection may prevent a result from being measured directly; in those situations, using proxy indicators is recommended. For example, "fair and efficient administration of justice" may be measured by surveying public confidence in the justice system, and the level of toxins in duck eggs might serve as a proxy indicator of water quality in a lake. UNDP also recommends:

- Using disaggregated data – by location, gender, income level and social group (as relevant);
- Involving stakeholders in the development of indicators (see also Section 2.4);
- Distinguishing between quantitative and qualitative indicators, and choosing one or the other based on the nature of the intended result to be measured;
- Limiting the number of indicators, choosing "a few credible and well-analysed indicators that substantively capture" changes; a balance should be struck between what should be measured, and what can be measured;
- Ensuring timeliness, so the indicator target date corresponds to the expected progress of the activity being evaluated.

A report by the Organisation for Economic Co-operation and Development (OECD) provides the first empirical assessment of M&E frameworks used by development cooperation agencies for their projects and programmes with adaptation-specific or adaptation-related components, drawing on the experience of six bilateral development agencies (Lamhauge et al. 2012; see also Lamhauge et al. 2013). Based on a review of 106 projects and programmes, the authors find that selection of appropriate and measurable indicators is a critical aspect of M&E for adaptation. They recommend that M&E frameworks for adaptation combine qualitative, quantitative and binary indicators, and note that on its own, any category of indicator is insufficient. For instance, to establish the successful development of a policy framework, you need also to find indicators to assess implementation and sustainability. Policy development indicators thus need to be augmented by quantitative indicators that measure, for example, the number of projects that have been developed in response to the policy, or the number of households that have benefitted from it.

The Bellagio Framework (McGray et al. 2009) also identifies criteria for indicators to be used in M&E processes:

- Broad applicability;
- Flexibility to accommodate national circumstances;
- Logic and straightforwardness;
- User-friendliness and common sense;
- A top-down approach that empowers bottom-up action;
- Comprehensiveness with regard to key national adaptation functions;
- Compatibility with other tools, frameworks, and decision criteria.

The OECD review (Lamhauge et al. 2012) found a wide variation in the level of detail of the data that were being collected for adaptation evaluations. Some projects had detailed indicators corresponding to every component of an intervention, while others used more aggregate indicators. The authors suggest that the preferred approach is likely to depend on the type and the scale of the activity. It is clearly important to be rigorous and careful in identifying indicators to develop credible and effective evaluations that can be used to capture learning and provide accountability. However, there is a danger that too much focus is placed on results measurement and indicators, diverting those managing the process from useful and potentially more effective, but less measurable activities.

2.5.5.1 Process and outcome indicators

UNDP (2007) notes that adaptation "is not generally an outcome, but rather consists of a diverse suite of ongoing processes (including social, institutional, technical and environmental processes) that enable the achievement of development objectives". It is thus important to distinguish between two basic types of indicators that may be used in M&E: **process indicators**, which measure progress in a process leading towards the desired outcome (e.g. number of farmers trained in water-saving techniques), and **outcome indicators**, which define a specific outcome (e.g. change in irrigation water losses). Process indicators are relatively easy to use, and they are used frequently; using outcome indicators for the evaluation of adaptation interventions can be more challenging, because outcomes often take a long time to be realized given the long time horizons of climate change. Still, both types can be valuable, and any evaluation is likely to be a mix of both types. Defra (2010) explains the roles of the two types of indicators thus:

> **Illustrative example of a 'process' indicator:** A process that could contribute to improving the UK's resilience to our changing climate might be to ensure that the Government estate was embedding adaptation into its management. Progress by departments increasing their estates' resilience to the impacts of climate change might be monitored through an indicator that measures:
>
> ***"the number of government departments improving the capacity of their estates to adapt to the impacts of climate change"***
>
> Levels of performance could be gauged through a grading system, (0–4) with a higher number representing further progress made in planning to adapt to climate change. '1' might represent gathering evidence or increasing understanding of the issues; whereas '4' might represent taking and reviewing actions based on a completed risk assessment and action plan. Such an indicator could be monitored annually or less frequently, e.g. once every few years.
>
> **Illustrative example of an 'outcome' indicator:** An outcome of adaptation to climate change in the UK could be reflected in our ability to adapt to hotter summers. One aspect of our progress in adapting to these might be monitored through:
>
> ***"the number of excess deaths from heat related illnesses during the hottest 3 months of the year"***
>
> Such an indicator might be analysed in a number of ways: it could be looked annually or over longer time periods. Limiting increases or observing a sustained decrease in such a number, in the face of increased heat, might reflect an increase in the UK's ability to adjust to our changing climate. However, such an outcome indicator could be influenced by a great variety of factors drawn from systems right cross society.

Clearly no one set of indicators will work for all adaptation interventions, and indicators must be chosen based on the relationship between planned adaptation activities and the context in which they are to be implemented. The AdaptME guidance (Pringle 2011) offers some useful questions to consider:

- Refer back to the objectives of the intervention – do the metrics and indicators help you to understand whether the objectives have been met?

- Consider and thoroughly test the logic behind your chosen indicators. Are they fit for purpose? Would they be more robust if worked into a *package* of indicators?
- How might changes in availability of data over the study period affect what can be measured, and when? This may affect which metrics you choose.
- Resist the temptation to distil your findings into a *single number* – this may be attractive to policy-makers, but does it tell them the full story?
- Remember that while metrics may be objective, the choice of indicators is not; these may reflect a particular framing of climate change. For example, a business may develop metrics to look at the economic viability of an adaptation action rather than examine the social distribution of benefits. Consider and challenge your own framing so it provides you with as full a picture as possible, as well as meeting your organizational needs.
- Quantitative metrics are attractive, but should be balanced with qualitative data which examines the facts behind the figures.
- Do the metrics you have chosen reflect a particular idea of success? Do you need to consider success from the point of view of other stakeholders or community members? For example, the success of a project to increase green space in urban areas could be measured in terms of *reduced impact of the urban heat island effect, increased biodiversity* or *increased recreational space*. All may be valid success measures depending on an individual's perception.

2.5.6 Common challenges

Adaptation activities take place within complex systems, and in the quest to develop indicators that can be used right away, it is easy to oversimplify, and pick indicators that distract from the actual goals, or that even skew the process (since people will naturally prioritize what is being measured). Evaluation processes may also cover too short a time-span to capture the slow process of creating real, sustainable and effective change. Methods that capture something of the complexity of the system (beyond linear causality), such as outcome mapping and "most significant change" evaluations, enable projects to capture "surprise" and unanticipated consequences of an intervention, which is useful in challenging assumptions of how change happens and what type of intervention is likely to be most effective.

Other challenges described in the growing literature on M&E systems for adaptation include:

- Choosing appropriate indicators to monitor performance;
- Lack of experience to draw on, as the implementation of projects and programmes that specifically target adaptation is still relatively recent;
- Difficulties in defining baselines in order to measure project or programme impact;
- Uncertainties around the timing and scope of change that can be anticipated;
- Difficulties figuring out how to measure the effectiveness of adaptive measures taken in anticipation of climate changes that will not occur for decades still;
- Uncertainty about how society, technology, the country as a whole and the climate will change over the same period;
- Focus on things that are easy to measure, or where monitoring already exists, even when they may not be the most relevant; this can also be a disincentive for undertaking activities for which outcomes are not easily measurable;
- Difficulty in measuring "soft" areas of capacity-building, even though these may be very significant in supporting effective adaptation;
- Existence of many other factors influencing a particular outcome or output, which makes it difficult to attribute them to a particular intervention.

This clearly makes it difficult to know what to measure as an indicator of success. Also, as adaptation is mainstreamed into existing policies and risk-management processes of organizations it will become harder to attribute the actions taken for adaptation to the desired outcomes. For more useful guidance on managing "tricky issues" associated with designing adaptation evaluations, see Pringle (2011).

2.5.7 Common approaches

The OECD review (Lamhauge et al. 2012) of M&E frameworks in projects and programmes by development cooperation agencies finds that the most commonly used approaches to distinguish between outcomes, outputs and activities are results-based management and logical frameworks. These are briefly described here, but more information is available in Section 3.10.

2.5.7.1 Logical frameworks

A logical framework is an analytical management tool which can help planners and managers to analyse a situation and identify objectives, the means by which they will be reached, potential obstacles, and a way to monitor and evaluate outputs and outcomes. The findings are usually summarized in a four-by-four matrix, called a logframe. The rows list a vertical hierarchy of objectives and the columns present how each objective will be assessed and means of assessment. The columns also outline assumptions that may affect project achievements. Table 2.5.1 outlines a typical logframe.

2.5.7.2 Results-based management

Results-based management is a management approach that focuses on ensuring that all of a project's (or organization's) processes, products

TABLE 2.5.1 **The logical framework approach.**

Narrative summary	Objectively verifiable indicators	Means of verification	Assumptions
Goal – the overall aim to which the project is expected to contribute	Measures (direct or indirect) to show the project's contribution to the goal	Sources of information and methods used to show fulfilment of goal	Important events, conditions or decisions beyond the project's control necessary for maintaining progress towards the goal
Outcomes (or objectives) – the new situation which the project is aiming to bring about	Measures (direct or indirect) to show progress towards the objectives	Sources of information and methods used to show progress against objectives	Important events conditions or decisions beyond the project's control that are necessary if achieving the objective is going to contribute towards the overall goal
Outputs – the results that should be within the control of the project management	Measures (direct or indirect) to show if project outputs are being delivered	Sources of information and methods used to show delivery of outputs	Important events conditions or decisions beyond the project's control that are necessary if producing the outputs is going to help achieve the objectives
Activities – the things that have to be done by the project to produce the outputs	Measures (direct or indirect) to show if project outputs are being delivered	Sources of information and methods used to show that activities have been completed important events	Important events, conditions or decisions beyond the project's control that are necessary if completing activities will produce the required outputs
Inputs: Resources – type and level of non-financial resources needed for the project Finance – overall budget Time – planned start and end date			

Source: Adapted from Mikkelsen (1995), as cited in Bakewell and Garbutt (2005) and services contribute to achieving the desired results. It requires clearly defined accountability for results and systematic monitoring, self-assessment and reporting on progress. Results-based management provides a way to prioritize an organization's (or project's) work and systematically link activities carried out by it at all locations and regardless of the funding sources. M&E in a results-based management approach focuses on:

- Active *application* of monitoring and evaluation information to the *continuous improvement* of strategies, programmes and other activities;
- Monitoring of substantive *development results* instead of just inputs and implementation processes;
- Monitoring and evaluation of results *as they emerge* instead of after project completion;
- Conduct monitoring and evaluation as *joint* exercises with development partners.

2.5.7.3 Outcome mapping

Outcome mapping was developed by the International Development Research Centre (IDRC) in Canada as a methodology for planning, monitoring and evaluation. The approach is grounded in an understanding of development as a complex and non-linear process that involves multiple actors, some of whom work for, and some whom work against, change. Outcome mapping has a lot to offer in the evaluation of adaptation interventions, as it gets away from assumptions made in impact-based methods, such as that it is possible to make simple cause-and-effect links. It also acknowledges that positive outcomes are usually due to a number of factors coming together rather than the actions of a single intervention or actor. Outcome mapping provides a mechanism for drawing together different contributions to an outcome, which is essential in order to learn more about what supports successful adaptation.

2.5.7.4 Most significant change

Most significant change is a participatory form of monitoring and evaluation based on listening to what people (beneficiaries/participants/stakeholders) consider to have been the most significant change resulting from the project or initiative. The approach requires no special professional skills and is easy to communicate across cultures, as people generally find it easy to tell stories about events they think were important. There is no need to explain what an indicator is. It is also a good way to pick up unanticipated changes and changes that may challenge your assumptions of what is happening. This approach encourages people to engage in analysis as well as data collection stages of a project as they have to explain why they believe one change is more important than another. It can be used to monitor and evaluate bottom-up initiatives that do not have pre-defined outcomes against which to evaluate.

2.5.8 Evaluation as an opportunity for learning

Spearman and McGray (2011) suggest that M&E systems play two critical roles in ensuring effective adaptation: they support the long-term process of learning "what works" in adaptation, and they provide a tool for practitioners to manage their work in the context of the uncertainty surrounding climate change impacts. Evaluation processes can be specifically designed to enhance learning by encouraging the use of all insights from the evaluation of indicators in order to adapt the current plan, improve the design of the next project, or compare with other evaluations in an iterative cycle. Evaluations are often spoken of as an opportunity to learn, but as noted earlier, this needs to be consciously built into the process if it is to be effective. This requires thinking through who needs to be learning, how people can provide insight and feedback, what kind of things can be learned (facts, skills, stories) and what level of challenge is available to move people beyond "business as usual" thinking. It also requires that "spaces" are made available for this in the process. For this learning to feed into later programmes of work there has to be a process for how feedback from the evaluation feeds into other processes when the evaluation is complete.

It is also important to provide for both fast (short-term) and slow (long-term) learning. For example, it might take 10–15 years to learn that a measure meant to reduce vulnerability to increasing water scarcity (e.g. planting trees) does or does not work well. We need quick ways to check our assumptions about what needs to change and how it will change – e.g. are farmers actually adopting new practices after an intervention, and if not, why not? – while also building our knowledge over time, both about adaptation and about climate change impacts (e.g. the long-term effects of various stressors on mangroves).

Spearman and McGray (2011) conclude by highlighting ways to "learn by doing" in the development of M&E practice for adaptation, and proposes areas for further development and research:

- **Think outside the project box:** The challenges of M&E for adaptation are largely shaped by factors outside the individual project cycle. Therefore, developers of M&E systems need to move toward measuring changes in broader systems.
- **Explore options for overcoming barriers to participation:** Further work is needed to understand how technology, capacity-building, and wise use of financial resources can reduce the costs associated with stakeholder participation in M&E, improve inclusion processes, and scale up use of participatory approaches.
- **Link existing M&E systems:** Stronger connections between bottom-up and top-down information and decision-making could help focus scarce resources by eliminating duplicate reporting structures, sharing common relevant information, and potentially improving accessibility and transparency. Integrated adaptation M&E systems could also be used to link disparate sectoral or thematic activities.
- **Promote experimentation:** Useful experimental approaches for adaptation from the industrialized world are beginning to gain traction in the development sphere. M&E will play an important role in helping to learn when such approaches have value and how they can be adjusted to specific locations.
- **Face tensions and trade-offs openly:** M&E of adaptation presents challenges in a world of limited resources, where it is rarely possible to manage multiple processes for a given place, issue, or activity. Open discussion of tensions and trade-offs can ensure that a given system is used appropriately, and that its results are not misunderstood, misinterpreted, or used for cross-purposes.

Farmer learning event, lower Nyando, Kenya © Flickr/CGIAR

3 Methods and tools

3.1 Participation and engagement

3.1.1 Introduction to participatory processes

Adapting to a changing climate, in a world that is simultaneously changing in many other ways, is a good example of a "wicked" or unbounded problem, as described by Chapman (2002): one where there is no clear agreement on what the problem is, there is uncertainty and ambiguity about how to solve it, and there are no limits to the amount of time or resources the problem could absorb. Such situations require considering the perspectives of all involved, even if it is not easy, as when there is a history of conflict. Dialogue processes are needed that engage all those with influence over the process or those affected by it, and enable them to contribute freely and be heard and understood by the others. This section describes tools to guide you in setting up and managing participatory processes. We begin with an outline of the benefits of stakeholder engagement, adapted from Twigg et al. (2001):

1. Participatory processes can make initiatives more sustainable, by building on local capacity and knowledge, and by creating a sense of "ownership" among participants, making them likelier to comply with any decisions made.

2. Working closely with local communities can help decision-makers gain greater insight into them, enabling them to work more effectively and produce better results. Community members, in turn, learn how the decision-making process works and how to influence it.

3. Working and achieving things together can strengthen communities and build adaptive capacity by creating awareness of different people's priorities and finding ways to address them. It can reinforce the role of local organizations, and build confidence, skills and capacity to cooperate. In this way it increases people's potential for reducing their vulnerability and may give them confidence to tackle other challenges, individually and collectively.

4. Stakeholder participation in planning, implementing and evaluating projects is consistent with people's right to participate in decisions that affect their lives. Participatory processes can also improve the likelihood of equity in decision-making and help resolve conflicts.

5. Although engaging stakeholders is time-consuming, it may make processes more cost-effective in the long term than externally driven initiatives, because the process allows the ideas to be tried, tested and refined before adoption.

Adaptation processes need to be flexible and support improvisation, rather than focus on control and on predictable outputs that may be impossible to achieve in such a dynamic and unpredictable system. The focus when engaging others in participatory processes for adaptation should thus be on creating the conditions and capacity to pick up signals of change, have options that are robust to a range of situations, and be able to respond effectively. This requires developing the capacity to notice change, reflect on assumptions of what is happening and what needs to change, and learn so that the actions that follow benefit from this experience.

A key benefit of participatory processes is that they help ensure that tools and methods make

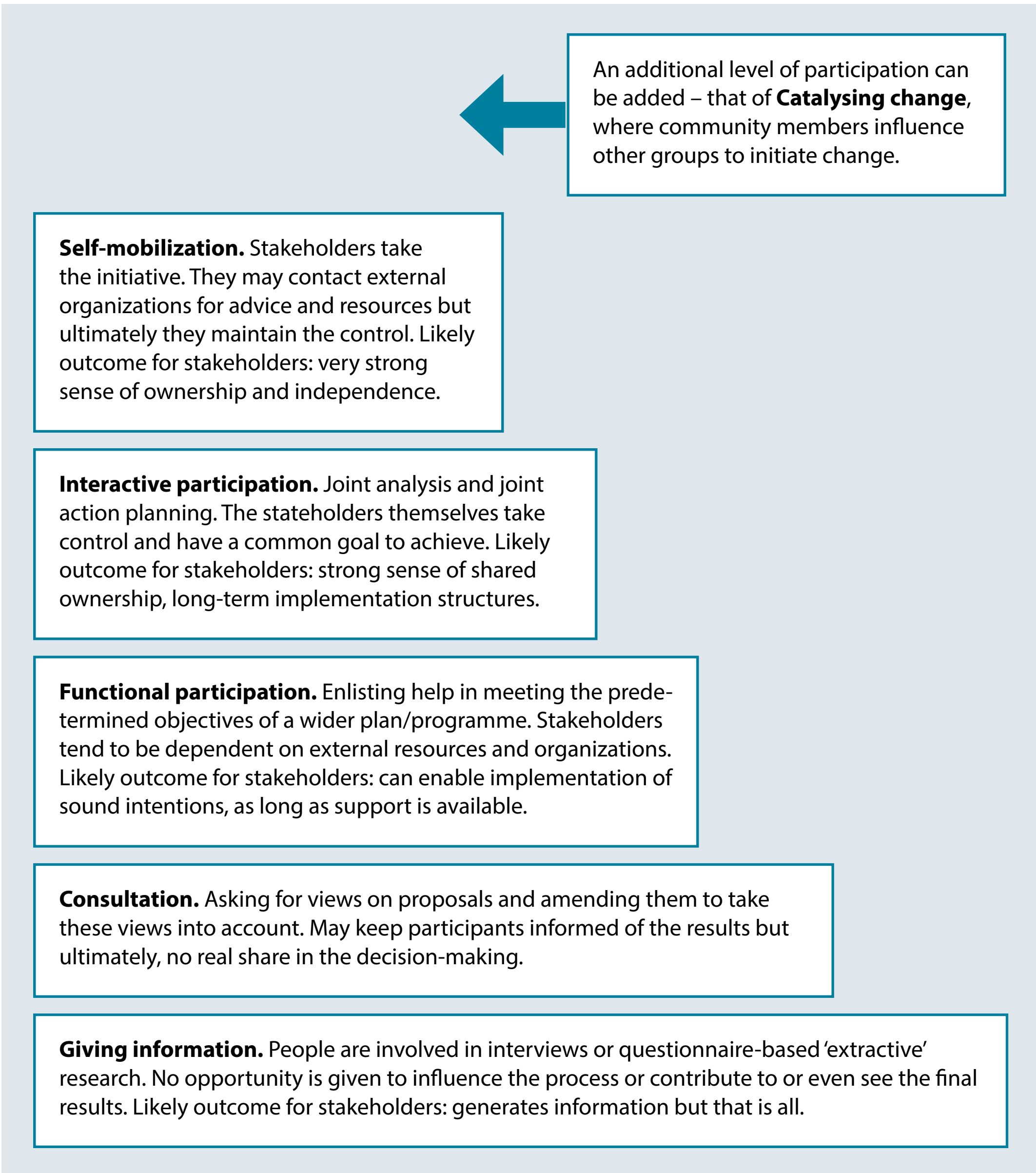

FIGURE 3.1.1 **Ladder of participation** (adapted from Pretty 1995).

sense "on the ground", which is essential if they are to be absorbed and implemented. In adaptation practice, one effective way to accomplish this is through "co-production" of knowledge, with collaborative learning between experts and users. This can be challenging: issues around power and who controls the process can have a significant impact on the effectiveness of the collaboration, and there is a risk of reproducing (or even reinforcing) previously held and unhelpful perceptions and a sense that "things will never change". These processes all depend on the quality of the relationships between the individuals in the system. People need to be supported to be able to engage, especially if they are new to such exercises, or else the level of the interaction will be reduced. The facilitator can play an important role in encouraging and supporting engagement and dialogue.

3.1.1.1 The level of participation varies

O'Hara (2006) warns that "there is a thin line between facilitating a process driven by community members for long-term positive change and 'facipulation' of a community to come up with a short-term, tangible success story for donor consumption". Arnstein (1969), on the other hand, viewed citizen participation as a form of citizen power, defining it as "the redistribution of power that enables the 'have-not citizens' presently excluded from the political and economic processes, to be deliberately included in the future". Some have suggested viewing participation on a spectrum, or on a ladder. One such ladder, offered by Pretty (1995), is shown in Figure 3.1.1.

The key factor here is how much power and influence stakeholders have in the process. Engagement approaches can range from quite passive interactions, where the stakeholders are simply informed or provide information, to "self-mobilization", where the stakeholders themselves initiate and design the entire process. Engagement closer to self-mobilization is not necessarily "better" for being more participatory; different levels of participation are appropriate for different stages of a project, or under different circumstances (for a thoughtful discussion of the challenges of ensuring meaningful participation, based on experiences with adaptation on the UK coast, see Few et al. 2007). It is important to consider who is making the decisions at each stage of the process: defining the research agenda for a climate risk assessment; identifying adaptation options; appraising the options; developing an adaptation plan; implementing the plan; monitoring and evaluating the actions and drawing lessons.

Kanji and Greenwood (2001) distinguish between five possible levels of participation:

- **Compliance:** Where tasks and incentives are aligned, but the agenda and process are directed by outsiders;
- **Consultation:** Where stakeholders' opinions are sought, and outsiders analyse and decide the course of action;
- **Cooperation:** Where stakeholders work with outsiders to determine priorities, but the outsiders are still responsible for directing the process;
- **Co-learning:** Where stakeholders and outsiders share knowledge, create new understanding and work together to form action plans; and
- **Collective action:** Where stakeholders set their own agenda and mobilize to carry it out in the absence of outsiders.

An important factor to consider is that stakeholders need to understand why it is worth their while to participate, or else they may see the process as a waste of their time and effort. Rigid, externally imposed agendas may narrow the discussions so much from the outset that they become uninteresting or even irrelevant to those being asked to participate. Stakeholders may also get frustrated if no adjustments are made in response to new insights generated through the engagement process. A lack of concrete action resulting from the work can undermine stakeholder engagement over time, leading to "participation fatigue".

3.1.1.2 Ethical and social-justice considerations

Defining the role of participatory approaches in the adaptation process is a key part of designing the process. Given the iterative nature of adaptation, the role of stakeholders is likely to change over time, but it is still important to be honest with ourselves and with the people we work with about the nature of their participation, how the information they provide will be used, what power they might have to influence decisions, and what decisions have already been made. Blackburn and Holland (1998) write that participation "is a way of viewing the world and acting in it. It is about a commitment to help create the conditions which can lead to significant empowerment of those who at present have little control over the forces that condition their lives."

Participatory approaches are often overtly about empowering and building the capacity of those involved to analyse and act and increase their control over resources necessary for their lives. Processes that engage people in decisions that affect key aspects of their lives and livelihoods inevitably need to give serious consideration to the boundaries of such engagement and what the impact might be of low involvement, false expectations or a failure to include key voices. Participatory processes can also be viewed as "exercises in the use and control of power to depict reality, its causes and what to do about it" (Mbilinyi and Rajani 2001) and thus need to be seen as far more than a set of tools and methods. There has been a backlash against the use of participatory approaches in both developed- and developing-world contexts (Cooke and Kothari 2001) as they have been used without attention to the ethical aspects, to extract information quickly with no follow-up or reporting of results to those who participated. Purely extractive research may be appropriate in certain situations, but it becomes unethical if it is labelled as "participatory".

"Outsiders" coming into a situation may also be unaware of the power dynamics in the community, and not realize that some people are excluded from participatory processes or don't feel comfortable speaking when certain other people are in the room (Chambers 1995). Local people can help to overcome this, but outsiders should also constantly verify and cross-check information for trustworthiness throughout the process.

In his book *The Reflective Practitioner: How Professionals Think in Action* (1983), Donald Schön explains that in order to achieve participation on the empowering end of the spectrum, outside experts have to change how they view their role, from an authority, to a "facilitator". Rather than being in control, they have to "learn to be silent, to listen, to sit on the ground attentively and not to lecture, not 'to wag a finger or a stick'". Table 3.1.1 outlines the implications of such a shift.

3.1.1.3 Being a good facilitator

Facilitators play a crucial role in participatory processes, guiding the discussion, ensuring that everyone's voice is being heard, checking periodically that activities are proceeding as planned, and making adjustments as needed. Doing this well does not require advanced technical skills, but it does require a personal commitment to a participatory process (rather than a particular outcome), reliability, being a good listener, and being a good questioner (for clarification and deepening understanding). A good facilitator must also be able to reflect back and summarize clearly and without bias, be able to work as part of a team, understand

TABLE 3.1.1 **From expert to reflective practitioner – per Schön (1983).**

Expert	Reflective practitioner
I am presumed to know and must claim to do so regardless of my own uncertainty.	I am presumed to know but I am not the only one in the situation to have relevant and important knowledge. My uncertainties may be a source of learning for me and for them.
Keep my distance from the client and hold onto the expert role. Give the client a sense of my expertise but convey a feeling of warmth and sympathy as a "sweetener".	Seek out connections to the client´s thoughts and feelings. Allow his respect for my knowledge to emerge from his discovery of it in the situation.
Look for deference and status in the client's response to my professional persona.	Look for the sense of freedom and of real connection to the client as a consequence of no longer needing to maintain a professional façade.

and be able to manage group dynamics, and communicate well with all stakeholders. This is a lot to expect from one person, but several people can work together and support one another.

Relationship-building is an important part of participatory approaches, and that requires strong interpersonal skills, which are often undervalued in organizations – there can even be an assumption that everyone can do this, or that good facilitation is just about "being nice". As Pelling and High (2005) emphasize, it is also important to make connections and build trust outside the formal process; informal "spaces" that allow people to get to know one another are also important for relationship-building.

Facilitators need to be clear about the goal of the work, the scope of involvement at different stages and what people can expect to get from being involved. They need to use techniques that get below the surface of the issues, but also need to be skilled in creating a feeling of safety in order to do this. It may feel very dangerous for people to say what they really think, especially about shared and scarce resources. There is a clear ethical aspect to this: What can people safely talk about here? In whose presence? Who dominates in this group? Where possible, it is helpful to engage local facilitators who understand the local situation and speak the local language. Training local people who are recognized as unbiased and trustworthy by the local community is also a way to build local capacity and ensure that the work has a legacy beyond the end of the project.

It is also important to recognize the many subtle judgements made in recording the discussion: what information is included or excluded, and how it is summarized. As Cornwall and Gaventa (2000) note, "What emerges is neither a neutral set of 'facts', nor a neutral process." Participatory processes can produce large amounts of unstructured information that still needs to be analysed and incorporated into the overall study, analysis or plan. As this material is analysed and reflected upon, patterns are noticed, deeper meanings are identified and shared, and true learning can occur. As in any editing or prioritization process, the people who manage this stage have a great deal of influence over the results. Ideally, those who contributed to the generation of the information should also be involved in this stage, as this will build their capacity for analysis, allow for clarification as needed, and potentially increase the quality and social equity of the outputs. If, on the other hand, the information is analysed remotely, away from those who generated it, it is easy to misunderstand meanings. Undertaking the process of reflection and analysis within a community and with the people that produced the original material not only increases the quality of the data, the suitability of the ideas and solutions that come out of the process but also enables those involved to gain confidence in their ability to represent their views to others. This also provides an opportunity to delve deeper into the causes of the problems and understand more about why these issues are important and identify realistic and relevant solutions (Guijt and Braden 1999).

3.1.1.4 A general note about participatory tools

Participatory processes often use multiple tools together: e.g. timelines, Venn diagrams, seasonal calendars, ranking exercises. There is an ethos of "open source" sharing and adaptation in the use of participatory tools. Tools can be adapted to a specific context and do not have to be applied rigidly – they are meant to help you, not prescribe what to do. The most important thing is to know why you are using a particular tool.

Many of the tools described below can be used at different stages of the process: e.g. the same tool (rich pictures or H diagram) can be used to scope the problem, gain others' perspectives, identify priorities for learning, and evaluate the process. Several are also explicitly designed to engage stakeholders throughout the adaptation process, ensuring that they play a role at every stage: from identifying climate risks, to implementing adaptation actions and evaluating their effectiveness. We have grouped those tools together in Section 3.1.3; be aware that many have names that suggest a narrower focus on identifying adaptation needs, but they actually go beyond that. A closely related discussion of participatory processes – community vulnerability assessment and participatory scenario development – is included in Section 3.2.3.

Along with tools and guidance developed specifically to support adaptation, we list more general tools that are valuable for a wide range of participatory processes, in adaptation and beyond. These include tools for stakeholder analysis (Section 3.1.2), tools for facilitation (Section 3.1.4), participatory analysis tools (Section 3.1.5), large-group and whole-system techniques (Section 3.1.6), and conflict resolution tools (Section 3.1.7). In addition, see Ayers et al. (2012), and the discussion of it in Section 3.10.3, for a participatory approach to evaluating community-based adaptation, and Section 3.11 for participatory tools for learning and reflection.

The majority of the materials listed here are available as free downloads on the internet; however, where relevant, we have also included some useful books and peer-reviewed journal materials.

3.1.2 Stakeholder, social network and participation analysis tools

A key step in engaging stakeholders is to understand who all the actors are in a given adaptation situation: who is affected by a climate risk or a proposed adaptation measure, who has the power to make various decisions, and how different actors influence one another. The tools described in this section are designed to help identify who needs to be consulted, assess their interests and relationships with one another, and understand what support they might need in order to be able to participate effectively. For an in-depth introduction to stakeholder engagement, see Conde and Lonsdale (2005), or for a quick overview with a useful bibliography, see Bharwani et al. (2011).

3.1.2.1 Stakeholder analysis

These tools –including tables and matrices – help you to think through who is involved and what their particular interests in the work or decision might be. This clearly affects how they should be involved in the work and at what stages. The tools can be used for diagnostics, for sharing understanding in a team and cross-checking with stakeholders, for planning, or for monitoring and evaluation (e.g. reflecting on whether the right people involved at the right times and in the right ways). For quick overviews, see Hovland (2005, pp.8–9) or Lonsdale (2011), both available free online. A subset of this type of analysis is stakeholder influence mapping, which examines and visually displays the relative influence that different individuals and groups have over decision-making. Examples of the application of this approaches include:

- Stakeholder influence mapping to examine changes in the UK's international development policy; changes in influence over Costa Rican forestry policy, and policy influences on a wildlife-based enterprise in Kenya – plus an in-depth explanation of this approach (Mayers and Vermeulen 2005);
- Scenario-based stakeholder engagement, including stakeholder analysis, applied to two case studies of coastal planning for climate change in the UK (Tompkins et al. 2008);
- Stakeholder analysis combined with social network analysis (see below) to support water infrastructure planning amid climate change in Switzerland (Lienert et al. 2013).

3.1.2.2 Social network analysis

Social network analysis is used to create a visual map of relationships and flows between people, groups, organizations, sectors, government entities, etc. It is used to understand who is involved in a system of interest, how they relate to one another, who has power in a situation, and at what points interventions might be most effective. Social network analysis is used in a very wide range of fields and settings – see the journal *Social Networks* (**www.journals.elsevier.com/social-networks**), published since 1979, or the comprehensive guide by Knoke and Yang (2008). For a quick overview and links to many tools, see: **www.kstoolkit.org/Social+Network+Analysis**. Examples of applications to climate risk assessment and adaptation include:

- "Strategic influence network planning" for a new water governance board in Ghana (2008);
- Social network analysis as part of study of livelihoods adaptation by smallholder farmers in South Africa and Mozambique (Osbahr et al. 2010);
- Analysis of the decision-making context and information networks in five climate-sensitive sectors in the Carolinas, U.S. (Lackstrom et al. 2012).

3.1.2.3 Ladders, scales and spectrums of participation

Different types and levels of participation are appropriate for different adaptation situations. As discussed earlier in this chapter, thinking of participation in terms of a "ladder" or a spectrum can help clarify what role stakeholders are expected to play, at what stages in the process, and how much power they will have in shaping the process. Ladders and spectrums can be used as diagnostic tools in the scoping stage, as a planning tool when designing stakeholder engagement approaches, and as a monitoring and evaluation tool to challenge assumptions. For a discussion of the "ladder" approach, see Pretty (1995); for a discussion of scales of participation, see Bradley and Schneider (2004). The International Association for Public Participation has a one-page overview the spectrum approach (IAP2 2007); also useful is the Joseph Rowntree Foundation's guide to assessing levels of community involvement (Burns and Taylor 2000).

3.1.3 Participatory tools and methodologies designed to support adaptation

The tools described in this section have been developed to engage stakeholders in both impact and capacity analysis, as discussed in Section 2.1 – but they do not stop there: they also provide for stakeholder engagement in identifying and appraising adaptation options, and for building adaptive capacity within local institutions and communities. Two of these approaches, community vulnerability assessment and participatory scenario development, are discussed in depth in Section 3.2.4. Here we briefly describing those and other participatory tools designed specifically to support adaptation.

3.1.3.1 The CARE Community Vulnerability and Capacity Analysis methodology

CARE created this methodology (Dazé et al. 2009) to help development practitioners understand the implications of climate change for the lives and livelihoods of the people they serve. It is meant to provide a framework for dialogue within communities, as well as between communities and other stakeholders, enhancing scientific data with local knowledge and building adaptive capacity.

The process engages all stakeholders in understanding climate-related challenges, identifying adaptation solutions, and taking steps towards those solutions. The handbook is available as a free PDF download in English, Spanish, French and Portuguese (**www.careclimatechange.org/cvca/**). It provides an overview of the methodology, as well as practical guidance for using it in the design and implementation of adaptation actions. A separate document (Fontenla et al. 2011) offers a case study of the application of the methodology in Ecuador, Peru and Bolivia.

The case study, which was done as part of the Regional Project for Adaptation to the Impact of Rapid Glacier Retreat in the Tropical Andes (PRAA), for which CARE is implementing pilot projects to support adaptation. Glacial retreat not only limits water availability, but also increases exposure to geomorphological hazards, such as landslides, mudslides and lake outbursts. Use of the CARE methodology highlighted the differential nature of vulnerabilities, and thereby enabled appropriate adaptation responses to be identified.

A complementary document, Ayers et al. (2012), guides local practitioners through participatory approaches to monitoring, evaluation, reflection and learning. The guide notes that adapting to climate change amid uncertainty requires a "learning by doing" approach, and it envisions ongoing stakeholder engagement to support social learning.

3.1.3.2 The CRiSTAL Screening Tool

CRiSTAL (Community-based Risk Screening Tool – Adaptation and Livelihoods) is a screening tool developed as part of a collaboration led by the International Institute for Sustainable Development (IISD). It is designed to help project planners and managers integrate risk reduction and climate change adaptation into community-level projects. It helps them:

- Understand the links between livelihoods and climate in their project areas;
- Assess a project's impact on community-level adaptive capacity; and
- Make project adjustments to improve its impact on adaptive capacity and reduce the vulnerability of communities to climate change.

The CRiSTAL toolkit is available at **www.cristaltool.org**, in multiple languages and formats. It includes two modules, on synthesizing information on climate and livelihoods, and on planning and managing projects for adaptation. The site also includes written guidance, a video and other resources.

CRiSTAL has been applied in Central and South America (Bolivia, Costa Rica, Dominican Republic, Ecuador, Guatemala, Haiti, Honduras, Nicaragua and Peru); Africa (Ethiopia, Kenya, Mali, Niger, Tanzania and Zambia) and Asia (Sri Lanka).

3.1.3.3 Participatory Learning and Action: Community-based adaptation

For 25 years, the International Institute for Environment and Development (IIED) published the PLA notes, an informal journal on participatory methods and approaches, providing a wealth of examples of the use of participatory tools in various settings.

PLA 60 (Reid et al. 2009) focuses on community-based adaptation to climate change. The book-length volume provides a useful overview of the role of participatory processes in adaptation and describes an array of approaches tested in case studies around the world, such as:

- Combining different types of knowledge in Small Island Developing States;
- Engaging children in disaster risk reduction and adaptation (El Salvador and the Philippines);
- Participatory rice variety selection in Sri Lanka;
- Farmers as filmmakers to support adaptation in Malawi;
- Development of rain calendars with farmers in Ethiopia.

It is important to note that these approaches are grounded in the principles of "action research", which works to bring about positive change by building "communities of inquiry and action" to explore an issue and address it collaboratively (Reason and Bradbury 2008). To access the entire archive of PLA notes, go to **pubs.iied.org/search.php?s=PLA**.

For a separate discussion of action research to support adaptation, in Africa, see German et al. (2012); for an in-depth review of action research, see Burns et al. (2012) and the journal issue it introduces.

3.1.3.4 Participatory scenario development

Participatory scenario development (discussed at more length in Section 3.2.4) is a process that involves the participation of stakeholders to explore the future in a creative and policy-relevant way. It is used to identify the effects of alternative responses to emerging challenges, to determine how different groups of stakeholders view the range of possible policy and management options available to them, and identify the public policies, or investment support needed to facilitate effective future actions. It is particularly useful in complex situations where multiple climatic and non-climatic factors are at play, increasing uncertainty. Below are three useful guides:

- *Participatory Scenario Development Approaches for Identifying Pro-Poor Adaptation Options: Capacity Development Manual* (The World Bank 2010a);
- *Formulating Climate Change Scenarios to Inform Climate-Resilient Development Strategies: A Guidebook for Practitioners* (UNDP 2011);
- *Decision-making for Climate Resilient Livelihoods and Risk Reduction: A Participatory Scenario Planning Approach* (CARE International 2012).

3.1.3.5 Other participatory tools for adaptation

Christian Aid's (2013) "Good Practice Guide" to participatory vulnerability and capacity assessment explains what this type of analysis entails, then provides a step-by-step guide to conducting one, including the main challenges that are likely to occur at each step and how to overcome them. This approach was developed in the realm of disaster risk reduction, but is increasingly being applied to a wider set of livelihood risks.

Drawing on case studies from around the world and on its own experience with rural communities, **Oxfam International** produced a report

(Pettengell 2010) that shows how "bottom-up" participatory approaches can be combined with top-down approaches to enable people living in poverty to adapt to climate change. The underlying philosophy is that "learning to adapt is as important as any specific adaptation intervention"; participatory processes thus not only identify adaptation needs, but help prepare communities to make informed decisions about adaptation in an ongoing change process.

ActionAid International has developed a tool for "participatory vulnerability analysis" for its work on emergencies and conflicts that involves communities, local authorities and other stakeholders in an in-depth examination of what makes them vulnerable. A step-by-step guide for field staff (Chiwaka and Yates 2005) explains how to analyse people's vulnerability, draw action plans, mobilize resources and work to enact appropriate policies, laws and strategies to reduce vulnerability.

The **International Centre for Integrated Mountain Development** (ICIMOD) has published a framework (Macchi 2011) for assessing environmental and socio-economic changes affecting the livelihoods of rural, natural resource-dependent communities living in mountainous environments. It also gives guidance on how to gain a better understanding of the various forces which shape mountain communities' vulnerabilities, and places a special focus on the capacities inherent to these communities for coping with and adapting to environmental and socioeconomic changes.

The UK-funded **Livelihoods and Development Programme** in Nepal prepared a community-based toolkit for practitioners (Regmi et al. 2010) that explains how participatory tools can be used to assess adaptation needs and explore adaptation options. It covers climate hazard trend analysis, hazard ranking and impact assessment, livelihood resources assessment, vulnerability assessment, the use of vulnerability matrices, coping and adaptation strategies assessments, and community-based adaptation planning, among other tasks. Though written for Nepal, the material is broadly applicable.

Further resources include:

- The **Red Cross and Red Crescent** vulnerability and capacity assessment guide (IFRC 2007), and an application of the methodology in Rwanda (IFRC 2003);
- **Practical Action** (n.d.) has incorporated climate risk into a commonly used vulnerability and capacity assessment methodology to make the Adaptive Livelihoods Framework operational;
- **Bread for All** and **HEKS** have developed a tool (Keller 2009), largely based on the CARE methodology and CRiSTAL (see above) to help analyse existing or planned development projects with respect to climate change and disaster risks;
- A **UN-HABITAT** (2010) toolkit guides local governments and others through participatory climate change assessments, based on the experience of Sorsogon City, Philippines.

3.1.3.6 Tools to ensure participation of people who are often excluded

There is extensive evidence that climate change impacts will disproportionately affect people who are poor, illiterate or marginalized (due to their sex, age, disability, caste, ethnicity, etc.). Without close attention to these issues, adaptation efforts can fail to address the needs of the most vulnerable, and even reinforce existing disparities. The same is true of participatory processes: it takes a concerted effort to ensure that *all voices* are heard.

Many of the tools and guides described above directly address this concern. Below we describe some resources to support inclusive participatory processes.

Engaging indigenous peoples:

- The Indigenous Peoples Biocultural Climate Change Assessment Initiative has developed a methodological toolkit for local assessments (IPCCA n.d.), including methods and practical examples. It provides a general framework that can be adapted to different local contexts.
- A synthesis of a 2008 conference held by the International Work Group for Indigenous Affairs (Nilsson 2008) provides a good overview of key issues, with recommendations (see also Polack 2008 for valuable context on procedural justice).

Addressing gender issues in adaptation:

- The *Gender, Climate Change and Community Based Adaptation Guidebook* (UNDP 2010b) provides examples of mainstreaming of gender issues in adaptation projects around the world.
- CARE has produced a guide (CARE International 2010a) to integrating gender and women's empowerment in adaptation projects, starting with assessment of differentiated vulnerabilities.
- The Global Gender and Climate Alliance website (**www.gender-climate.org**) offers a wealth of resources, including a distillation of alliance members' experiences (Askin et al. 2012)

One promising set of approaches is **participatory audio, video and photo stories** – multimedia tools that allow people to share their perspectives. This kind of work can be time-consuming and resource-intensive, but it has the great benefit of bringing the voices and faces of people "on the ground" – and scenes from their communities – directly to decision-makers and others whom they might never encounter in person. These tools can also be fun to use, and can involve youth, the elderly, people who can't read or write, and others whose voices might otherwise be excluded. Photo stories accomplish many of the same goals, but are less resource-intensive, require less bandwidth than video when shared online, and can also be shared in print. Here are some helpful resources:

- InsightShare, a specialist in participatory video, offers extensive guidance on its website, including a detailed manual (Lunch and Lunch 2006); see **insightshare.org/pv/pv-nutshell**;
- The Red Cross/Red Crescent Climate Centre has videos of participatory video training of farmers in Africa: **www.climatecentre.org/site/films-by-farmers**;
- The Zeitz Foundation has published a blogpost on photo stories, with practical tips and guiding principles: **www.zeitzfoundation.org/index.php?page=newsblog&id=116**;
- ResourceAfrica UK has multiple examples of both photo stories and videos, many directly related to adaptation projects; see **www.resourceafricauk.org**;
- The Institute for Development Studies (IDS) has used photo-audio stories to bring knowledge about climate change and adaptation to communities in East Africa; for a discussion and a sampling of the resulting work, see **community.eldis.org/.5b7d3fc4**.

3.1.4 Facilitation toolkits

As discussed earlier in this chapter, good facilitation is crucial in participatory processes. In this section we present some toolkits and guidance to help facilitators be more effective. We should note that several resources cited earlier in this section are very valuable in this regard:

- The CARE methodology described in Section 3.1.3.1 (Dazé et al. 2009) offers practical tips (see pp. 30–33) and stresses the importance of effective, sensitive facilitation;
- Bradley and Schneider (2004), a guide to participatory approaches published by the

Voluntary Service Overseas, is geared specifically to facilitators, with extensive advice, tools and tips;
- Hovland (2005), which looks more broadly at good communication, also offers useful advice on facilitation, as well as a list of additional resources.

Some additional helpful resources include:
- Australia's Department of Environmental Protection has published a clear and comprehensive guide to facilitation (Keating 2003), with advice on facilitation processes and techniques, tips for adding value and for working with difficult situations and people, and practical checklists.
- Smith (2009), a free online guide, offers an introduction to the theory and practice of the facilitator's role in supporting processes of change in groups.

3.1.5 Participatory analysis tools

The tools presented here illustrate some of the ways that data gathered can be prioritized and examined in more depth to establish clearer meanings and discuss alternative perspectives to encourage reflection with those who generate the information. They can also help participants to map out and understand complex relationships, interactions and influences. Several of the tools presented in this section are visual – which makes them particularly useful with people who are not literate – and require little input in terms of materials.

Note that these tools are most appropriate for informal discussion and analysis. For a more structured approach, see Section 3.1.3.4 and Section 3.2.3 to learn about participatory scenario analysis.

Problem and solution trees: This analytical tool helps to find solutions by exploring cause and effect around an issue in greater depth. It allows the problem to be broken down into manageable and definable chunks, enabling a clearer prioritization of factors and focus for objectives. When done in a group, the tool allows greater understanding of the interconnectedness and contradictory causes to develop which should lead to more workable solutions for everyone. See Hovland (2005, pp.12–13).

H Diagram: This simple tool – literally, a diagram shaped like a wide H – can be used in numerous settings to rate something along a scale (e.g. concern about drought – from not worried at all, to extremely concerned, or quality of a workshop – from not useful, to very useful), providing an easy-to-understand visual representation of participants' responses.

Rivers of Life: This tool that can be used in many different ways: to help people get to know one another, reflect on their relationships, explore hopes and fears about a new venture, discuss what was surprising or difficult in a project, etc. Participants are invited to use the symbol of a river to reflect on key stages in their lives or in the experience they are focusing on, and identify positive influences (tributaries) and challenges (rough waters). See Moussa (2009).

Force field analysis: This framework, developed by Kurt Lewin, helps to understand the factors that influence a given situation, either by driving movement toward a particular goal (motivating forces) or blocking such movement (constraining forces or barriers). Such forces can be very dynamic, varying both over time and with the experience and awareness of those tasked with identifying them. They can include aspects such as motivations, values, needs, personalities, goals, anxieties, and ideals as well as more structural aspects of organizational decision-making. See Hovland (2005, pp.14–15).

For descriptions of several other participatory analytical tools, see Bradley and Schneider (2004) and **www.reflect-action.org/how**.

3.1.6 Large-group and whole-system techniques

The tools described below take diverse approaches but are all based on trust and cooperation between a wide variety of participants, with the goal of encouraging creativity and new ways of thinking. Participants create strategies and action plans together and take joint responsibility for implementation. There is also a tendency to focus on a positive vision of a desirable future rather than on what has gone wrong in the past; this creates energy and optimism (see also Section 3.1.3.3 for a discussion of the "action research" approach).

Open Space Technology: This approach, used in a wide range of settings since the late 1980s, brings people together to discuss a topic of mutual interest, then lets them set the agenda and manage the process. Open Space works best when the issues are complex and urgent, there are diverse ideas and agendas, and the desire for a resolution is high, as this helps to focus people's minds on having conversations that matter. It is structured in a way that allows a great deal of flexibility to allow to new ideas that may emerge through the process, and can be used with groups of a handful of people, or 2,000+, at a weekly staff meeting, or a multi-day conference. See **www.openspaceworld.com**.

World Café: This approach creates an informal and relaxed setting for discussions, like a real café, with people seated around small tables – perhaps with tablecloths and drinks. World Café is good for engaging large groups and generating input, sharing knowledge, and stimulating innovative thinking. It is also good for exploring different perspectives of e.g. key challenges or opportunities. The process can build capacity by giving a group a sense of their own knowledge and insight. The method has been used with groups from a few to over 1,000 participants. See **www.worldcafe.com**.

Action Learning Sets: These are small groups (five to eight people) who meet regularly to support one another in their learning in order to take purposeful action on an issue. A facilitator helps participants to ask searching questions and to reflect on the actions to be taken. The Asian Development Bank has published a short guide in English and French; see Serrat (2008).

Systemic action research: This is a strategy for whole system change that works with live social and organizational issues to uncover their complex dynamics in order to identify interventions and action to support whole system change. It consists of a set of concepts and approaches to extend action research beyond the individual and group level to organizations, governance systems and networks. See Burns (2012) for an overview and Harvey et al. (2012) for a discussion in the context of participatory action research in southern Ghana.

Citizens' juries: This approach works on the notion that given adequate information and an opportunity to discuss an issue, a group of stakeholders can be trusted to make a decision on behalf of their community, even though others might be considered to be more technically competent. Citizens' juries are most suited to issues where a selection needs to be made from a limited number of choices, and it works better on value questions (whether certain choices or pathways are deemed acceptable or desirable) than on technical issues. The jury that is assembled is meant to represent a microcosm of the community, including its diverse interests and sub-groups. They hear testimony from experts chosen by a disinterested panel, and they may also call additional experts to clarify points or to provide extra information. For an example from Mali, see Bryant (2008).

Barefoot Guides: The Barefoot Collective has developed several free guides to support leaders and facilitators working towards organizational change, seeking to improve their learning processes, etc. The guides and supporting website explain key concepts of organizational change, provide examples, and offer tips and suggested exercises. The guides are aimed at leaders and facilitators of civil society organizations, but can be helpful to anyone managing processes of engaging people around an issue or collaborating in a project. See **www.barefootguide.org**.

3.1.7 Conflict resolution techniques

Conflict resolution tools can be used to reframe how an issue is being presented, create opportunities for dialogue and encourage engagement even where actors are in dispute. Useful tools include:

Nonviolent Communication: This is a communication process that is often used in conflict resolution. It focuses on three aspects of communication: self-empathy (defined as a deep and compassionate awareness of one's own inner experience), empathy (defined as listening to another with deep compassion), and honest self-expression (defined as expressing oneself authentically in a way that is likely to inspire compassion in others). See **www.nonviolentcommunication.com**.

Conflict spectrum: This is a practical exercise to foster understanding about an issue in which there is conflict. People are asked to stand along an invisible spectrum line in relation to how strongly they feel about the issue. Individuals can then be quizzed about why they chose that spot and what might encourage them to move in a different direction along the spectrum. See Kraybill (2000, p.8), which also provides useful advice on facilitation.

3.2 Impact analysis

Approaches for analysing the impacts of climate change were introduced in Chapter 2 as impact-analytical methods (Section 2.1.2). In this section we further separate those approaches into the detection and attribution of observed impacts (Section 3.2.1) and the modelling and indication of future impacts (Section 3.2.2). Each of the methods described in this section relies on climate variables in one form or another, so it is useful to start by differentiating between three key terms: weather, climate and climate change.

Weather is the set of meteorological phenomena we experience on a daily basis: temperatures, rainfall, cloud cover, windiness, etc. (AMS 2012). We expect changes in weather to occur from day to day; and researchers often pay particular attention to extreme weather events that can have damaging impacts on human activities and the natural environment, such as heat waves, strong winds or intense precipitation.

Climate in its wider sense is the state, including a statistical description, of the climate system (IPCC 2012, p.557). In more narrow applications, climate is usually defined as the average weather, or more rigorously, as the statistical description in terms of the mean and variability of relevant quantities over a period of time ranging from months to thousands or millions of years. The standard period for averaging these variables is 30 years, as defined by the World Meteorological Organization; the most recent climate updated issued by the WMO was for 1961–1990. Many national meteorological agencies, however, issue rolling averages every 10 years (most recently for 1981–2010), to provide more timely data on recent and ongoing changes in climate. The relevant types of data covered are most often surface variables such as temperature, precipitation, humidity and wind. **Climate variability** refers to fluctuations in climatic variables around their average state, which are due both to natural processes internal to the climate system as well as to external influences (such as modulations in solar cycles and volcanic eruptions).

Climate change is a change in the state of the climate that can be identified (e.g. through statistical tests) as altered means and/or variability of its climatic variables that persist for an extended period, typically decades or longer. Climate change may be caused naturally, by internal processes or by external influences affecting the climate system, or due to human-induced causes, such as persistent changes in the composition of the atmosphere or in land use (IPCC 2012, p.557). In contrast to the more general definition used by the IPCC, the United Nations Framework Convention on Climate Change (UNFCCC) defines climate change only as a change attributable to human activity that alters atmospheric composition and occurs in addition to natural climate variability (United Nations 1992, p.3).

3.2.1 Describing current impacts of climate change

In many places around the world, people report changes in weather and seasonal patterns, as well as in natural systems. Scientifically verifying these observations involves two kinds of exploratory data analysis: trend detection and impact attribution. The first focuses on establishing a pattern, to distinguish climate change from climate variability – e.g. is rainfall really decreasing, or did we just have a couple of dry years, with no observable long-term trend? The second involves linking specific impacts to climatic changes – e.g. attributing an increase in pest infestation to climate change. These approaches thus start by demonstrating recent trends in impacts (i.e. systematic changes in aspects of the natural environment or in human activities), for whatever cause (detection), and then relate them statistically to trends in climate (attribution). Determining whether a trend in climate is due to natural or anthropogenic causes is also a type of attribution (see Box 3.2.2). Such relationships, if they can be established, may be very instructive in understanding and anticipating future impacts, which is, of course, vital to choosing appropriate adaptation actions. They rely on empirical observations derived from systematic measurements, which are analysed in relation to time (Section 3.2.1.1) or to other variables (Section 3.2.1.2).

3.2.1.1 Detection of trends via statistical methods

Time-series datasets document the long-term behaviour of variables observed through repeated measurements collected over a period of time. Detection studies (Box 3.2.1) use statistical techniques to determine whether or not a variable has changed over time, with no judgement made about the likely causes of that change (Hegerl et al., 2007).

At its simplest, trend detection applies a statistical model to time-series data in order to establish the form and the strength of changes over a given

BOX 3.2.1 ***Overview of trend detection***

Question addressed
Is there a trend in observations?

Data requirements
Time-series data for the study unit (e.g. rainfall measurements at a particular weather station)

Typical result
Statistically significant trend in the data – or no statistically significant trend

Generic steps
1. Select variables of interest
2. Apply statistical methods

period. For example, Figure 3.2.1 below shows a graph depicting flowering dates for aspen trees in Canada from 1901 to 1997, relative to the mean bloom date for that period. The data appear to show aspens have been blooming earlier in recent decades. To demonstrate this, the authors have fitted a linear trend to the data for the entire period, which shows a coefficient of determination (r^2) of 0.35. However, the dataset is incomplete, with notable gaps in the time series. Here it is advisable to plot trends for sub-periods as well, and the authors note that the same trend (0.26 days per year) is seen in the well-reported years 1973–1997. Once such a trend is detected, its likely causes can be investigated through impacts attribution.

Trend detection can be applied to data associated with either natural or human systems. For example, Emanuel (2005) studied the destructiveness of tropical storms between 1949 and 2003 by using measures derived from systematic observations of cyclone activity over five ocean basins. He found an upward trend in the strength of tropical cyclones after the mid-1970s, especially over the western North Pacific and North Atlantic Oceans. Pielke et al. (2008), on the other hand, analysed the economic damages associated with U.S. mainland hurricane landfalls from 1900 to 2005, normalizing the data to account for changing societal conditions over the time series. Their results showed no long-term trend in economic damages over the study period.

3.2.1.2 Attribution of impacts

In the context of impacts, attribution refers to a confirmation that an observed trend in impacts can be related directly to a trend in climate. We use that definition below, but readers should be aware that this is only one of several alternative definitions used by researchers investigating the attribution of observed impacts to different causes (Box 3.2.2). In Box 3.2.2 this form of attribution is referred to as Method IV.

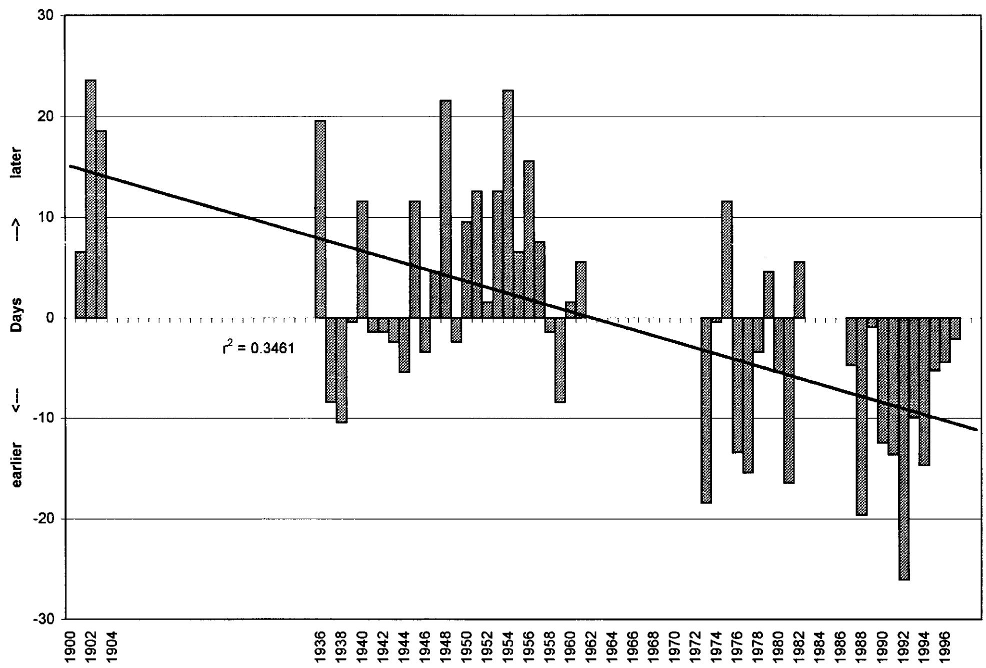

FIGURE 3.2.1 **First-flowering dates of Aspen (*Populus tremuloides*) at Edmonton, Alberta plotted as deviations in days from the long-term mean date bars relative to the mean bloom date (bars). A linear trend has been fitted to the data for 1901–1997.** Source: Beaubien and Freeland (2000).

In studies of impact attribution (Box 3.2.3), relationships between pairs of variables (i.e. univariate analysis) or sets of variables (i.e. multivariate analysis) are commonly explored through inferential statistical methods such as regression analysis, correlation and analysis of variance. Both external factors such as climate, land-use change and air pollution, as well as factors internal to a study unit (e.g. adaptive capacity; cf. Tol and Yohe 2007) can account for observed impacts, so explanatory variables should be carefully selected based on theory and literature. A general issue for attribution studies can be the sheer number of possible explanatory variables, which is not conducive to building statistical models. Other challenges confronting analysts may include:

- **Discontinuous time series:** Abrupt changes or breaks in the time series must be identified and treated prior to analysis.
- **Scale issues:** Data for the explanatory variables must be matched to data on observed impacts.
- **Sample biases:** Systematic errors can prejudice evaluations and findings, especially biases in the sampling of observed impacts (e.g. over-reporting of climate-sensitive

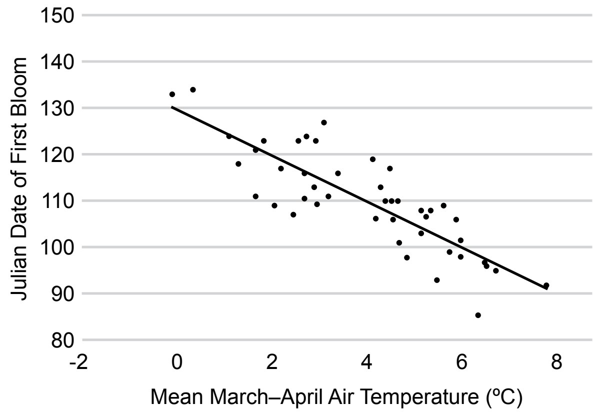

FIGURE 3.2.2 **Relationship between mean March–April temperature and flowering dates of aspen (*Populus tremuloides*) during 1936–1998 in the area of Edmonton, Alberta. Each point represents a single year.** Source: Beaubien and Freeland (2000).

BOX 3.2.2 ***Approaches to attribution of change (based on Hegerl et al. 2010)***

The IPCC convened an experts meeting in 2009 to clear up confusion about attribution among different research communities. The result was a guidance document (Hegerl et al., 2010) that distinguishes between four methods of attribution commonly found in the literature. The first three focus on attribution of impacts and/or climate change to external forcings, a rise in greenhouse gas levels in the atmosphere. The fourth addresses the link between impacts and climate as the main driver, without addressing the possible causes of any changes in the climate.

- **Method I: Single-step attribution to external forcings** involves detecting a significant change in a variable of interest (e.g. mean daily temperature, or aspen bloom date) and then comparing the observed changes with those expected, usually based on modelling the response of the variable to external forcings and drivers. Attribution is demonstrated if a statistically significant match is found and other confounding factors can be ruled out. An example is the direct statistical association established in Root et al. (2005) between a northward shift in the range of species in the Northern Hemisphere and the responses predicted by models of anthropogenic climate change.

continued

BOX 3.2.2 *continued*

- **Method II: Multi-step attribution to external forcings** involves attributing an observed change in a variable of interest to a change in climate and/or environmental conditions, then attributing that change in climate and/or environmental conditions to external drivers and external forcings. An example would be to first attribute changes in spring phenology in a region, such as earlier bloom times, with observed increases in mean temperatures (see example in Figure 3.2.2), and then in a subsequent step, relate those warmer temperatures to anthropogenic climate change by comparing them with modelled temperature changes. This differs from Method I example in that it takes two steps to make the connection. Each step in multi-step attribution has its own level of confidence, with confidence in the combined result weaker than in each individual step.

- **Method III: Associative pattern attribution to external forcing** is similar to Method II, but rather than analysing a single variable of interest, this method involves the synthesis of large numbers of results (often across multiple systems) and the demonstration of an association between impacts in these and climate change, followed by the attribution of this climate change to external forcing and drivers (often using spatial and temporal measures of association). For instance, Rosenzweig et al. (2008) demonstrated that the pattern of changes in natural physical and biological systems in datasets of at least 20 years' duration since 1970 could be explained better by the pattern of observed temperature over the same period than by temperature patterns simulated by climate models assuming no external forcing.

- **Method IV: Attribution to a change in climatic conditions (climate change)** involves assessments that demonstrate an association (based on process knowledge) between an observed change in a variable of interest and an observed change in climate conditions – for example, between warmer springs and earlier aspen bloom dates. This method can be one of the steps in multi-step attribution, but it can also be used on its own to address climate impacts on a variable of interest.

One of the most scientifically and politically important conclusions of the IPCC in its *Second Assessment Report* was the attribution statement (using Method I) that "the balance of evidence suggests a discernible human influence on global climate" (IPCC 1996, p.4). This conclusion has been strengthened in subsequent reports, and new evidence presented on observed impacts using Methods II and III to show that "it is likely that anthropogenic warming has had a discernible influence on many physical and biological systems" (IPCC 2007a, p.9). Moreover, any historical change in climate, regardless of cause, that resulted in observed impacts (e.g. determined using Method IV) could also have led to adaptation responses. Hence, study of such situations might be instructive in preparing for adaptation under future climate change.

BOX 3.2.3 *Overview of impact attribution*

Theoretical assumption
Climate and/or non-climate drivers are responsible for observed impacts

Question addressed
Which combination of variables can explain observed impacts on the study unit?

Data requirements
- Data on observed impacts
- Data on potential explanatory variables

Typical result
Statistical model explaining observed impacts

Generic steps
1. Select potential explanatory variables based on theory and literature
2. Apply statistical methods

biological species vs. less sensitive species) or publication bias towards results showing positive associations with climate and away from results exhibiting no long-term change.
- **Non-climate drivers:** Climate is not the only variable that gives rise to impacts;
- **Correlation vs. causation:** Care must be taken not to conflate the two.

The example in Figure 3.2.1 demonstrated a trend in flowering dates of Aspen during the 20th century. The authors then explored possible causes or attribution of this trend, and concluded that March-April mean temperatures in the Edmonton region exhibited a strong correlation with flowering dates (Figure 3.2.2). They also established relationships with ocean temperatures in the Pacific, including

TABLE 3.2.1 **Impact attribution studies by sector.**

Sector	Examples
Agriculture	Crop responses (Lobell 2010) Livestock productivity and welfare (Gould et al. 2006; Mellor and Wittmann 2002)
Water Resources	Groundwater resources (Gemitzi and Stefanopoulos 2011) Drinking water resources (Kistemann et al. 2002)
Health	Mortality associated with extreme weather (Conti et al. 2005; Hajat et al. 2002; Keatinge et al. 2000; Barnett et al. 2005; Zanobetti and Schwartz 2008) Weather events and disease outbreaks (Wu et al. 2007; Reyburn et al. 2011; Checkley et al. 2000; Singh et al. 2001; Hurtado-Díaz et al. 2007; Keay and Simmonds 2006) Temporal patterns in the start dates of pollen seasons (Emberlin et al. 2002; van Vliet et al. 2002)
Coastal/ Marine	Fisheries catch rates (Ménard et al. 2007; Corbineau et al. 2008) Open-sea species range (Edwards and Richardson 2004) Species responses (Beaugrand et al. 2002; Beaugrand and Reid 2003; Brander 2005; Dutil and Brander 2003)
Biodiversity	Vegetation dynamics (Herrmann et al. 2005) Phenological events (Schleip et al. 2006) Animal responses (Sandvik and Erikstad 2008; Chan et al. 2005)
Other	Insurance and reinsurance markets (Romilly 2007; Klawa and Ulbrich 2003)

the influence of the El Niño Southern Oscillation phenomenon (Beaubien and Freeland 2000).

Table 3.2.1 identifies examples of impact attribution studies across different sectors. Shumway and Stoffer (2011) provide additional guidance on techniques for the detection and attribution of observed impacts. They have written a textbook on time series analysis accessible to non-statisticians, which includes software examples for the R computing environment.

3.2.2 Modelling future impacts

A key insight from climate science is that the sharp rise in anthropogenic greenhouse gas emissions has begun, and will continue, to alter climatic patterns around the world. Whilst we can use historical trends to detect and attribute recent observed changes, to determine the likely future impacts – and the need for adaptation planning – it is necessary to make use of models.

The selection of methods for projecting future impacts of climate change starts with a determination of whether causal relationships between variables describing the behaviour of a study unit and the external drivers of change can be formally represented as a computational model (Section 3.2.2.1). In adaptation situations where models are not available, vulnerability indication approaches (Section 3.2.2.2) can be used to say something about possible future impacts based on data collected on the current state of the study unit, combined with projections of changes in climate variables to which the study unit is known to be sensitive. Alternatively, knowledge elicitation (Section 3.2.4) provides a means of surveying and classifying expert and lay opinions about climate change and its potential impacts. We conclude this section with a detailed overview of studies employing these methods in a variety of different contexts (Section 3.2.5).

Modelling future impacts involves the deployment of methods and tools drawn from a formidable and ever-expanding range of options. A large proportion of climate change impact assessments make use of predictive models that describe the causal relationships between climate and a study unit. However, modelling tools tend to be available only for certain sectors, such as agriculture, water resources, coastal zones, and terrestrial ecosystems.

Technical requirements for projecting climate change impacts are generally high and often difficult to meet, so in many cases it will be preferable to adopt an existing model and tailor it for the adaptation context or to meet specific assessment

BOX 3.2.4 *Overview of impact projection*

Theoretical assumptions
- Interaction between the study unit and drivers of change can be formally represented as a computational model
- Adaptation can be formally represented as a computational model

Question addressed
What are the impacts of climate change?

Data requirements
- Climate and socio-economic scenarios
- Information about adaptation options

Typical result
A list of propositions that map each scenario and adaptation option to an impact.

Generic steps
1. Select climate and socio-economic scenarios
2. Select adaptation options for use in the model
3. Compute the impacts of the scenarios and adaptations

needs. Models vary enormously in their complexity, in the spatial and temporal scale of their application, and in their assumptions about adaptation, but the process of impact projection is generally the same: select climate and socio-economic scenarios, select different adaptation options and strategies to examine, where these can be simulated, and then compute impacts. Each of these steps is described in detail in the following sub-sections. For a discussion of scenario analysis in adaptation, see Section 3.4.

3.2.2.1 Representing adaptation

Projecting impacts of climate change depends not only on the climate and socio-economic scenarios that are selected, but also on the assumptions that are made about adaptation. It is therefore important to carefully consider whether to choose models that project *potential impacts*, which are those that may occur without considering adaptation (Füssel and Klein 2006), in contrast to tools that project *residual impacts*, which include adaptation.

Most natural and human systems will undergo some form of autonomous adjustment in response to either gradual changes in climate or sudden shocks, so it is generally understood that potential impacts will almost certainly not occur. However, it is important to note that the purpose of representing adaptation in impact projection is not to compute an optimal adaptation policy, but to model how different assumptions about possible adaptation measures translate into differences in impacts. In other words, the selection of adaptation strategies to represent in impact projection serves the same purpose as the selection of climate and socio-economic scenarios: to explore a range of possible futures. This is a good example of the iterative and non-linear nature of adaptation: when this approach is taken, impact analysis, which is part of the first stage of the adaptation process (Section 2.1), incorporates the results of the second stage, identifying adaptation options (Section 2.2) and, by modelling residual impacts, informs the third stage, appraising adaptation options (Section 2.3). We should note that some adaptation options (e.g. new infrastructure, or drought-resistant crops) may be easier to model than others (e.g. strengthening local institutions).

3.2.2.2 Model-based projections

With scenarios selected and adaptation strategies identified, projecting climate change impacts comes down to the deployment of models that can calculate the interaction between drivers of change and the study unit. It is common to discriminate between models that represent the direct physical or biological responses of systems to climate, sometimes referred to as first-order or *biophysical models*, and models that estimate the socio-economic implications of such biophysical impacts, known as higher-order or *socio-economic models*. There is also *model-based integrated analysis,* which attempts to capture the complex interactions of first and second-order effects in order to provide insights about their implications in a changing climate and changing world.

Biophysical models

Biophysical impact models range in complexity, from simple monotonic relationships established between a single climate variable and a single type of response (e.g. high temperature effects on excess mortality among elderly people), through to complex simulation models where developers have attempted to incorporate all of the processes thought to be of importance in determining system responses. Examples of the latter include dynamic vegetation models and basin-scale hydrological models.

All biophysical models rely on empirical relationships between driving variables and system responses at some scale of analysis, but the level of empiricism varies enormously. In process-based models, many of the equations describing physical or biological processes are well established theoretically and have been verified empirically (e.g. photosynthetic processes in plants or water flow in soils). Other processes may be less well established, and are subject to greater uncertainty (e.g. the long-term response of different tree species to increases in atmospheric CO_2 concentration). Taken together, the description of interacting processes allows for a deeper understanding of the behaviour of different components of a complex system and hence a better appreciation of the reasons for a given response of a system. However, such models tend to be very demanding of data, expertise and time for model testing and application, which may limit their use in different regions.

Model estimates of future impacts increasingly rely not only on climate projections, but also on scenarios of other conditions that either affect impacts directly (e.g. changes in atmospheric composition or sea level) or precondition sensitivity to impacts (e.g. population, income, land use and land cover change or technology). To assist users, process-based models with a potentially wide application are being packaged in user-friendly decision support systems, where users are able to tailor the impact model to the needs of their own assessment, being provided with detailed guidance on data collection and procedures for model calibration and testing, as well as advice and built-in graphical and statistical tools for the analysis and interpretation of model outputs.

Table 3.2.2 identifies examples of decision support tools that are used in conjunction with impacts projection.

In contrast, at the other end of the spectrum are simple empirical-statistical models that are based on a statistical association between the overall response of an exposure unit and a set of climatic

TABLE 3.2.2 **A selection of decision support tools by sector.**

Sector	Examples
Agriculture	APSIM, the agricultural production systems simulator (**www.apsim.info**) DSSAT, Decision Support System for Agrotechnology Transfer (**dssat.net**) GRAZPLAN, four models to support decisions for grazing systems (**www.csiro.au/en/Organisation-Structure/Divisions/Plant-Industry/GRAZPLAN-integrated-decision-support-for-farming.aspx**)
Water Resources	WEAP, a water evaluation and planning system (**www.weap21.org**) RiverWare, a general river and reservoir modelling tool (**www.riverware.org**) WaterGap, Water - a Global Analysis and Prognosis (**www.usf.uni-kassel.de/cesr/index.php?option=com_project&task=view_detail&agid=47&lang=en**)
Biodiversity	GLOBIO3, a global biodiversity assessment model (**www.globio.info**) LPJmL, Lund-Potsdam-Jena managed Land Dynamic Global Vegetation and Water Balance Model (**www.pik-potsdam.de/research/projects/lpjweb**)
Coastal/ Marine	DIVA, Dynamic Interactive Vulnerability Assessment, is an integrated model for assessing consequences of sea-level rise (**www.globalclimateforum.org/index.php?id=divamodel**) Roadmap for Adapting to Coastal Risk (**www.csc.noaa.gov/digitalcoast/training/roadmap**)
Multi-sector	SimClim, the Simulator of Climate Change Risks and Adaptation Initiatives (**www.climsystems.com/simclim/**) CLIMSAVE IA, Integrated Assessment Platform for impacts, adaptation and vulnerability in Europe (**86.120.199.106/IAP/**) CIAS, Community Integrated Assessment System, a system of linked energy, climate, impacts and economic models (**www.tyndall.ac.uk/research/cias**)

predictors, without consideration of the intermediate process that might have produced a given response. Here, statistical associations are sought between responses to climatic variations observed over long time periods or across geographical or altitudinal climatic gradients (cf. impact attribution in Section 3.2.1.2). Impacts of future climate change are estimated by applying the same statistical relationships observed in the past and assuming they can be extrapolated to future conditions represented using climate scenarios.

The advantages of such models include minimal data requirements (usually only observations and scenarios of readily accessible climate variables) and speed of application. However, there can be major pitfalls in relying on extrapolation of statistical relationships to represent responses under future conditions. Consider, for example, the effects of climate warming on wheat yield in central Europe. Simple regression of wheat yield and temperature might reveal a negative association between wheat yield and temperature (decreased yields in warmer years and higher yields in cooler years). Applying such a statistical relationship with scenarios of future warming would hence predict reduced crop yields. However, use of a process-based model that incorporated not only the negative effects of increased temperature on yield, but also positive effects of future CO_2 fertilization, as well as effects of changes in soil moisture, might produce yield responses that are quite different for a scenario with the same warming but also increased CO_2 concentration and precipitation changes.

To conclude, analysts wishing to apply biophysical models in projecting future impacts, whether process-based or statistical, need to carefully consider the outcomes required from the modelling exercise. This involves weighing their confidence in the capability of a model to provide a reliable representation of responses to changed future conditions alongside the simplicity of its application and possible limitations imposed by data, expertise and computing capacity.

Modelling of socio-economic impacts

Higher-order effects of climate change on human society are most commonly expressed in terms of economic cost, though other metrics may also be employed (e.g. number of persons affected or at risk of potential negative impacts, Parry et al. 2001). This guidance provides only partial consideration of higher-order effects, although their assessment is necessary for a full understanding of future impacts.

In a recent review of economic assessments of adaptation costs in Europe for the ClimateCost project, Watkiss and Hunt (2010) observe that the boundary between assessment of impacts (damage) and adaptation costs is drawn differently depending on the study authors. They also identify a number of variations in approaches to assessment, including whether:

- Future socio-economic change is adequately accounted for in cost estimates for future impacts;
- Climate changes are sufficiently distinguished from present-day climate variability and the so-called "current adaptation deficit", which relates to the (in)effectiveness of current adaptation to account for ongoing climate variability;
- Costs of climate change should be weighed against possible benefits and reported as "net costs" (e.g. where increased energy costs of summer cooling are assessed alongside reduced costs of heating).

Some of the main methods of assessment of economic costs, examples of their application, along with their advantages and other issues are summarized in Table 3.2.3.

TABLE 3.2.3 **Methodological frameworks and models for economic assessment of climate change and adaptation (modified from Watkiss and Hunt 2010).**

Approach	Description	Examples	Advantages	Issues
Economic integrated assessment models (IAM)	Aggregated economic models; values in future periods are expressed in absolute terms (e.g. in £), as % GDP, and as values over time (present values)	Global studies (e.g. de Bruin et al. 2009) that provide outputs for Europe	Provide headline values for raising awareness Very flexible – wide range of potential outputs	Aggregated and low representation of impacts; generally exclude extreme events and do not capture adaptation in any realistic form; not suitable for detailed national planning
Investment and financial flows (I&FF)	Financial analysis; calculates costs of adaptation (increase against future baseline)	Global studies (e.g. UNFCCC 2007; Parry et al. 2009) National studies, (e.g. Swedish Commission on Climate and Vulnerability 2007)	Costs of adaptation in short-term policy time-scale Easier to apply even without detailed analysis of climate change	No specific linkage with climate change or adaptation (though can be included) No analysis of adaptation benefits or residual impacts
Computable general equilibrium models (GCE)	Multi-sectoral economic analysis	National level – Germany (Kemfert 2007); EU review (Osberghaus and Reif 2010)	Capture cross-sectoral linkages in economy wide models (not in other approaches) Can represent global and trade effects	Aggregated representation of impacts Issues with projections of sectoral linkages Omits non-market effects Not suitable for detailed national planning
Impact assessment (scenario-based assessment)	Physical effects and economic costs of climate change with sectoral models in future periods, and costs and benefits of adaptation or in cost-effectiveness analysis	Multi-sectoral PESETA study (Ciscar et al. 2009); national scale: flooding in the UK (Thorne et al. 2007) and Finland (Perrels et al. 2010)	More sector-specific analysis Provides physical impacts as well as economic values – therefore can capture gaps and non-market sectors	Not able to represent cross-sectoral, economy-wide effects Tends to treat adaptation as a menu of hard (technical) adaptation options Less relevant for short-term policy
Impact assessment – shocks	Use of historical damage loss relationships (statistics and econometrics) applied to future projections of shocks combined with adaptation costs (and sometimes benefits)	Sector level, e.g. National Audit Office study in the UK (NAO 2009) and FINADAPT study in Finland (Perrels et al. 2005)	Allow consideration of future climate variability (in addition to future trends)	Issues of applying historical relationships to the future Issues with high uncertainty in predicting future extremes
Impact assessment – econometric based	Relationships between economic production and climate parameters derived with econometric analysis and applied to future scenarios – and to consider adaptation; Ricardian analysis relates regional land prices to climate and other factors	National-, sector- or household-level Ricardian analysis has been applied in agriculture (e.g. Lippert et al. 2009)	Can provide information on overall economic growth and allow analysis of longer-term effects Provide greater sophistication with level of detail	Mostly focused on autonomous or non-specified adaptation Very simplistic relationships to represent complex parameters No information on specific attributes Issues on whether relationships are applicable to future time periods

TABLE 3.2.3 ***continued***

Approach	Description	Examples	Advantages	Issues
Risk management	Current and future risks to climate variability; probabilistic approach.	Flood risk studies (coastal and river)	Well suited for current and future risks and uncertainty, often used with cost-effectiveness analysis Has been applied in adaptive management and iterative analysis	Extra dimension of complexity associated with probabilistic approach Limited applicability: focused on thresholds (e.g. risk of flooding)
Adaptation assessments	Risks over a range of policy / planning horizons; often linked risk management and adaptive capacity	No real economic examples; emerging number of adaptation assessments	Stronger focus on immediate adaptation policy needs and decision-making under uncertainty and greater consideration of diversity of adaptation (including soft options) and adaptive capacity	Less explored in relation to economic assessment

Model-based integrated analysis

An important technique for assessing broader scale effects of climate change is to integrate bio-physical and socio-economic models. Rather than attempting to represent all processes within a single integrated assessment model (IAM) as some researchers do at global scale (see, for example, the models used to develop scenarios for the IPCC in Nakicenovic et al. 2000), model-based integrated analysis can also be based on separate models that are run independently and in parallel. The models are "soft-linked", with outputs of one serving as inputs for another, in order to explore relationships between components of an integrated system. Many multi-sector impact assessments have been conducted using this type of framework, often using a common set of exogenous climate and socio-economic scenarios to ensure consistency and promote synthesis across the modelling exercises.

Examples at different scales include a global study of climate change impacts on food security, water stress, coastal flood risk and wetland loss, exposure to malaria risk and terrestrial ecosystems (e.g. Arnell et al. 2004), an evaluation of climate change and ecosystem services in Europe, including models of species biodiversity, water resources, forest growth, terrestrial carbon cycling and land use change (Schröter et al. 2005), and modelling of regional climate change impacts on agriculture, biodiversity, coastal zones and water resources in East Anglia and northwest England in the REGIS project (Holman et al. 2005; Holman et al. 2005).

A development of this approach, positioned at the boundary with IAMs proper, is the class of models represented by the Community Integrated Assessment System (CIAS – Warren et al. 2008). The CIAS seeks to address some of the challenges to integrated assessment modellers posed by Risbey et al. (1996) by:

- Connecting together alternative sets of component modules (Figure 3.2.3). Each connected set of component modules is broadly equivalent to an IAM. It is flexible and multi-modular to allow a range of policy questions to be addressed, thus facilitating iterative interaction with stakeholders.

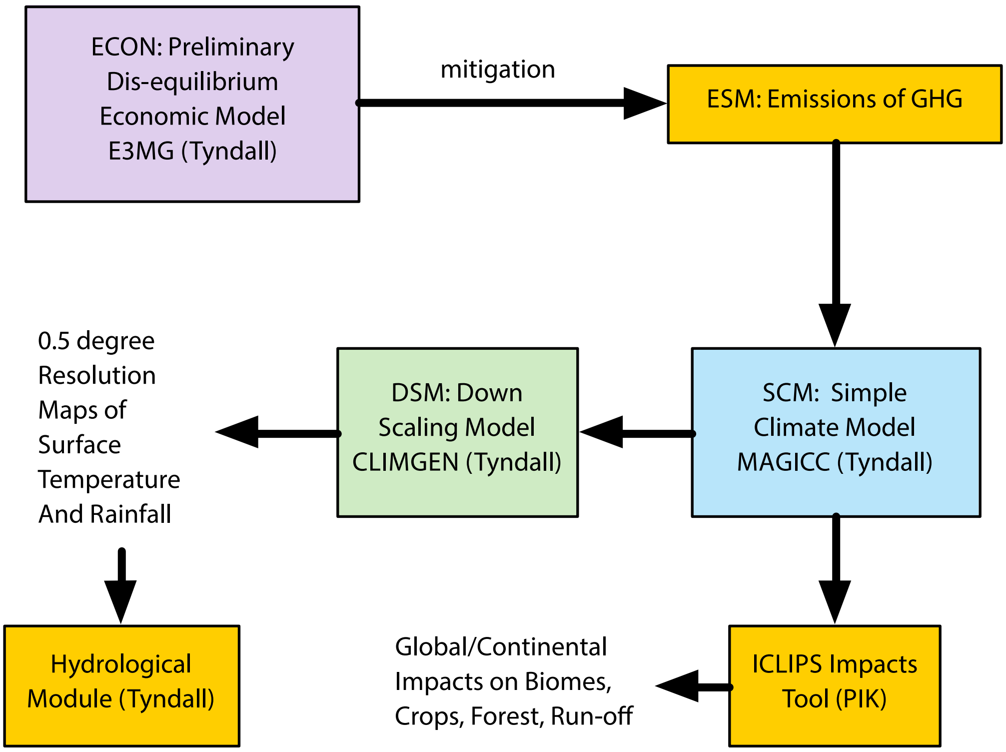

FIGURE 3.2.3 **Operational components of the Community Integrated Assessment System (CIAS) at the time of reporting, with distributed contributors in parentheses (Warren et al. 2008). Note that the Tyndall Centre is itself distributed among eight research institutions throughout the United Kingdom.**

- Operating a distributed model system deployed across a wide range of institutions in different countries, which promotes greater diversity and comprehensiveness of modelling components, drawing on a wide range of international expertise
- Enabling models to communicate with each other regardless of operating system or computer language.

Various combinations of the modules depicted in Figure 3.2.3 can be used to address different policy questions (Warren et al. 2008).

3.2.3 Vulnerability indication

Vulnerability indication has been used in many contexts around the world to assess and compare the vulnerability of different populations to climate change impacts. Indicators and indices are also a popular option for prioritizing adaptation interventions (Klein 2009; see also Klein 2010). Section 2.1 discusses some of the major criticisms and concerns relating to vulnerability indication. However, when used to gauge social vulnerability – in lieu of or, preferably, in conjunction with impacts analysis – these approaches can provide crucial information for a climate risk assessment. Social vulnerability analysis assumes that political, institutional, economic and social structures interact dynamically to influence exposure. From this perspective, adaptation involves "altering the context in which climate change occurs, so that individuals and groups can better respond to changing conditions" (O'Brien et al. 2007, p.76). That type of analysis is the primary focus of this section.

Before delving into social vulnerability indication, we should note that many indices and indicators go well beyond these aspects, and aim to cover the

BOX 3.2.5 ***Overview of vulnerability indication***

Theoretical assumption
Individual or social capacities and external climate drivers are responsible for impacts, but their interactions cannot be reliably simulated using computational models

Question addressed
Which combinations of variables give an indication of how climate change may impact the study unit?

Data requirements
Data on potential indicating variables

Typical result
A function that maps the current state of the study unit to a measure of possible future impacts

Generic steps
1. Select potential indicating variables based on literature
2. Aggregate indicating variables based on theoretical and normative arguments

full range of climate risk, including exposure and sensitivity to hazards. Accordingly, some indicators (primarily of exposure and sensitivity) are drawn from the biophysical realm, while others (mainly describing adaptive capacity) are drawn from socio-economic statistical sources. Indicators can then be combined to form indices: either as a composite, where the make-up of the component indicators is apparent, or an aggregate, where it is not (Eriksen and Kelly 2007). Many indices have focused on adaptive capacity, for use in conjunction with exposure and sensitivity (biophysical vulnerability) data. Increasingly, these kinds of analyses also produce spatially explicit information – literally, mapping vulnerability and adaptive capacity – to show how adaptation needs vary across locations (see, e.g., Preston et al. 2011; Acosta et al. 2013).

There have been several attempts at developing national-level indicators and indices for aspects of social vulnerability, each varying in the nature of vulnerability addressed, the hazards involved, and the geographic region. There is a strong trend of each index building on and attempting to refine its predecessors by adding to the complexity. This can occur through a variety of means: e.g. by increasing the number of variables considered, and/or using more sophisticated techniques of econometric and statistical modelling to transform and aggregate the indicators. The first vulnerability indices focused on Small Island Developing States (e.g. Briguglio 1995; Crowards 1999; Easter 1999; Kaly et al. 1999a). An index of social vulnerability to climate change-induced changes in water availability has been created for Africa (Vincent 2004). Assessments of vulnerability to climate change have also taken place at sub-national level. For instance, Figure 3.2.4 depicts district-level vulnerability to climate change of the agricultural sector in India, based on a set of composite indicators (O'Brien, Leichenko, et al. 2004).

Whilst many indices have focused on specific regions, others have taken more global approaches to assessing vulnerability and resilience, explicitly in regard to climate change (UNEP 2001; Moss et al. 2001). In recent years various explicit indices have been released, including the Global Adaptation Index (**index.gain.org**), World Risk Index (**worldriskreport.org**), and Climate Vulnerability Monitor (**daraint.org/climate-vulnerability-monitor/climate-vulnerability-monitor-2012/**). Clearly there is a policy appeal for such global indices, particularly given the need for transparent allocation of a growing pool of adaptation funding. However, a recent study showed the sector-specific or hazard-specific criteria give a more robust assessment of vulnerability, since the

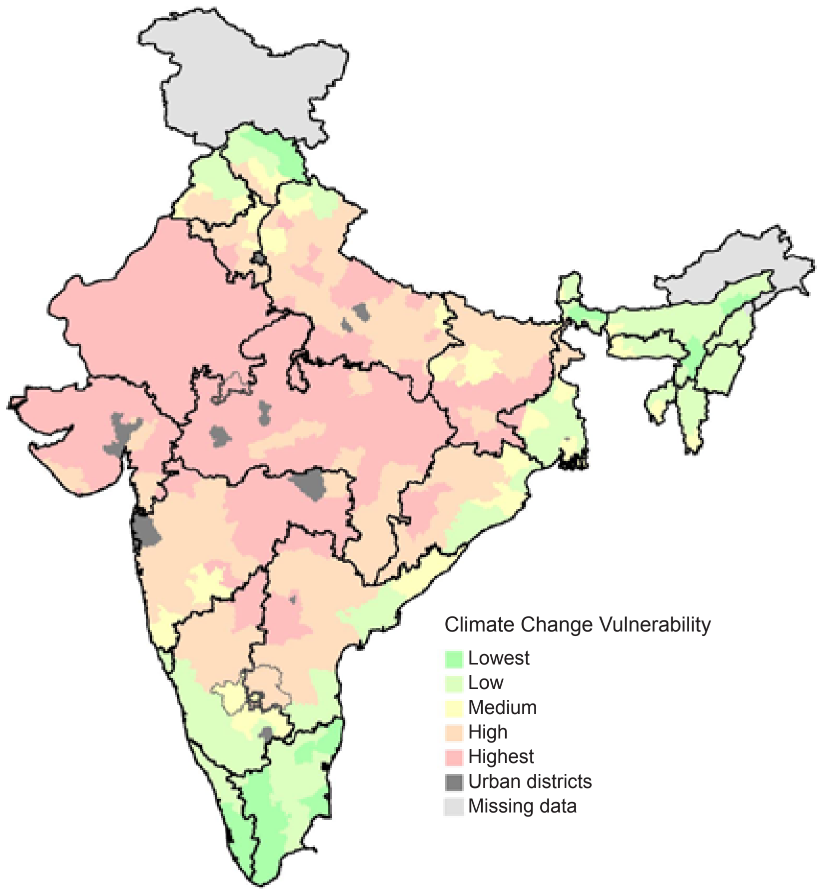

FIGURE 3.2.4 **Vulnerability of the agricultural sector to climate change in India by district. Vulnerability is computed as a composite of indices of adaptive capacity and climate sensitivity under exposure to climate change.** Source: O'Brien, Leichenko et al. (2004).

patterns of vulnerability factors for different sectors vary geographically (Füssel 2010).

The methodological debates on the use and construction of indicators have grown, commensurate with the range of indicators and indices (for a review, see Füssel 2009). One of the most fundamental distinctions is between an inductive (data-driven) and a deductive (theory-driven) approach (Niemeijer 2002). In the former a large number of potential vulnerability indicators might be chosen in what has been labelled a "vacuum cleaner" approach (UNEP 2001). Final selection might occur by means of expert judgement (Kaly and Pratt 2000; Kaly et al. 1999a; 1999b), or principal components analysis to determine those that account for the largest proportion of vulnerability (e.g. Easter 1999). However, the weakness in this is that a proxy variable for vulnerability must be chosen as the benchmark against which indicators are tested – somewhat paradoxically, as the very reason why vulnerability indicators are needed is that there is no such tangible element of vulnerability. The alternative is the theory-driven approach, in which existing theoretical insights into the nature and causes of vulnerability are used to select variables for inclusion (Adger 2006), although in practice this necessarily occurs within the limits placed by data availability (Briguglio 1995). This inevitably leads to subjectivity in the choice of indicators, but this can be addressed by ensuring all decisions are grounded in the existing literature and made fully transparent.

Although a number of indicators and indices have been devised for assessing social vulnerability to climate change, there is no "one size fits all" blueprint that can be used regardless of the context. Indicators are context-specific and typically cannot be transferred to different scales of analysis (e.g. GDP per capita might work as a national-level indicator, but does not easily translate to the village level). Whilst the driving forces of social vulnerability might be similar, the appropriate indicator to capture that at a national level will likely be different from that at a sub-national level (Vincent 2007; Eriksen and Kelly 2007). A recent paper reviewed the use of indices in a variety of circumstances, concluding that they are most appropriate for identifying vulnerable populations at the sub-national level (Hinkel 2011). Various indices have been created for assessing social vulnerability at community level (Vincent 2007; Hahn et al. 2009; Bell 2011), based on household-level data.

The value of vulnerability indices is disputed in the literature (Hinkel 2011). Some of these criticisms relate to indices in general; and others relate to the nature of vulnerability. A critical evaluation needs to take account of the limitations of indices in general when assessing vulnerability. Vulnerability is multi-dimensional in nature and a potential state that is time- and scale- specific. It is impossible to verify vulnerability at this point in time, and thus indicators can generally only portray a measure of relative vulnerability (e.g. between places, or between time periods). Similarly it is impossible to represent the inter-relationships between different determinants or driving processes that interact in different ways according to the temporal and spatial scales of analysis (Wilbanks and Kates 1999; Dow 1992). Given these uncertainties, many of the indices presented above use current data to show current social vulnerability, on the grounds that if the vulnerability exists now, it will likely be magnified when exposure changes in the future.

However, current conditions are unlikely to remain constant into the future, when climate changes are projected to occur. Although some indices have embraced the use of socio-economic scenarios (e.g. Moss et al. 2001), others suggest that current vulnerability is the best possible proxy (e.g. Adger and Kelly 1999), and is appropriate for identifying the means of increasing resilience, coping ranges and adaptive capacity (Adger et al. 2003). Ideally the index should be updated annually with new data in order to capture temporal shifts. An argument for modelling future socio-economic conditions, on the other hand, is that it allows analysts to explore the sensitivity of the resulting composite indices to plausible future trends – for example, does a change in GDP make a bigger difference than changes in women's educational levels? As with all

BOX 3.2.6 ***UNFCCC Compendium on methods and tools to evaluate impacts of, and vulnerability and adaptation to, climate change***

As part of the Nairobi Work Programme on impacts, vulnerability and adaptation to climate change, the Secretariat of the United Nations Framework Convention on Climate Change (UNFCCC) maintains a compendium of knowledge sources on its website: **unfccc.int/adaptation/nairobi_work_programme/knowledge_resources_and_publications/items/5457.php**. The Compendium was developed in 1999 has been updated several times, most recently in 2009. The entries are searchable through three filters: sector (e.g. agriculture, forestry), theme (climate scenarios, impact assessment), and type (e.g. guidance document, modelling tool).

indices, the assumptions and subsequent methods of transformation used should be evident, and the index should be subject to a process of continual testing and refinement. If decision-makers require more specific information, then estimates of impacts might be more appropriate.

Figure 3.2.5 below shows how biophysical and social determinants combine to shape vulnerability, based on Preston and Stafford-Smith (2009). However, while they distinguish between "present vulnerability" and "future vulnerability", we have modified their schema to refer to vulnerability to climate variability and vulnerability to climate change (Figure 3.2.5). This avoids using the term present vulnerability, given that vulnerability refers to potential harm in the future, but still recognizes that there are two different time horizons of interest in framing vulnerability, especially with respect to the implementation of adaptation responses.

It has been argued that adaptations that are robust under *projected* biophysical changes will also be robust for existing vulnerabilities (sometimes known as no-regret or low-regret measures – Willows and Connell 2003). It is also argued, however, that *present-day* social determinants of vulnerability should guide adaptation, and that such interventions will then drive future development pathways that are less vulnerable to climate change. This tendency to superimpose projected exposure on current adaptive capacity also reflects international funding goals, which have tended to target capacities to cope with climatic conditions experienced today, rather than projected longer-term climate change. Interestingly, future socio-economic changes are rarely explored as a guide for targeting adaptation in anticipation of future vulnerabilities, one argument being that such anticipatory adaptation may not necessarily adequately address current vulnerabilities (Preston and Stafford-Smith 2009).

3.2.4 Knowledge elicitation

An alternative or complementary approach to quantitative indicator studies is to involve stakeholders in agreeing on the main issues to be addressed in a vulnerability assessment (Malone and Engle 2011). Such stakeholder involvement is critical in a new model of knowledge production for vulnerability assessments that goes beyond the traditional one-way flow of information from science into policy (Vogel et al. 2007). We recommend

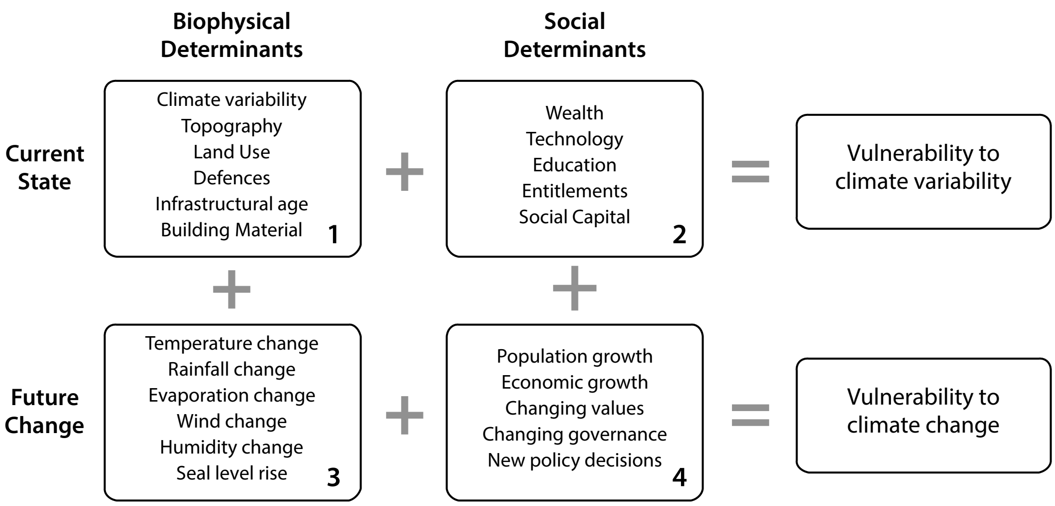

FIGURE 3.2.5 **Current and future determinants of vulnerability to climate variability and climate change (modified from Preston and Stafford-Smith 2009). A notable gap in knowledge relates to adaptation that targets future changes in social determinants of vulnerability.**

BOX 3.2.7 ***Overview of knowledge elicitation***

Theoretical assumption
The stakeholders who will experience climate change (depending on the scale of analysis) have valid knowledge and experience which can be used to add value to vulnerability assessments

Question addressed
How can the context-appropriate knowledge of communities, and technical expertise of experts, contribute to the robustness of the vulnerability assessment?

Data requirements
Data on potential vulnerability drivers as appropriate to the context

Typical result
A more robust and comprehensive vulnerability assessment.

Generic steps
1. Identification of salient domains
2. Selection of drivers and strategies by stakeholders
3. Knowledge representation

reading Section 3.1 along with this section to learn more about stakeholder engagement and tools to support it.

Stakeholder involvement can take many forms, depending on the scale of analysis and purpose of the impact assessment. At the community level, if high-resolution vulnerability and impact assessments are required, stakeholder participation not only enables local insights to be taken into account, but also encourages ownership of the process. Stakeholders can also provide invaluable information about non-climate factors that may affect the potential impacts of climate change. It may also be appropriate to assess the opinions of a panel of experts in the field to find out what communities are vulnerable to, who is vulnerable, how future vulnerability may be characterized, and at what scales. Expert judgement methods can also be appropriate in regions where quantitative data availability is poor (Downing and Patwardhan 2005). Experts can also offer sectoral expertise: on health, biodiversity or food production, for example. As these are often cost-effective ways to gather information in places with limited data available, such participatory methods also suggested to fill data gaps in developing-world contexts (Kates et al. 2000).

It is important to note that stakeholder engagement, done well, is not a quick or easy task. Engaging stakeholders means recognizing that every actor has a valid view and relevant information to contribute to a task. Multi-stakeholder processes can help ensure that the views of all the main actors are incorporated and that a consensus is reached (Hemmati 2002), but this requires ensuring that *all views are actually heard*. Facilitating multi-stakeholder processes requires a willingness to participate on the part of the stakeholders, and skilled and sensitive facilitation (see Section 3.1.1.3). The facilitator must be able to adapt to varying circumstances and be willing to deviate from a plan, if needs arise, whilst still ensuring that the end goal is achieved. Several tools to support facilitation are suggested in Section 3.1.4; in addition, two books not listed there may be useful: *Facilitator's Guide to Participatory Decision-Making* (Kaner 2011) and *Participatory Workshops: A Sourcebook of 21 Sets of Ideas and Activities* (Chambers 2002).

3.2.4.1 Community vulnerability assessment

NGOs and civil-society organizations working at the local scale commonly assess vulnerability using participatory stakeholder methodologies (see also Section 3.1.3). Early examples include

Capacities and Vulnerability Analysis (Anderson and Woodrow 1998) and the Vulnerability and Capacity Assessment Tool (IFRC 1999). Although many organizations use their own approaches, some generic toolkits and guides have been produced to outline good practice (e.g. Twigg 2007; Abarquez and Murshed 2004). Common understanding of good practice is that assessments should be based on a participatory methodology (e.g. Participatory Rural Appraisal), require local ownership, and integrate other, non-stakeholder processes (Davis et al. 2004).

Although participatory vulnerability assessments may yield valid data, concerns have arisen over the years about the uncritical use of tools, without adapting appropriately to local circumstances – and, related to that, viewing communities as homogeneous (and harmonious) social units (Davis et al. 2004). A study of assessments conducted by Red Cross/Red Crescent societies highlighted the important of keeping community risk assessments simple enough for wide application, which requires better tool design and guidance for interpretation of outcomes (van Aalst et al. 2008).

At their most basic, many community vulnerability assessments are designed to use low technology and thus be appropriate even in impoverished and remote environments. But the same principles of knowledge elicitation are similarly popular in higher-technology, developed-country contexts. Here there is often scope (and greater existing data availability) for a more comprehensive approach.

Community vulnerability assessments vary in their scope. Some focus specifically on adaptive capacity, while others also include exposure and sensitivity to climate hazards. The U.S. National Oceanic and Atmospheric Administration (NOAA) developed a Community Vulnerability Assessment Tool that supports the linking of environmental, social and economic data in the coastal zone. It is a static GIS map overlay procedure for analysis of the relative risk or vulnerability analysis of coastal communities to a series of existing threats. Seven steps are followed in the procedure:

1. Hazard identification and prioritization;
2. Hazard analysis;
3. Critical facilities analysis;
4. Social analysis;
5. Economic analysis;
6. Environmental analysis;
7. Mitigation opportunities analysis.

3.2.4.2 Expert judgement

Community vulnerability assessments elicit knowledge from community members, who have intimate knowledge of their local situation. Expert judgement, meanwhile, solicits informed opinions from individuals with particular expertise. This approach is often used to obtain a rapid assessment of the state of knowledge concerning particular aspects of climate change. Expert judgement is most effective when used in a panel format, bringing together experts with a range of experience and/or opinions.

Expert judgement has been used in a variety of ways. Some of the earliest climate impact studies – in the late 1970s and early 1980s – used this method, which drew criticism at the time (Stewart and Glantz 1985). More recently, in developed-country studies, it has been used to validate the findings of vulnerability and impact assessments, indicators, studies that attempt to place boundaries on what constitutes adaptation, or the thresholds of dangerous climate change (Brooks and Adger 2005; Doria et al. 2009; Arnell et al. 2005; Smith et al. 2009).

There are also some examples of expert judgement forming the key method, or being integral to the creation of an assessment. Alberini et al. (2006)

used conjoint choice questions of public health and climate change experts to determine which of two hypothetical countries (described by a vector of seven socio-economic and health attributes) they deemed to have the higher adaptive capacity. Probit models indicated that respondents viewed per capita income, low levels of income inequality, universal health care coverage, and high access to information as important determinants of adaptive capacity. They then used the estimated coefficients and country socio-demographics to construct an index of adaptive capacity for several countries. In panel data regressions, this index proved to be a good predictor of mortality in climate disasters, affirming the value of expert judgement in vulnerability and impact assessments.

Despite its widespread use and evidence for utility, caution has been expressed over the use of expert judgement as a method for climate impact and vulnerability assessments. Those who prioritize empirical and quantitative data, in the interests of comparability, warn against the potentially subjective nature of expert judgement (Füssel 2007). Even the way experts understand climate change and its risks is subjective, and thus the way they bring their knowledge to bear is shaped by their values and understanding of climate and social systems (Lowe and Lorenzoni 2007).

3.2.4.3 Participatory scenario development

The predominant stakeholder method for assessing how vulnerability will change in the future is participatory scenario development. Scenarios can be defined as plausible representations of how the future may unfold. Community scenario writing is a participatory approach based on dialogue between futures researchers and climate-vulnerable communities that enables context-awareness (Gidley et al. 2009). Participatory scenario building is a popular approach in visioning environmental futures, and guidance has been produced on good practice (Pahl-Wostl 2008; Bizikova et al. 2009). A number of authors have contended that future changes in socio-economic systems have been insufficiently integrated with an analysis of climate change impacts, and that participatory methods of scenario development are the ideal approach for analysing potential change in socio-economic systems (Berkhout et al. 2002). In particular, participatory scenario planning is intrinsically linked with the understanding that anticipatory learning is required to bring about adaptation to climate change (Tschakert and Dietrich 2010).

As with community vulnerability assessments and expert judgement, there are many examples of participatory scenario development within various sectors and regions. One study took an integrated approach to the construction of socio-economic scenarios required for the analysis of climate change impacts on European agricultural land use (Abildtrup et al. 2006). It started from global scenarios developed in the IPCC *Special Report on Emissions Scenarios* (SRES – Nakicenovic et al. 2000), but used a stepwise downscaling procedure based on expert judgement and pairwise comparison to obtain quantitative socio-economic parameters, such as prices and productivity estimates, which were then included in the model.

Another project used participatory modelling for assessment of climate change impacts on water resources in the Thukela River Basin from 2007 to 2009 (Andersson et al. 2011). The study used several regionally downscaled climate change scenarios linked to hydrological and agro-hydrological models, and combined them with stakeholder identification of prominent climate and water-related issues, including information to be produced and institutional-related obstacles to be overcome to reduce vulnerability. Likewise, participatory scenario processes were applied to water issues in the flood-prone municipality of Delta, British Columbia, Canada, producing 3-D computer-generated images of climate change futures (Burch et al. 2010).

For a more in-depth discussion of scenario analysis, see Section 3.4.

3.2.3.4 User-controlled learning tools

New types of mapping tools have appeared in recent years that offer users the flexibility to explore vulnerability indicators themselves (albeit from a pre-selected list, though stakeholders can also help define that list), and to combine and weight them according to their interest (e.g. Carter et al. 2013; Harrison et al. 2013). Such tools place the definition of vulnerability firmly and more transparently in the hands of the user rather than the researcher, whose role is simply to compile the requisite data for analysis. This form of direct stakeholder participation may address at least one Hinkel's critiques of vulnerability indicators (Hinkel 2011 – see above), that they express vague concepts and may not convey any information that is relevant to stakeholders. Clearly, if the stakeholders select the indicators themselves and combine and map them according to their knowledge of a given situation, this would appear to present a real learning opportunity.

Whether the development of interactive vulnerability tools and the user-controlled learning they can promote should be regarded as scientific research (the sixth purpose of vulnerability assessment listed and dismissed by Hinkel above) may also merit further attention. Causality does not necessarily need to be explicitly represented by researchers to describe vulnerability; it can also be inferred subjectively, but still usefully by an expert user (for example, by comparing patterns of a given impact with patterns of candidate indicators that might contribute to those impacts). Moreover, study of user decisions in such an environment might yield very useful insights into how stakeholders actually perceive vulnerability to climate change in the specific context in which they work.

3.2.5 Application of methods for projecting future impacts

Numerous studies have been conducted, at various scales of analysis, to determine the future impacts of climate change, using the different methodologies discussed throughout this section. Below we present an overview of studies to point the reader towards further sources of information.

Table 3.2.4 is a matrix of impact studies, organized by sector of analysis and geographic area. Symbols after each study indicate the methods employed by the study: various types of modelling, integrated assessment, participatory scenario development, expert judgement and indicators. Some of the studies – particularly those with a global focus – use historical data as analogues, or base their methods on existing literature reviews. On the whole, studies presented in this table are impact assessments looking to the future that use climate projections and provide analysis on how those projections will affect the various sectors in the various locations.

In contrast, Table 3.2.5 gives an overview of studies that have used the context (starting point) vulnerability approach to look at current vulnerability to the potential future change in climate. These studies are typically smaller-scale in approach, and place-based. Again, an illustrative variety of examples from around the world are presented. ■

TABLE 3.2.4 **Selection of impact studies, divided by sector and geographical focus, and highlighting methods employed. Symbols are explained at the foot of the table.**

Location / Sector	Europe	Americas	Africa and Middle East	Asia	Australasia	Global
Agriculture	Abildtrup et al. (2006) A C Falloon and Betts (2010) h	Zhang, Liu, Li, et al. (2011) H Jones and Thornton, (2003) D Meza et al. (2008) D K Ruane et al. (2013) D	Abraha and Savage (2006) D Al-Bakri et al. (2011) D Jones and Thornton, (2003) D Roudier et al. (2011) H Thornton et al. (2010) D	Chavas et al. (2009) D Lioubimtseva and Henebry (2009) K Masutomi et al. (2009) D Srivastava et al. (2010) D Xiong et al. (2008) D Wei et al. (2009) D I Thomson et al. (2006) D Simelton et al. (2009) K M	Luo et al. (2003) D, Pearson et al. (2011) B H	Berg et al. (2013), tropics F Fraser (2006), famines J Jacxsens et al. (2010), food safety supply chain H Kang et al. (2009) D I Mera et al. (2006), soybean and maize D Nardone et al. (2010), livestock K Ramirez-Vallegas et al. (2013), sorghum B D Sutherst et al. (2000), pests H Thornton et al. (2009), livestock in developing countries K
Pollution	Alcamo et al. (2002) C	Macdonald et al. (2005) K				
Coasts and fisheries (marine)	Philippart et al. (2011) K					Badjeck et al. (2010) E Brander (2010) H
Ecosystems and/or biodiversity	de Chazal et al. (2008) A H Lindner et al. (2010) C H van Minnen et al. (2002) H M Schröter et al. (2005) H Metzger et al. (2008) H M	Andalo et al. (2005) H Coops and Waring (2011) H Coops et al. (2012) H Dale et al. (2001) G Dalla Valle et al. (2007) H Ehman et al. (2002) G Ivits et al. (2012) H McRae et al. (2008) G H Nitschke and Innes (2008) G Taner et al. (2011) G	Pettorelli et al. (2012) F	Tanaka et al. (2012) H		Chakraborty et al. (2000), plant diseases H Şekercioğlu et al. (2012), tropical birds H K Sietz et al. (2011), drylands C Stock et al. (2011), living marine resources H

TABLE 3.2.4 ***continued***

Location / Sector	Europe	Americas	Africa and Middle East	Asia	Australasia	Global
Urban	Bonazza et al. (2009) Ⓗ	Hayhoe et al. (2010) Ⓒ Wuebbles et al. (2010) Ⓒ Romero Lankao et al. (2012), more adaptation, less quantitative Ⓒ Ⓚ				Gasper et al. (2011) Ⓚ Li et al. (2012), energy use in buildings Ⓗ Romero Lankao and Qin (2011) Ⓚ Willems et al. (2012), urban drainage Ⓗ
Water	Eckhardt and Ulbrich (2003) Ⓘ Falloon and Betts (2010) Ⓗ	Boyer et al. (2010) Ⓘ Chang and Jung (2010) Ⓘ Kienzle et al. (2012) Ⓘ Zhang, Huang, Wang, et al. (2011) Ⓘ		De Silva et al. (2007) Ⓘ Kelkar et al. (2008) Ⓘ Ⓛ Lioubimtseva and Henebry (2009) Ⓚ Park et al. (2010) Ⓚ Park et al. (2011) Ⓚ Varis et al. (2012) Ⓗ Ⓜ		Green et al. (2011), groundwater Ⓚ
Transport						Koetse and Rietveld, (2009) Ⓚ
Health		Patz et al. (2008) Ⓗ Romero Lankao et al. (2012), more adaptation, less quantitative Ⓒ Ⓚ		Lioubimtseva and Henebry (2009) Ⓚ Nelson (2003) Ⓚ Vineis et al. (2011) Ⓚ		
Energy		Burkett (2011) Ⓗ Ⓚ				Mideksa and Kallbekken, (2010) Ⓚ
Coasts						Nicholls, (2002), sea-level rise and flooding Ⓗ

Key for methods:

Ⓐ = participatory scenario development
Ⓑ = expert judgement
Ⓒ = integrated model/integrated assessment
Ⓓ = crop simulation model
Ⓔ = livelihoods framework
Ⓕ = vegetation models
Ⓖ = forest ecosystem models
Ⓗ = modelling
Ⓘ = water models
Ⓙ = landscape ecology
Ⓚ = literature review / analysis / historical data
Ⓛ = participatory knowledge elicitation
Ⓜ = indicators

TABLE 3.2.5 **Selection of studies using starting point vulnerability, organized by geographical location.**

Continent	Country	Authors	Methods
Asia	Philippines	Acosta-Michlik and Espaldon (2008)	Behavioural model (agent-based model)
	Vietnam	Few and Tran (2010)	Qualitative household level
Americas	Mexico	Eakin (2005)	Ethnographic data on multiple stresses
	Latin America and the Caribbean	Manuel-Navarrete et al. (2007)	Post-disaster assessments
	Bolivia	McDowell and Hess (2012)	Qualitative household study
	Canada (health)	Ford et al. (2010)	Identifying driving forces of vulnerability
	USA	Hill and Polsky (2007)	Historical data (including models) and qualitiative interviews
Africa	Mozambique	Eriksen and Silva (2009)	Household vulnerability to multiple stresses
	Mozambique	Osbahr et al. (2008)	Qualitative household (coping/adaptation)
	Uganda	Hisali et al. (2011)	National household survey
	Tanzania	Paavola (2008)	Qualitative household data
	South Africa	Reid and Vogel (2006)	Sustainable livelihoods framework
Australasia	Solomon Islands	Schwarz et al. (2011)	Integrated assessment community mapping and multivariate Probit approach
Europe	Norway	O'Brien et al. (2004)	Multi-scale-indicators and downscaled scenarios at local level

Highland tea farming in Vietnam © Flickr/CGIAR-CCFAS

3.3 Capacity analysis

The methods and tools described in Section 3.2 focused on assessing the current and future impacts of climate change. This section focuses on methods and tools for another crucial task: assessing the capacity of individuals, communities, systems and institutions to adapt to climate change, and thus reduce harm and/or seize opportunities. Capacity analysis is typically done in the first stage of the adaptation process, identifying adaptation needs (Section 2.1), but it is also relevant in appraising adaptation options (Section 2.3) and planning and implementing adaptation measures (Section 2.4). Along with the resources presented in this chapter, readers may also find it useful to consult Section 3.1, on participatory tools for adaptation, which describes several approaches designed to both assess and build adaptive capacity.

In its *Fourth Assessment Report,* the IPCC notes that adaptive capacity is shaped by the characteristics of the society exposed to climate risks, and identifies six factors that seem to determine adaptive capacity: economic resources, technology, information and skills, infrastructure, institutions and equity (IPCC 2007a). Some of those factors are easier to quantify than others, and several assessments of adaptive capacity have used proxy indicators that focused largely on economic resources, poverty and inequality (Brooks et al. 2005; Dulal et al. 2010). Such analyses are useful in helping understand and compare the resources available to a nation (or a community or a household) in adapting to climate change, but they miss other key aspects of adaptive capacity that are just as important – from the effectiveness of local institutions and networks, to social norms and values that may constrain adaptation.

3.3.1 'Adaptation functions' and institutions to support adaptation

Assessing and building adaptive capacity thus requires an understanding of the complexity of the system and how it changes, including decision-making processes, policy development, organizational culture and innovation, and risk perception. This means looking not just at what a system *has* that enables it to adapt, but more important, at what it *does* that enables it to adapt. That is the approach taken by the Bellagio Framework (McGray et al. 2009), also discussed in Section 2.5, which identifies fundamental "adaptation functions" that countries must perform if they are to respond effectively to climate change. The framework identifies three categories of functions: planning (assessment, prioritization, high-level coordination), management (information management, addressing incentives and barriers, coordinating across government), and service delivery (with a focus on infrastructure, natural resources management and social protection).

The World Resources Institute has built on this concept with its National Adaptive Capacity framework (Dixit et al. 2012), which helps governments to systematically assess institutional strengths and weaknesses that may help or hinder adaptation. The framework measures a country's overall adaptive capacity on the basis of its national institutions' performance in five key functions: assessment, prioritization, coordination, information management, and climate risk management. The tool can be applied at the national or sectoral levels; it was tested in pilot projects in Bolivia, Ireland and Nepal.

A different approach to the same kind of analysis is proposed by Gupta et al. (2010), who look at the *characteristics* of institutions that enable them to effectively support adaptation (see Section 3.6 for a closely related discussion). Institutions, they argue, "should allow actors to learn from new insights and experiences in order to flexibly and creatively 'manage' the expected and the unexpected, while maintaining a degree of identity". This leads them to identify six key traits of institutions that support adaptation: variety, learning capacity, room for autonomous change, leadership, resources and fair governance. To visually represent their framework, they propose an Adaptive Capacity Wheel that shows those characteristics and their components (e.g. fair governance includes equity, legitimacy, responsiveness and accountability). They suggest colour-coding each wedge of the wheel, from red to green, to show social actors how their institutions compare.

All three of the approaches described above assume that there are institutional functions or characteristics that are crucial to adaptation in any setting (see Section 3.6.3 for a related discussion). However, analyses "from the ground up" can also identify institutional needs for adaptation, which can then be compared with what currently exists. One such approach is the Climate Learning Ladder, developed as part of studies in the Alxa League in Inner Mongolia, China, and the Guadiana river basin in Spain and Portugal (Tàbara et al. 2010). The ladder offers a way to structure policy analysis, support reflection and identify critical decisions to support climate adaptation at the local, regional or national scale. It works in four steps: (1) learn to manage different framings of the issues at stake while raising awareness of climate risks and opportunities; (2) learn to understand different motives for, and generate incentives or sanctions to ensure, action; (3) develop feasible options and resources for individual and collective transformation and collaboration; and (4) institutionalize new rights, responsibilities and feedback learning processes for climate adaptation in the long term. Notably, this framework also assumes it is possible to "unlearn" or "move down the climate ladder", whenever agents and institutions lose the knowledge and capacities acquired over time to cope with climate risks.

3.3.2 Organizational adaptive capacity

The Adaptive Capacity Wheel and the Climate Learning Ladder can both be applied not only to countries, regions or local communities, but also to organizations – which, like social institutions, can have traits and capacities to support adaptation, or may lack them. The term "organization" is used broadly here, to describe anything from a business, to an NGO, to a group or network (e.g. a forestry association) – any of which might need to engage in private collective adaptation (see Section 2.1). In assessing such organizations' needs, it is useful to consider what attributes might enable them to identify opportunities, gather resources, capture expertise, create partnerships and opportunities for dialogue, and manage and monitor the underlying processes, for example.

There are a number of frameworks available, most developed through practice, that explore what it means for an organization to have high adaptive capacity, and how to assess those attributes. UKCIP reviewed 17 recent studies and framings of adaptive capacity, focusing specifically on aspects that enable an organization (or occasionally another unit of exploration, e.g. a national adaptation plan or a network) to be "well adapting" (Lonsdale et al. 2010). It found a number of commonly cited attributes across the frameworks, which can be summarized as eight questions to address when assessing organizational capacity:

1. Does the organization have leadership that understands and promotes adaptation?

2. Does the organization have access to or know where to access, accurate, usable information and expertise?

3. Is there space to translate the information throughout the organization?

4. Are novel projects, experiments, opportunities for innovation (and the individuals promoting them) supported?

5. Does the organization customarily engage with others through collaboration or in partnerships, and is attention paid to how this collaboration can be done well and improved as required?

6. Is adaptation integrated into the organization's processes and practices?

7. Are there regular opportunities for questioning core assumptions of how the organization works and its core purpose?

8. Does the organization have a culture of continuous learning? Are there systems in place for the retention of knowledge and experience within the organization when key individuals leave?

One tool that has been widely applied across the UK (and included in the UKCIP review) is PACT: Performance Acceleration through Capacity Transformations, a framework developed by Alexander Ballard Ltd (see **alexanderballard.co.uk/pact/**). The PACT framework can help organizations assess their current capacity to respond to climate change, identify who needs to get involved and what milestones need to be achieved, and monitor and evaluate actions. It provides customized reports that supports progress from assessing the status of current work programmes to planning improvements.

3.3.3 Adaptive capacity and social vulnerability

As noted in the introduction, adaptive capacity has many dimensions – only some of which can be captured by frameworks focused on institutions. Another important type of analysis involves social vulnerability, which can be seen as the "flipside" of adaptive capacity in some respects: for example, people who can read and write may have a greater capacity to adapt than those who are illiterate – and the latter may thus be more vulnerable. Like social vulnerability, adaptive capacity is dynamic, varying across time and space, and shaped by an array of economic, social, cultural, institutional, environmental and other factors (IPCC 2012). Therefore, like vulnerability assessments, capacity analyses can only reliably tell us about capacity *here and now,* but not necessarily in the future, or under different circumstances. Section 3.2.3 discusses the use of indicators and indices to measure social vulnerability and adaptive capacity, as well as common concerns raised about such approaches. In short, as Füssel (2009) puts it, all existing vulnerability/adaptive capacity indices "show substantial conceptual, methodological and empirical weaknesses including lack of focus, lack of a sound conceptual framework, methodological flaws, large sensitivity to alternative methods for data aggregation, limited data availability, and hiding of legitimate normative controversies" (pp.8–9).

The problems with indices do not, however, negate the importance of the socio-economic context in assessing adaptive capacity – they highlight the need for better analyses, and for a recognition that adaptive capacity cannot be easily quantified and compared across countries or populations. There is no agreed-upon formula by which to calculate adaptive capacity, and in fact, different factors will determine adaptive capacity under different circumstances. In that context, the factors suggested by the IPCC (2007a; see the discussion at the beginning of Section 3.3) can be seen more as rough categories that warrant attention. Which aspects of adaptive capacity are given priority will depend, at least in part, on normative choices: for example, an emphasis on poverty, inequality and lack of self-determination might be associated with a social-justice perspective (see, e.g., Dow et al. 2006).

Approaches to adaptive capacity that focus on socio-economic factors may also point to development interventions as useful ways to reduce social vulnerability and increase adaptive capacity – going back to our earlier example, if illiteracy is impairing people's capacity to adapt, teaching them to read and write might be a sensible solution. However, adaptation and development (or, more narrowly, measures to address climate risks and measures to reduce social vulnerability) can just as easily work at cross-purposes. For example, intensive shrimp farming in coastal Asia has brought new trade income, but has also led to mangrove deforestation, reducing the livelihood options of local communities and removing an important protective barrier during storms (Adger et al. 2005). Technological adaptation measures such as irrigation systems, meanwhile, can lead to groundwater salinization and wetlands degradation, leaving people more vulnerable to water scarcity (Klein et al. 2007). Policy can play a major role in avoiding maladaptive outcomes; for a related discussion on portfolio screening, see Section 3.6.2.

3.3.4 Participatory and community-based approaches

Oxfam's approach to building the adaptive capacity of people living in poverty (Pettengell 2010) combines multiple elements of adaptive capacity, including institutional aspects, socio-economic factors, and practical issues such as access to knowledge and resources. The approach starts from the premise that "poverty, more than any other factor, determines vulnerability to climate change and limits adaptive capacity" (p.4), but it does not narrowly target poverty to solve that problem. Instead, it suggests a two-pronged approach: to build adaptive capacity – through knowledge generation, awareness-raising, supportive policies, innovation, etc. – and to address factors that limit adaptive capacity – political and economic conditions, marginalization, gender inequality, lack of access to services, etc. The Oxfam framework also makes it clear that different aspects of adaptive capacity are determined at different levels, from households, to communities, up to national governments, and addressing them all requires a combination of top-down and bottom-up approaches.

The CARE Community Vulnerability and Capacity Analysis methodology (Dazé et al. 2009; see also Section 3.1.3.1) takes a similar approach. Starting from the IPCC (2007a) definition of adaptive capacity, it notes that "one of the most important factors shaping the adaptive capacity of individuals, households and communities is their access to and control over natural, human, social, physical, and financial resources" (p.5). This access varies within countries, communities and even households, and is influenced by external factors such as policies, institutions and power structures; it can vary over time based on changing conditions, and it may differ in relation to particular hazards. In addition, the guidance notes that adaptive capacity is closely linked to resilience – the ability to recover quickly and efficiently from negative impacts, preserving or restoring essential basic structures, functions and identity.

CARE translates this view of adaptation into a framework that identifies "enabling factors" which must be in place at household/individual, community/local and national levels to support effective adaptation. They fall into four categories: climate-resilient livelihoods, disaster risk reduction, capacity development, and addressing underlying causes of vulnerability. For example, at the local level, institutions must have capacity and resources to plan and implement adaptation activities; one factor at the household/individual level is whether women and other marginalized groups have equal access to information, skills and services. The methodology also notes that such an analysis requires "significant engagement" with communities and stakeholders and a substantial investment of time and resources. Moreover, it requires a wide range of skills and experience:

- Research skills – for background research;
- Knowledge of climate change – to analyse and summarize available climate information;
- Policy and institutional analysis – to analyse the enabling environment;
- Scientific expertise – in agriculture, water, and other relevant sectors;
- Facilitation of participatory processes – to animate and balance the participation of everyone in the group, keep the group on track and to construct an environment of trust and openness;
- Gender and diversity – to ensure gender and diversity-sensitive facilitation and to analyse differential vulnerability;
- Conflict management – to help the group understand diverse perspectives and opinions, and to come to conclusions and/or consensus;
- Qualitative interviewing – to listen actively and push for deeper reflection/additional information;
- Writing skills – to present a convincing, clear and robust argument to various audiences for incorporating adaptation strategies within projects or as new activities. ■

3.4 Scenario analysis

There is a formidable literature on the use of data and scenarios in climate impact and vulnerability assessments, and this guidance does not seek to repeat earlier extensive reviews (e.g. Carter et al. 2001; Mearns et al. 2001; Carter et al. 2007; Rounsevell and Metzger 2010). Instead, our goal here is to provide an overview of some of the most useful resources, and to highlight important issues to consider when using scenario analysis in the context of adaptation.

In 1996 the IPCC formed the Task Group on Data and Scenario Support for Impact and Climate Analysis (TGICA), a special cross-Working Group committee charged with making relevant data and scenarios assessed by the IPCC accessible to the climate change research community worldwide (see the group's mandate: IPCC 2003). TGICA has prepared a number of guidance documents on data and scenarios (e.g. IPCC-TGICA 2007; Nicholls et al. 2011), arranged regional workshops (e.g. Leary et al., 2009), and established the IPCC Data Distribution Centre (**www.ipcc-data.org**) to facilitate the timely distribution of consistent data and scenarios for use in climate risk and mitigation assessments that can ultimately feed into the IPCC assessment process.

At the World Climate Conference-3 in 2009, the Global Framework for Climate Services was launched (**www.gfcs-climate.org**), coordinated by the World Meteorological Organization, to bring together researchers and the producers and users of information to improve the quality and quantity of climate services worldwide, particularly in developing countries. Many governments and organizations are also investing heavily in their own data portals to provide data and scenario support for climate change research. Examples include:

- **Global:** The World Bank Climate Change Knowledge Portal 2.0 (**sdwebx.worldbank.**

org) provides information on climate and impacts, an adaptation screening tool and some limited coverage of mitigation. Users can query, map, compare, chart and summarize key climate and climate-related information from various data sources and reports.

- **Global (developing countries):** UNDP Climate Change Country Profiles (**www.geog.ox.ac.uk/research/climate/projects/undp-cp/**), posted at the University of Oxford, UK, offer information on observed and projected climate for 52 developing countries.
- **Africa:** The Climate Information Portal of the Climate Systems Analysis Group, University of Cape Town, provides climate information and scenarios for Africa and, to a more limited extent, Asia and other parts of the world (**cip.csag.uct.ac.za/webclient2/app/**); the tool is also linked to weADAPT (**weadapt.org**), which allows cross-referencing with studies in the areas of interest.
- **Asia and the Pacific:** The Asia Pacific Adaptation Network (APAN) maintains a portal with an array of resources to support climate change adaptation in the Asia and Pacific region (**www.asiapacificadapt.net**).
- **Europe:** The European Climate Adaptation Platform, CLIMATE-ADAPT (**climate-adapt.eea.europa.eu/**), is a portal operating under the auspices of the European Environment Agency; it offers links to European and national climate, impacts and adaptation information.
- **Australia:** OzClim (**www.csiro.au/ozclim/**), developed by CSIRO, is a tool for generating climate change scenarios for Australia.
- **Canada:** The national Canadian Climate Change Scenarios Network (**www.cccsn.ec.gc.ca**) distributes climate scenarios and adaptation information, including a mapping tool for providing climate projections; the Pacific Climate Impacts Consortium (**www.pacificclimate.org**) is a regional climate services centre at the University of Victoria that provides information for the Pacific and Yukon regions; the private, nonprofit consortium Ouranus maintains climate databases and other tools to support adaptation research (**www.ouranos.ca**) maintains climate databases and adaptation resources for Quebec and other regions of Canada (in English and French).
- **Caribbean:** The Caribbean Community Climate Change Centre (**www.caribbeanclimate.bz**) provides regional climate data and projections and information and advice on adaptation responses.
- **Central America:** The SERVE project (Sistema Regional de Visualización Monitoreo de Mesoamérica) provides climate projections and other data for Mexico and Central America (**www.servir.net**).
- **Denmark:** The Danish Meteorological Institute provides climate data and scenarios through the Climate Change Adaptation portal (**www.klimatilpasning.dk**, in Danish and English).
- **Finland:** The national portal **Climateguide.fi**, co-ordinated by the Finnish Meteorological Institute, Finnish Environment Institute and Aalto University, provides data and information on climate, impacts, adaptation and mitigation (in Finnish, Swedish and English).
- **Germany:** The Federal Environment Agency (Umweltbundesamt) maintains the web portal KomPass (**www.umweltbundesamt.de/themen/klima-energie/anpassung-an-den-klimawandel/kompass**); there is also a government-funded Climate Service Center – Germany (**www.climate-service-center.de**, in German with limited coverage in English).
- **Netherlands:** Climate services, including climate scenarios, are provided by the Royal Netherlands Meteorological Institute (**www.knmi.nl**) and accessible from

the Dutch climate change portal Platform Communication on Climate Change (**www.klimaatportaal.nl**, in Dutch and English).
- **Norway:** Climate scenarios from the Norwegian Meteorological Institute (**met.no**) are accessible from the Norwegian Climate Change Adaptation Programme web portal hosted by the Norwegian Ministry of the Environment (**www.regjeringen.no/en/dep/md/kampanjer/klimatilpasning-norge-1.html**, in Norwegian and English).
- **Spain:** Climate scenarios prepared by the State Meteorological Agency of Spain (AEMET, **www.aemet.es**) in support of the Spanish National Climate Change Adaptation Plan are available on a special AEMET portal (**escenarios.inm.es**, in Spanish).
- **United Kingdom:** The UK Government has produced five sets of official climate projections since 1991, the most recent being UKCP09 (Murphy et al. 2009), and one set of socio-economic scenarios in 2001 (UKCIP 2001). These are distributed by UKCIP (**www.ukcip.org.uk**). There have also been critical reviews of the effectiveness of both the climate scenarios (Hulme and Dessai 2008) and socio-economic scenarios (Hughes et al. 2009).
- **USA:** The National Oceanic and Atmospheric Administration (NOAA) has a prototype Climate Services Portal (**www.climate.gov**) offering observed climate data; the Nature Conservancy offers climate information for the USA and world, available through a Climate Wizard (**www.climatewizard.org**); there are also regional providers of climate data and projections, such as the Climate Impacts Group at the University of Washington (**cses.washington.edu/cig/**) for the Pacific Northwest.
- **Global:** WorldClim (**www.worldclim.org**) is a set of global climate layers (grids) with spatial resolution of approximately 1 square kilometre for mapping, spatial modelling and use in GIS (Hijmans et al. 2005).

As a note of caution, while data portals often present an appealing interface and readily accessible data for download, the quality of the data and scenarios they provide can vary. If well-documented guidance is provided on the site, that is usually a good sign that the authors recognize the complexities of scenario selection and application, and the limitations of the data. Thus, before embarking on the sometimes resource-intensive activity of data and scenario extraction, it is strongly recommended first to consult general guidance documents such as those provided at the IPCC Data Distribution Centre.

The following sub-sections describe a number of issues to consider in identifying data, developing scenarios and presenting such information for use in assessments. They also provide supporting literature offering additional explanation and examples.

3.4.1 Qualitative information

Qualitative descriptions of past, present or future conditions can be very effective ways of conveying information to non-specialists and making quantitative data easier to understand. Moreover, narrative descriptions of possible future developments (storylines), by virtue of not specifying precise numbers, can be useful devices for framing the future that allow analysts some flexibility in interpreting future regional trends (Rounsevell and Metzger 2010). Through dialogue and negotiation, they can also allow for direct stakeholder participation and eventual buy-in to an agreed set of storylines (Alcamo 2001; see also Section 3.2.4.3 for a discussion of participatory scenario development).

3.4.2 Quantified variables and their sources

As climate change is the central focus of study, most assessments of climate change impacts and adaptation, especially those employing models, use climate data for a wide range of variables (near-surface air temperature, precipitation, solar radiation, wind speed and humidity are the most common). Data may also be required to describe those relevant attributes of a system or activity that are exposed to climate change, or that precondition human responses to climate change. Data may be physical (e.g. forest productivity, river flow, water quality or soil nutrient status), economic (e.g. income, or prices), social (e.g. population, employment, education) or technical (e.g. irrigation, forest equipment, building materials). Potential sources of data are highly case-specific.

Some data are observed or collected operationally, such as weather, streamflow, sea level and wave heights, population, economic activity. These are commonly available from national or international agencies and government statistical offices. They might also be collected especially for a study, in targeted experiments or surveys. Climate information from the past may have been inferred from proxy information such as historical accounts, tree rings or ice cores. Information on regional climate can also be simulated using climate models. Some climate information can also be derived from other climate variables (e.g. accumulated temperatures, evaporation, number of air frosts). Data are often reformatted to suit the needs of users, for example, by aggregating population data by regional units, or by interpolating observed climate data from weather stations to a regular spatial grid.

3.4.3 Characterizing future climate

In addition to assessing the characteristics of current climate, there is also likely to be interest in assessing how the climate might change in the future. This embodies additional uncertainties and requires an understanding of how the climate is projected to change in the future. Projections of future climate that are applied in such assessments are conventionally referred to as *climate scenarios*

CASE STUDY ***Using qualitative data to determine climate impacts in London***

The London Climate Change Partnership (LCCP) was established in 2001. Chaired by a high-profile businessman, the partnership comprises representatives from the central and local governments, utilities, transportation and public health agencies, emergency management, environmental consulting firms and UKCIP, among others. Its role is to collect information on the impacts of climate change on London, provide inputs into the development of the city's adaptation strategy, and generally ensure preparedness for climate change.

As part of the development of an adaptation strategy, 15 workshops were conducted between 2005 and 2006 to raise awareness of how climate change might affect their services. The workshops started by asking participants to identify the measures they use to judge the success of their work (numbers of people served, effective delivery of service, costs, etc.) and then used an interactive process to explore how climate changes in London might affect those measures. In this way significant qualitative information was gathered on the potential impacts of climate change on different services in London.

Source: Ligetti et al. (2007)

TABLE 3.4.1 **Selected methods of climate scenario development classified according to their resource needs and potential applications for adaptation planning** (based on tables in Wilby et al. 2009 and amended, with major additions in italics).

Level of resource needs	Methods	Spatial application and input requirements	Applications for adaptation planning
Limited	Sensitivity analysis	Local (site/area) (Observed climate data)	Resource management, sectoral
	Climate analogues		Communication, institutional, sectoral
	Trend extrapolation		New infrastructure (coastal)
Modest	"Delta" change	Regional (AOGCM and simpler global model outputs)	Most adaptation activities
	Pattern-scaling		Institutional, sectoral
	Stochastic weather generation		Resource management, retrofitting, behavioural
	Empirical/statistical downscaling		New infrastructure, resource management, behavioural
High	Dynamical down-scaling (RCM)	Regional-global (AOGCM outputs)	New infrastructure, resource management, behavioural, Communication
	Coupled AOGCMs	Regional-global	Communication, financial
	Probabilistic	*Global-regional-local (Multiple sources)*	*New infrastructure, resource management, communication*

(Mearns et al. 2001), which distinguishes them from climate predictions or forecasts, to which probabilities can be attached. However, this distinction is becoming blurred as climate scientists have moved towards expressing future climate in terms of conditional probabilities. A useful recent comparison of different methods of climate scenario development for use in climate risk assessments is provided by Wilby et al. (2009). Table 3.4.1 combines elements of that review into a summary of different scenario construction methods, their resource needs and potential applications.

The most credible and sophisticated tools for simulating the response of the Earth's climate to increasing emissions of greenhouse gases and aerosols are coupled atmosphere-ocean general circulation models (AOGCMs). There is agreement among all models that the planet will warm, globally, though the magnitude varies from model to model. There is less unanimity in the projected regional pattern of changes in other climate variables such as precipitation, radiation or wind speed, and the spatial resolution is quite coarse (grid box dimensions are seldom finer than 150 km). Since most impacts of climate change will be manifest locally, there have been great efforts to downscale AOGCM projections to a finer spatial resolution (Fowler et al. 2007), either using numerical models (Mearns et al. 2003; Rummukainen 2010) or statistical techniques (Wilby et al. 2004), and sometimes involving the use of stochastic weather generators (Wilks 2010). There have been several major research projects conducted to this end in Europe, such as. PRUDENCE (Christensen et al. 2007), and ENSEMBLES (van der Linden and

Mitchell 2009); in North America (e.g. NARCARP – Mearns et al. 2009), and globally, with a current focus on Africa (CORDEX – Giorgi et al. 2009).

An alternative method used to generate climate scenarios involves identifying spatial analogues (climates in other regions) or temporal analogues (climates from the past) that may resemble anticipated future conditions in a region (Ford et al. 2010). Other simple techniques involve adjusting present-day climate by fixed increments (e.g. warming in increments of 1°C; precipitation changes in increments of ±5%) to explore the sensitivity of exposure units to a changing climate (Carter et al. 1994), or applying simple extrapolation of past trends (Wilby et al. 2009).

Perhaps the most common technique for applying climate scenarios in climate risk assessments is the so-called "delta change" method, whereby

CASE STUDY *Use of GCMs to determine climate futures in New York and the Metropolitan East Coast region*

As part of the U.S. National Assessment of the Potential Consequences of Climate Variability and Change, an assessment of climate change and the Metropolitan East Coast (MEC) region – covering the 31 countries of the New York City metropolitan area and a total population of 19.6 million in the states of New York, New Jersey, and Connecticut – was undertaken. The goal was to understand the impacts of climate variability and change on the physical and human systems.

The assessment used five GCM scenarios: one based on current trends; two from the UK Hadley Centre and two from the Canadian Centre for Climate Modeling and Analysis, both of which consider greenhouse gases individually, and then a combination of greenhouse gases and sulphate aerosols that are emitted through industrial activities. Typically sulphate aerosols create a cooling effect by reflecting and scattering solar radiation, and thus they offset greenhouse gases to a certain extent. As a result, using these scenarios forecasts lower temperatures than scenarios that include only greenhouse gases. This gives a good estimate of the envelope of potential change.

Linear interpolation between GCM grid boxes meant that scenarios were obtained for several of the cities within the region. However, because the cities are relatively close, there is little variation between them, and so the study used the mid-point of the study region.

While each of the five future scenarios provide a distinct projection of precipitation change, it is important to note that the precipitation projections of the GCM scenarios do not agree either in magnitude or direction (as opposed to the projected temperature changes, which agree in direction, but not magnitude). The Hadley Centre's scenarios show increasing levels of precipitation, while the Canadian Centre projects decreasing precipitation over time.

Through the use of a range of plausible scenarios, the MEC assessment researchers are able to project possible impacts created by climate variability and change, and evaluate the MEC region's responses. An assessment exercise such as the MEC study is useful in enabling preparedness for extreme climate events in the present as well as readiness for a changing future climate.

Sources: Ligetti (2007) and Metropolitan East Coast Assessment (**metroeast_climate.ciesin.columbia.edu**)

TABLE 3.4.2 **Types of scenarios of future environmental and societal developments adopted for VIA assessments and examples of their application.**

Type of scenario	Examples of scenario development methods	Examples of scenario applications
Atmospheric composition	CO_2 concentration (IMAGE team 2001)	Impacts on ecosystems and agriculture (Schröter et al. 2005)
Sea-level	Guidance on sea-level scenario development (Nicholls et al. 2011)	Economic impacts on coastal systems in Europe (Richards and Nicholls 2009)
Socio-economic	Population (O'Neill, 2005)	Human health impacts in Europe (Watkiss et al. 2009)
Land-use	Land use scenarios for Europe (Audsley et al. 2006)	Vulnerability of agricultural land use and natural species (Berry et al. 2006)
Technology	Crop yield potential (Ewert et al. 2006)	Crop productivity and agricultural land use in Europe (Rounsevell et al. 2005)
Adaptation	Optimal crop management (Iglesias et al. 2009)	Crop productivity in Europe (Iglesias et al. 2009)

changes between modelled reference and future periods are appended as factors (or "deltas") to the climate observed during the reference period. This technique recognizes the common biases found in model representations of present-day climate (e.g. Fronzek and Carter 2007). Pattern-scaling is a method often applied in integrated assessment models (IAMs) for relating the regional patterns of changes in climate derived from individual AOGCM simulations to global mean annual temperature (which can be computed in simple climate models). The same pattern can then be scaled up or down according to the simple model's temperature projections for a wide range of emissions scenarios and future time periods (Mitchell 2003). Finally, as computer power has improved, multiple ensemble simulations with climate models have become feasible, allowing different model uncertainties to be explored and encouraging climate scientists to attach likelihoods to climate projections. The UKCP09 projections are probabilistic (Murphy et al. 2009), as are recent projections for Finland (Räisänen and Ruokolainen 2006), Australia and southern Africa (Moise and Hudson 2008) and Europe (e.g. Harris et al. 2010).

3.4.4 Characterizing other environmental and socio-economic futures

In parallel with future climate, it is also important to characterize future environmental and societal conditions that may influence vulnerability, impacts and risk management in general. Scenarios of these other factors have been categorized by Carter et al. (2007) and are summarized in Table 3.4.2 along with some examples of their application in VIA assessments. Many of the same issues as for climate, regarding data availability and temporal and spatial dimensions (e.g. van Vuuren et al. 2010), also apply to these scenarios.

3.4.5 Scenarios as integrating devices

The selection of common scenarios can be a useful device for imposing consistency and comparability across climate impact and adaptation assessments. During the past decade, most model projections of climate in the 21st century have been based on the set of six marker scenarios in the IPCC *Special Report on Emissions Scenarios* (Nakicenovic et al. 2000). The narrative storylines describing future worlds giving rise to the SRES emissions, and the demographic and economic assumptions that accompanied them, therefore offer a consistent framework for characterizing other environmental and socio-economic scenarios to be used alongside SRES-based climate projections. Several European assessments have developed scenarios using SRES as an integrating framework (e.g. Arnell et al. 2004; Carter et al. 2004; Holman et al. 2005; Rounsevell et al. 2006; Spangenberg et al. 2012). Other global scenario exercises matched to SRES emissions include those developed for the Millennium Ecosystem Assessment (Carpenter et al. 2005) and the United Nations Environment Programme's *Global Environment Outlook 4* (UNEP 2007).

A new generation of global scenarios (socio-economic, technological, land use and climate) was prepared by international research teams ahead of the IPCC's *Fifth Assessment Report* (Moss et al. 2010; van Vuuren et al. 2012). Climate projections are now available from the CMIP5 exercise (Taylor et al. 2012) based on four representative concentration pathways (RCPs). These correspond to four different levels of radiative forcing of the atmosphere by 2100 relative to pre-industrial levels, expressed in units of Wm^{-2}: RCP 8.5, 6.0, 4.5, and 2.6, representing unmitigated emissions (8.5) and progressively more aggressive mitigation targets (6.0, 4.5 and 2.6 – van Vuuren et al. 2012). These climate projections can be accessed on the IPCC Data Distribution Centre website (**www.ipcc-data.org**). ■

3.5 Behavioural analysis

Behavioural research uses a variety of methods – e.g. laboratory and field experiments, econometric analysis – to try to understand how people make decisions, and how those decisions vary according to contextual factors. The resulting insights can then help to explain decisions in other situation: for example, why people buy lottery tickets when their chances of winning are virtually nil.

In climate change adaptation, impact and vulnerability analysis, behaviour analysis can be used to explain how actors (organizations or individuals) make adaptation decisions – on the assumption that such knowledge is necessary to advance adaptation. For example, understanding the factors that shape household decisions on flood protection can help improve the design of flood risk communication strategies. It can also shed light on the limits to adaptation, leading to more realistic assumptions about autonomous adaptation in climate economics models and adaptation plans (Dow et al. 2013; Warren et al. 2012).

The top-level criteria for classifying behaviour analytical approaches are the theoretical assumptions they make about what drives individual behaviour. Cooke et al. (2009) distinguish between methods based on social psychology, and methods that assume rational actors and utility optimization. The former build on prominent approaches such as protection motivation theory, which explains actions in terms of individuals' perceptions of risks and capabilities. The latter draw on a wide-ranging literature in microeconomics and game theory. Table 3.5.1 summarizes these approaches, and they are discussed further below.

3.5.1 Social psychological

As briefly noted above, models based on social psychological theory explain behaviour through cognitive factors such as motivations for and barriers to action. Protection motivation theory, which has been applied to many adaptation situations, posits that actors take action based on four factors: the perceived severity of a threatening event, the perceived probability of the occurrence, the efficacy of the recommended preventive behaviour, and the perceived self-efficacy (Rogers 1983). In the domain of climate change adaptation, Grothmann and Patt (2005) examine farmers' adaptive behaviour in case studies in Germany and Zimbabwe, and find that protection motivation theory better explains the adaptive actions taken than traditional microeconomic models of decision-making.

3.5.2 *Utility maximization and bounded rationality*

Maximization models are based on the assumption of rational individuals maximizing utility. This

TABLE 3.5.1 **Overview of behavioural analysis methods.**

	Social psychology	Rational choice	
Method	**Protection motivation theory**	**Utility maximization**	**Bounded rationality**
Theoretical assumptions	Individuals take action based on their perception of risks and the perceived effectiveness of acting to reduce risks.	Individuals take action to maximize utility, and have complete information and the required analytical abilities.	Individuals take action to maximize utility, but have limited information and/or limited cognitive abilities.
Steps taken	1. Select explanatory factors based on literature 2. Identify actors and decisions	1. Select actors and constraints 2. Specify decision rule for actor	
Results achieved	Model explaining adaptive actions. Prediction of actions in different situations.	Prediction of actions. Consequences of predicted actions.	
Example cases	Grothmann and Patt (2005) examine the role of climate information in adaptation decision-making through two local-level case studies, in Germany and Zimbabwe. They conduct interviews and focus groups with farmers who have access to climate forecasts to understand the role of seasonal forecasts in crop-planting decisions. They find that actors' perception of their ability to act effectively to address a risk or threat is an important determinant of the action taken. Berkhout et al. (2006) examine how organizations adapt to current and projected future climate change. Drawing on models of organizational learning, they conduct interviews and focus groups with nine companies in the housing and water sectors in the UK to determine how, or whether, they have reacted to climate impacts or climate information. They find similarities to adaptations to regulatory or technological changes, but also differences due to the longer timescales of feedback to climate adaptation decisions. Businesses are reluctant to act due to uncertainties in the climate information and doubts about the benefits of taking action.	Rounsevell et al. (2003) apply a linear programming model to examine how crop rotations vary between locations. The model inputs costs and benefits of crop types and time constraints. The results predict how farmers would rotate crops in different locations if seeking to maximize profit.	Botzen and van der Bergh (2009) use bounded rationality assumptions to estimate risk premiums under different climate change scenarios for the Netherlands. They find estimation results suggest that a profitable flood insurance market could be feasible.
Issues involved	Difficult to observe cognitive barriers; studies often rely on stated intentions rather than observed behaviour.	Assumptions may not be realistic.	Assumptions may not be realistic.

is a vast literature, going back to the foundations of modern economic thought and utilitarianism (e.g. Mill 1863). It is beyond the scope of this guidance to comprehensively discuss developments in this field, but we can briefly discuss key issues relevant to the application of this approach to adaptation. Behaviour is typically predicted under the conditions of independent decisions, in which individuals are assumed to be rational, perfect maximizers: that they have complete information and are able to calculate outcomes for all contingencies, and optimize utility. This is referred to as maximization (Cooke et al. 2009).

While utility optimization approaches are used widely, they has been criticized for making unrealistic assumptions. Knowledge is often not freely available, and the limitations of human cognitive capacities are well-documented (van den Bergh and Gowdy 2000). Further, well-known cognitive biases exist. Bounded rationality relaxes the assumptions of utility optimization, and aims to predict behaviour based on, for example, heuristics or rules of thumb, which are simple rules that achieve an approximately optimal outcome (Kahneman et al. 1982). Bounded rationality suggests that people engage in a mental search of available options, and choose the first one that is satisfactory (Simon 1956). This so-called "satisficing" is different from optimizing in that instead of comparing all possible choices to achieve the optimal outcome, a choice is made among a narrower set of options that meet minimum criteria. Satisficing reduces the costs of collecting and processing information. Closely linked to bounded rationality is the concept of adaptive heuristics: people develop and use mental shortcuts to identify acceptable options quickly, with a minimal amount of necessary information (Payne et al. 1993).

3.6 Institutional analysis

Assessments of vulnerability, impacts and adaptation will often seek to understand the institutional context, including political, social and economic factors that structure individual choices. Such methods are broadly categorized as institutional analysis (Hinkel and Bisaro 2013a). Several approaches are described below; criteria for selecting a given method are given in Section 2.1.3.4.

3.6.1 Governance description

Governance description approaches describe the actors and institutions relevant for adaptation. These types of analyses have been done all around the world in the context of climate change. For example, Tol et al. (2008) review the institutional context for adaptation in coastal zone management in Europe, and identify three levels of decision-making: national governments, local governments and private individuals. They find that national level decisions are partly determined by EU policies, e.g. the Coastal Bathing Water Directive, the Water Framework Directive and the Habitat Directive. This type of approach requires no strong theoretical assumptions on the part of the analyst, and contributes to adaptation by providing a more comprehensive description of the policy context in which adaptation takes place.

3.6.2 Governance design

Governance design addresses the question of how to design effective institutions, on the theoretical assumption that the link between institutions and outcomes can be understood and predicted with some confidence. One particular kind of governance design approach that has been applied extensively in the adaptation literature is policy analysis. Policy analysis seeks to determine "which of various alternative policies will achieve a given set of goals in light of the relations between the policies and the goals" (Nagel 1999). It is applied ex-ante to improve the design of policies, programmes or projects.

An expanding body of literature has employed policy analysis to analyse mainstreaming of adaptation into policies. Because adaptation occurs in all sectors and at all levels of social organization, the goal of adaptation policy is generally to ensure that existing policies address relevant climate risks and to increase the capacity of individuals and societies to respond to these risks. In this sense, adaptation is not a stand-alone policy domain, but rather the task to integrate, or *mainstream*, the consideration of climate change risks into existing sectoral policies. The recommendations of high-level adaptation policy documents, such as the EU White Paper on Adaptation (European Commission 2009), are illustrative, as they focus on the need to increase the consideration of climate risks across all sectors.

One focus of mainstreaming studies has been development policy (e.g. Gupta 2009; McGray et al. 2007). Mainstreaming has been carried out through portfolio screening in order to identify climate risks which might conflict with development policy goals. For example, Sietz et al. (2011) report on the proportion donor investments in Mozambique made in climate sectors, while Dasgupta and Baschieri (2010) identify which goals in the national poverty-reduction strategy are threatened by climate impacts in Ghana. Klein et al. (2007) screen the project portfolios of six development agency donors to identify the extent to which climate hazards are considered. These studies address the question of whether existing policies are at risk due to climate hazards.

On the other hand, if climate is already being considered, the critical task is "climate-proofing" the policy in question. "Proofing" policies involves addressing relevant risks early in the policy formulation process, to identify any obvious effects on other sectors or objectives. The practice of proofing policies is well-established in other sectors, such as health, and rural development (Urwin and Jordan 2008). In the case of climate adaptation, this activity is in its infancy, though several tools have been developed to support this process. For example, GIZ, the German development agency, has developed a tool for climate-proofing development plans (Fröde et al. 2013; Hahn and Fröde 2011); Norad has published a short practical guide (Ibrekk 2010), and the Asian Development Bank published case studies for its members in the Pacific (ADB 2005). CARE's *Toolkit for Integrating Climate Change Adaptation into Projects* also provides relevant advice (CARE International 2010b).

3.6.3 Governance emergence

Within those methods which aim at understanding and explaining governance emergence, a distinction is made between those approaches that assume that it is possible to generalize beyond a single case, and those that do not. Several anthropological and ethnographic approaches assume that this is theoretically not feasible.

For example, Mosse (2006), in a case study of water management institutions in southern India, finds that collective action is correlated with the presence of ceremony and rituals surrounding village water tanks. He argues that the causal mechanism behind this relationship can only be explained by understanding the meaning and symbolism of local institutions, which requires in-depth anthropological methods. Such an understanding of causal relationships is not generalizable beyond the case study, because it depends on location and historically specific processes. Based on these findings, Mosse criticizes the social capital approach (e.g. Putnam 1994), which relates quantitative measures of institutions, e.g. the number of associations in a study unit, to levels of collective action.

Although such a relationship may hold in a particular case – in fact, it would in the villages Mosse has studied – generalizing to other cases without understanding the causal processes may lead to flawed interventions and maladaptation. Results from these approaches can thus only inform adaptation policy development for the particular case analysed.

On the other hand, approaches from new institutional economics, which have made significant and extensive contributions to the natural resource and water management literature (e.g. Hagedorn et al. 2002; Bougherara et al. 2009), and frameworks for institutional analysis (Ostrom 2005) and analysis of the governance of socio-ecological systems (Folke et al. 2005; Ostrom 2007; 2009) assume that insights can be generalized beyond single case studies on a higher level of abstraction. These approaches face the general challenge that the ratio between the number of relevant variables and the number of cases is often too high to derive statistically significant results. Nonetheless, with these limitations in mind, carefully constructed studies comparing a large number of similar cases have produced an accumulation of evidence leading to conclusions about general characteristics of social-ecological systems that can be related to desirable outcomes.

Examples of such generalized insights are the "8 design principles for sustainable resource management" (Ostrom et al. 1999), "principles of adaptive governance" (Dietz et al. 2003), or "institutional prescriptions for adaptive water governance" (Huitema et al. 2009). These principles are, however, intentionally left very abstract and are thus difficult to make operational and verify empirically across differing contexts. In relation to adaptation, these prescriptions provide input regarding institutional attributes that enhance the adaptive capacity of actors faced with climate risks. These general prescriptions need to be supplemented by contextual knowledge when implementing adaptation interventions. The fact that the prescriptions remain general and require contextualization differentiates the approach from that of policy design, which assumes that outcomes can be predicted ex ante. ■

TABLE 3.6.1 **Institutional analysis methods.**

Method type	Governance description	Governance emergence		Governance design	
		Understanding case	Generalizing design principles	Policy screening	Policy proofing
Task	Identifying the relevant actors and institutions for adaptation	Explaining the emergence of governance systems which enables adaptation		Identifying policies that ensure goals are not negatively affected by climate change impacts	
Adaptation situation	Vulnerability impacts and adaptation are a result of many actors interacting and making interrelated decisions			Climate change risks to policy goals are not known	Climate change risks to policy goals are known
Theoretical assumptions	None	Attributing an outcome to an institution is only possible on a case by case basis.	It is difficult to attribute outcomes to a particular institution.	There is a direct predictable relationship between policies and outcomes.	

TABLE 3.6.1 ***continued***

Method type	Governance description	Governance emergence		Governance design	
		Understanding case	Generalizing design principles	Policy screening	Policy proofing
Steps taken	1. Identify actors and institutions	1. Select potential explanatory variables based on literature 2. Collect data 3. Apply cause-effect reasoning		1. Identify relevant institutions and actors 2. Analyse documents and interview actors on policy development 3. Analyse impacts of climate change on policy goals	
Results	Description of institutions and actors relevant for adaptation	Recommendations on a case by case basis	Design principles to be contextualized in a given case	Identified climate risks and opportunities for policy goals	Identified opportunities for improved policy
Example cases	Tol et al. (2008) review the institutional context for adaptation in coastal zone management in Europe. They identify three levels of decision-making: national governments, local governments and private individuals. The EU regulates certain areas through the Coastal Bathing Water Directive and nature, through the Habitat Directive. National governments are at different states of awareness regarding coastal management, different states of urgency.	Pelling et al. (2008) address the question of which social and institutional factors have led to the emergence of informal networks in public organizations. Active informal networks are assumed to be beneficial for adaptation. They look at integrated environmental policy making across different sectors in Wales. They find evidence for factors which have promoted the emergence of the shadow network, such as the promotion of the "Team Wales" identity, and the tendency for long careers with little out migration fostering long-term relationships.	Ostrom et al. (1999) address the question of which variables lead to the self-organization of communities for the management of natural resources. A framework taking an action situation as the unit of analysis describes the governance system in order to synthesize lessons from a large number of cases. Eight design principles are found to promote self-organization.	Klein et al. (2007) develop a method for mainstreaming climate adaptation concerns into development organizations. The study conducted interviews and examined project documents for several prominent aid organizations, considering the extent to which climate change has been taken into account in the policy and project planning stages.	Dasgupta and Baschieri (2010) analyse poverty reduction strategies and climate impacts on the rural poor in Ghana. They find that rural poverty reduction strategies do not account for climate impacts, and focus on money-metric indicators of poverty. They find that mainstreaming climate change into development strategies, which would mean including broader indicators of poverty, is necessary to protect poverty reduction goals.

3.7 Formal decision-making

This section describes and discusses formal decision-making methods. The first three, cost-benefit analysis, cost-effectiveness analysis and multi-criteria analysis, are summarized in Table 3.7.1 and discussed further below. Decision trees for selecting the appropriate methods are presented in Section 2.3.3.

3.7.1 Cost-benefit analysis

Cost-benefit analysis evaluates options in terms of monetary value, weighing the costs of option against the expected benefits. In general, the option with the highest net benefits or the highest cost-benefit ratio is selected from a set of options. Examples of the use of this approach in adaptation studies include Agrawala et al. (2008) with regard to sea-level rise; Callaway et al. (2007) with regard to freshwater systems; and Tubiello and Rosenzweig (2008) with regard to agriculture. One issue is that cost-benefit analysis in its conventional form does not address distributional issues associated with a given option. Costs and benefits accruing to different actors are generally aggregated, and the issue of winners and losers is addressed separately.

Cost-benefit analysis requires the setting of a baseline against which to measure future benefits of an option. Adaptation baselines should be calculated from impacts without the adaptation measure. This is particularly challenging for adaptation because developing baselines must be tailored to the location, sector and hazard, and therefore encompass understanding and predicting adaptation behaviour or "autonomous adaptation". Developing baselines for adaptation is more complex than for

TABLE. 3.7.1 **Three formal decision-making methods.**

Method	Cost-benefit analysis	Cost-effectiveness analysis	Multi-criteria analysis
	One metric by which the alternatives can be characterized in terms of their costs and outcomes	One metric by which the alternatives can be characterized in terms of their costs and a different metric by which alternative can be characterized in terms of their benefits (i.e., outcomes).	Several metrics by which the alternatives can be characterized in terms of their costs and benefits.
Steps taken	1. Identify a set of options. 2. Choose a baseline against which the benefits and costs will be measured. 3. Calculate present value of cost (PVC) and present value of benefits (PVB) for each. 4. Decision rule: chose alternative with the highest net-benefits or benefit cost ratio.	1. Choose a metric for effectiveness E (e.g. cost, low impacts). 2. Choose a baseline against which the effects will be measured. 3. Choose a set of alternatives that may be applied to reach the target. 4. For each alternative I, calculate cost-effectiveness ratio (CER): CERi = Ei/Ci. 5. Decision rule: choose alternative i* with the highest CER*.	1. Identify a set of options. 2. Identify multiple criteria and a weights for each criteria. 3. Associate a value for each criteria to each alternative. This steps yields a matrix. 4. Compute the weighted sum (called score) for each alternative. 5. Decision rule: choose the alternative with the highest score.
Results	A ranking of options		
Issues involved	A standard cost-benefit analysis cannot deal with the indirect benefits. A general equilibrium modelling approach would be needed. Does not consider distributional effects of options. Outcomes are highly dependent on discount rates.	An additional metric for outcomes (beside money) is necessary for cost-effectiveness analysis. This can be difficult to identify for adaptation.	

mitigation, where more well-established relationships between carbon emissions and macro-economic variables such as GDP or energy intensity can be used to establish baselines.

3.7.2 Cost-effectiveness analysis

Cost-effectiveness analysis aims to find the most economically efficient way to achieve a specific outcome – for example, which of several options best protects coastal ecosystems from sea-level rise at the lowest cost. It can only be used to compare options in relation to a single outcome; thus, it is generally not possible to compare adaptation strategies that affect different sectors, because it is very difficult to find a common outcome attribute across sectors. In contrast, mitigation measures can be easily compared across sectors, in terms of tonnes of carbon dioxide equivalent (CO_2e) avoided per unit of cost. The benefits of adaptation measures, however, are quite different depending on the climate risk at hand and the setting: It is very difficult to compare, for example, the relative cost-effectiveness of investing in sea-walls to reduce coastal flooding vs. air conditioning to protect from extreme heat (Zhu and van Ierland 2010). See Watkiss and Hunt (2011) for an extensive discussion of these issues.

Within sectors, it may be easier to compare adaptation options. For example, Kouwenhoven and Cheatham (2006) assess the cost-effectiveness of different ways to protect the freshwater supplies of Pacific Island nations affected by climate change. Based on financial records and interviews with project teams, they calculate the cost of implemented options, and alternatives, and evaluate the options on the basis of how much additional water harvesting potential they provide. They find that for three different communities, rainwater harvesting is the most cost-effective option for providing greater access to freshwater. Other options such as improving water main infrastructure are more expensive per unit delivered.

Mendes Luz et al. (2011) address the cost-effectiveness of options to reduce the transmission/incidence of dengue fever. They develop a dynamic model of dengue transmission that includes the effects of the development of human immunity and insecticide immunity to test the effectiveness in terms of DALYs (disability-adjusted life years) of 43 different strategies to reduce dengue incidence, including both larval targeted and adult targeted strategies. They find that all interventions lead to the emergence of insecticide resistance, which will increase the magnitude of future dengue epidemics when combined with the loss of community immunity. The model shows that adult-targeted strategies are more cost-effective than larvae-targeted strategies.

An important consideration is that cost-effectiveness analysis is only a relative measure of a set of options in relation to a previously defined outcome – it does not provide an absolute measure of costs and benefits to ensure that an option is "worth doing", as a cost-benefit analysis would. As with cost-benefit analysis, a baseline must be set against which to compare outcomes; see the remarks in the previous section.

3.7.3 Multi-criteria analysis

Multi-criteria analysis uses several metrics to characterize adaptation options in terms of their relative costs and benefits. It is appropriate when it is difficult to assign a monetary value to more than one of the outcomes of an adaptation measure. As with cost-benefit and cost-effectiveness analysis, a baseline must be set, with the concerns discussed above.

An example of the use of multi-criteria analysis in adaptation is the National Adaptation Plan of Action for Lesotho (LMS 2007), which identifies and ranks nine potential adaptation projects on the basis of criteria developed with a group of stakeholders including national-level ministries, NGOs, and local government. The options are ranked on the criteria of: i) impact on the economic growth rate of vulnerable communities; ii) impact on poverty reduction; iii) multi-lateral environmental agreement synergies; iv) employment creation; and vi) prospects for sustainability.

Miller and Belton (2011) evaluate policy options to improve water management faced with climate impacts in Yemen. They rank the options according to six criteria: public financing needs, implementation barriers, environment, social, economic, and political-institutional. A sensitivity analysis was also conducted in order to investigate how changes in weighting of criteria affected the ranking of options. They find that combining several options to provide incentives for water use efficiency, and to promote technology uptake into a portfolio, is the preferred option.

3.7.4 Robust decision-making

Uncertainty about the mid- to long-term impacts of climate change (and non-climatic conditions) will continue to make it difficult to construct probability density functions for impacts (Adger et al. 2009). Due to this uncertainty in climate models at the scales needed for adaptation decisions, optimal adaptation decision-making should be abandoned in favour of robust decision-making when considering the mid- and long term.

Robust decision-making entails running a large amount of scenarios and analysing different options over these scenarios on a given set of criteria. It does not require probabilities to be attached to the different scenarios. This way options can be eliminated which do not perform well in projected futures, even when the likelihoods of future evolutions are not well known.

In some cases model-based approaches have also been used to identify robust adaptation options, and these approaches are also applicable to other contexts. Lempert and Groves (2010) used the robust decision-making process in conjunction with the Inland Empire Utilities Agency (IEUA) in California to determine appropriate adaptation options for the water management agency. This approach is designed for use in a context of uncertainty, as is the case with climate change. It uses simulation models to assess the performance of agency plans over thousands of plausible futures, using statistical "scenario discovery" algorithms to concisely summarize those futures where the plans fail to perform adequately, and use these resulting scenarios to help decision makers understand the vulnerabilities of their plans and assess the options for ameliorating these vulnerabilities. For IEUA, the analysis suggests the agency's current plan could perform poorly and lead to high shortage and water provisioning costs under conditions of: (1) large declines in precipitation, (2) larger-than-expected impacts of climate change on the availability of imported supplies, and (3) reductions in percolation of precipitation into the region's groundwater basin. Including adaptivity in the current plan eliminates 72% of the high-cost outcomes. One promising robust adaptive strategy is to accelerate efforts to expand one of the agency's groundwater banking programs and implement its recycling program, while monitoring the region's supply and demand balance and making additional investments in efficiency and storm-water capture if shortages are projected; that approach eliminates more than 80% of the initially identified high-cost outcomes.

Robust decision-making thus can be, and generally is, combined with cost-benefit, cost-effectiveness or multi-criteria analysis. For example, Wilby and Dessai (2010) apply robust decision-making to help rank adaptation options in the water sector in Wales and England. The method identifies options that address policy goals in the current climate, then tests the sensitivity of the outcomes of these options across a large number of future scenarios. Cost-benefit analysis is used to identify options for which the benefits exceed costs across a wide range of scenarios of future impacts of climate change; these are robust options. Those measures that have a negative benefit-cost ratio for some projected future climate are not considered robust. The authors find that measures that are flexible and permit updating according to future conditions are more likely to be robust to future climate changes, though there may be other robust options that are not flexible.

3.7.5 Multiple-shot robust appraisal

A further challenge for adaptation decision-making arises in terms of estimating the value of waiting for more information before making a decision. This is particularly the case when the set of options includes options with long investment horizons, or when a decision is considering adaptation to mid- to long-term hazards, and when the options considered are flexible.

An option is *flexible* if it allows to switch to other options that might be preferable in the future once more is known about the changing climate. If one or more options are flexible over the lifetime of the decision, then the analyst can incorporate this into the appraisal of options, and the criterion of flexibility of options becomes important. More knowledge may become available through direct observations and improved scientific knowledge. For example, the analyst may know that a study on the impacts of sea-level rise in the region will be completed in two years. The consideration of options for coastal defence should include the expectation that improved probabilistic knowledge will become available.

When at least one option is flexible, a set of approaches uses the criterion of flexibility to decide between alternative strategies. Flexible options are favoured over non-flexible ones, and decisions are delayed to keep future options open (Hallegatte 2009). The adaptation pathways approach implements the criterion of flexibility by characterizing alternative strategies in terms of two attributes: i) adaptation tipping points, which are points beyond which strategies are no longer effective (Kwadijk et al. 2010), and ii) what alternative strategies are available once a tipping point has been reached (Haasnoot et al. 2012). Importantly, the exact time when a tipping point is reached does not matter – it is rather the flexibility of having alternatives available that drives the decision. Prominent applications of this approach include the Thames Estuary 2100 Plan (Lowe et al. 2009; Penning-Rowsell et al. 2013), the Dutch Delta Programme (Kabat et al. 2009) and the New York City Panel on Climate Change (Rosenzweig et al. 2011).

3.7.6 Adaptive management

Another method for decision-making under uncertainty is adaptive management. Adaptive management allows for the updating of actions on the basis of new information as it becomes available. In this sense, adaptive management is an ex-post evaluation of options based on the preferences of the decision-maker. Adaptive management requires the availability of new information on the effectiveness of an adaptation action, and therefore is closely related to monitoring and evaluating, and to learning (Armitage et al. 2008).

In the case of some options, this is straightforward. For example, an insurer setting premiums for flood insurance in a coastal zone can gather information on damages and adjust premiums accordingly. For other options, however, such as protective infrastructure, adjustments at a later stage – e.g. raising the level of a dike – are much more expensive. ■

3.8 Valuation methods

Valuation refers to computing a monetary value on the basis of non-monetary outcome attributes of an option. Valuation is necessary in situations in which monetary values of outcomes are considered important. Monetary aspects are particularly important in situations in which formal decision-making methods are applied, and thus valuation methods are frequently used as part of formal decision appraisal (Section 2.3). Valuation methods are also important in impact analysis, in order to identify adaptation needs (Section 2.1).

Various issues can complicate the process of assigning monetary values. Some of those issues are discussed below, and different valuation methods to address them are described. The methods are summarized in Table 3.8.1, and further examples are given.

The point of departure for valuation is those goods that people buy and sell on the market, such as bread, butter or bicycles. Their value can be established by observing the average prices that people pay for them. As prices change over time, a base year can be established, and a correction can be made for inflation of values obtained in the past or estimated for the future. From the simple case, there are several characteristics of outcomes that can make it more difficult to assign monetary values.

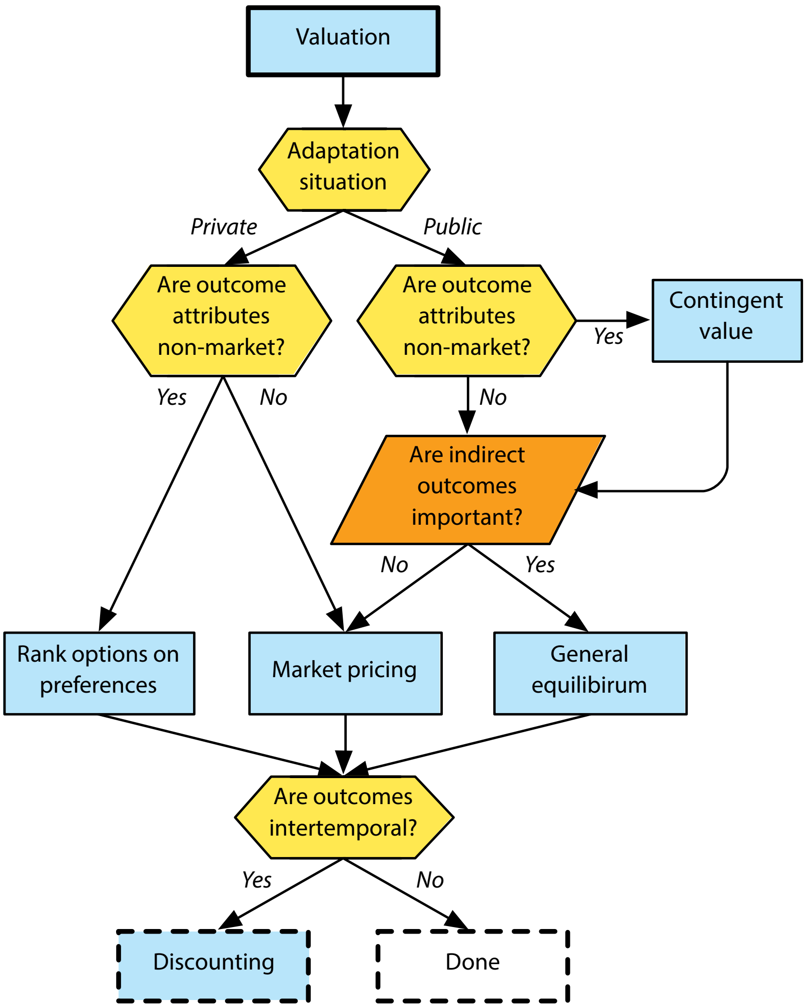

FIGURE 3.8.1 **Choosing methods for valuation.**

For outcomes that are traded on markets, valuation is straightforward, as prices exist for the attribute in question. For example, assigning a monetary value to the benefits of planting a drought-resistant wheat may be straightforward because the market price for wheat is well known and relatively stable. For other outcome attributes, such as the area of wetland conserved by a change in land use, it may be more difficult to assign monetary values.

TABLE 3.8.1 **Methods to assign a monetary value to the outcomes of adaptation options.**

Sub-types	Non-market outcomes	Indirect outcomes	Inter-temporal outcomes	Uncertain outcomes
Character-istics of adaptation situation	Assigning a monetary value to the costs and benefits of an adaptation option is considered important for decision-making. A common metric, e.g. money, can be applied across a range of outcomes and implications of a particular choice. Prices change over time; therefore it is appropriate to specify a base year for valuation, correcting for inflation.			
	Outcomes are to be valued by looking at the average prices that people are willing to pay for them.	The outcomes of a choice are large-scale and cause significant indirect effects.	The value placed on outcomes is a function of time (e.g. action today will benefit a future generation).	The value placed on outcomes is a function of how certain the outcomes are, the utility function can be esti-mated, and the probabil-ity of outcomes is known.
Results	A value is assigned to each outcome via a common metric.			
Example cases	Van Butsic and Valetta (2011) apply a hedonic framework to estimate the value of climate change impacts by estimating their impact on real estate prices near ski resorts in the western United States and Canada. They use data on individual home sales in four locations, combined with weather data and characteristics of nearby ski resorts, to estimate effects of snow-fall changes on housing values. Arrow et al. (1993) develop a set of guide-lines for applying contingent value to envi-ronmental and natural resources. Hamilton et al. (2005) apply the travel cost method to develop a model to estimate the impacts of climate change on international tourism flows.	Robinson et al. (2011; 2012) run a multi-sectoral regionalized dynamic computable general equilibrium model of Ethiopia with a system of country-specific hydrology, crop, road and hydropower engineering models to simulate the economic impacts of climate change towards 2050. They find that without externally funded adaptation investments Ethiopia's GDP in the 2040s will be up to 10 percent below the counterfac-tual no-climate change baseline.	Stern (2006) uses dis-count rates to calculate the net present value of climate change mitiga-tion policies.	Yohe et al. (2011) address the question of valuing adaptation options to the stochastic events related to sea-level rise in the coastal zone. They find that increases in decision-makers' aversion to risk increase the economic value of adaptations that reduce expected damages and diminish the variance of their inter-annual variability. For engi-neering and other adaptations that require large up-front costs and ongoing operational cost, increases in risk aversion increase the value of adaptation and therefore make implementation of these options economi-cally efficient at an earlier date.

continued

TABLE 3.8.1 ***continued***

Sub-types	Non-market outcomes	Indirect outcomes	Inter-temporal outcomes	Uncertain outcomes
Issues involved	The travel cost method is challenged by the fact that important costs of a trip may be unobservable. On the other hand, multi-purpose trips may cause the method to over value an environmental resource. Contingent valuation has been found to be highly dependent on question framing, e.g. "willingness to accept" surveys produce higher values for resources than "willingness to pay" surveys.		Behavioural research shows that most individuals do not apply an exponential model to their own decisions, but rather a hyperbolic model, in which the difference in value between an event occurring now and one occurring a year into the future is much greater than the difference in value between an event occurring one year into the future and occurring two years into the future.	

DECISION NODE: Public or private decision?

The first relevant decision node is whether options considered for valuation are related to a public or private actor's decision. Valuation methods relevant for public and private actors differ in two aspects. First, public actors must consider social welfare and, therefore, the preferences of other actors. When non-market outcomes are involved in a decision – e.g. clean air, good health, or nature preservation – public actors may have to find out the preferences of other actors regarding those non-market outcomes. Methods which compute monetary values for non-market outcomes thus enable a public actor to discover preferences over different outcomes. For example, the public actor may use contingent value methods to gauge the value that private actors assign to the enjoyment of preserved wetlands for recreation. Private actors, on the other hand, know their own preferences, consciously or otherwise, and therefore need not apply non-market valuation methods. Second, public actors are usually also interested in indirect outcome attributes such as the longer-term and cross-sectoral macroeconomic effects of outcomes, which are generally not relevant for private actors. For private actors, the relevant valuation tasks are for outcomes far in the future (discounting), or uncertain (probabilistic) outcomes.

DECISION NODE: Are outcomes non-market?

The next decision node, for both public and private actors, is whether valuation methods should be applied to outcomes that are not traded in markets. There are a number of methods to estimate the value of such outcomes relative to goods traded on market. These include hedonic pricing, contingent valuation, and the travel cost method (see Patt et al. 2011). An example of hedonic pricing would be to examine the extent to which prices of housing located near a natural wetland differ from similarly situated houses that are not near the wetland; from this, it is possible to impute a value for the landscape quality derived from the wetland. Similarly, Van Butsic and Valetta (2011) apply a hedonic framework to estimate the value of climate change impacts by estimating their impact on real estate prices near ski resorts in the western United States and Canada. They use data on individual home sales in four locations, combined with weather data and characteristics of nearby ski resorts, to estimate effects of snowfall changes on housing values.

An example of contingent valuation would be to ask people how much they would be willing to pay to preserve a wetland; from this it is possible to impute a value to the wetlands' existence. Arrow et al. (1993) develop a set of guidelines for applying contingent value to environmental and natural resources. An example of the travel cost method would be to survey visitors to a national park about where they came from and how much they are willing to pay for visiting the park and the calculating the value of the park as the consumer surplus (Patt et al. 2011). Hamilton et al. (2005), meanwhile, apply the travel cost method to develop a model estimate the impacts of climate change on international tourism flows.

If non-market outcomes are of interest, public actors may apply any of these methods (see Section 3.4.1). For private actors, non-market outcomes can be ranked according to their own preferences; no elicitation of preferences is necessary.

DECISION NODE: Are indirect outcomes important?

For public actors, the subsequent decision node to be addressed is whether the indirect outcomes of an adaptation option are important. This is relevant only for public decision-makers, as in considering social welfare, indirect outcomes can often have a significant effect. For private actors, it is unlikely that indirect outcomes will be of a magnitude to affect their own private interest. However, indirect outcomes may be produced at more aggregated levels of society, such as through cross-sectoral spillover effects. For example, a particular option may result in a segment of the population having more disposable income. If these individuals save that money, there may be no indirect effects – but if they spend it on goods and services, this will create indirect effects throughout the economy, increasing others' incomes, and possibly changing the relative prices of goods, and the output in different sectors. There are various methods for calculating the extent of these ripple effects. The simplest takes an empirically derived multiplier. A multiplier of 3, for example, would mean that for every euro in direct benefits, the society as a whole will experience €2 additional in indirect benefits, through the increase in consumption (Patt et al. 2011). A more involved method involves modelling the economy as a whole through, e.g., general equilibrium or input-output models. These partial or general equilibrium models allow one to estimate consumption levels, and hence total value, in the new equilibrium (Patt et al. 2011).

Robinson et al. (2011; 2012) run a multi-sectoral regionalized dynamic computable general equilibrium model of Ethiopia with a system of country-specific hydrology, crop, road and hydropower engineering models to simulate the economic impacts of climate change towards 2050. They find that without externally funded adaptation investments Ethiopia's GDP in the 2040s will be up to 10% below the counterfactual no-climate change baseline.

DECISION NODE: Are outcomes inter-temporal?

Finally, the analyst must consider whether the outcomes of interest are inter-temporal. This is a complication that often arises, as formal decision-making frequently requires comparing costs and benefits obtained at different points in time. Economists typically use a discounting function to decrease the importance of costs or benefits occurring farther in the future; for example, Stern (2006) uses discount rates to calculate the net present value of climate change mitigation policies. Discount rates relate future monetary values to the present, corresponding to the empirical reality that actors prefer current consumption to future consumption. Discount rates arise for two reasons. First, there is a macroeconomic basis to discount rates, whereby economic growth and inflation rates mean that the real purchasing power of a unit of wealth decreases over time. Second, there is a moral (or social) element of discount rates when seen from an intergenerational perspective, whereby the discount rate represents the preference of consumption of this generation over consumption of future generations.

The discount rate used can be extremely important in choosing options, especially when the time horizon of an option is long. A $1 million benefit that occurs 10 years from now, for example, is worth $737,000 today with a 3% discount rate; a benefit in 20 years is worth $544,000, and a benefit in 50 years is worth $218,000. This simple example demonstrates that a reasonable discount rate in market terms may provide limited support for investing in benefits that occur beyond one or two decades. Therefore both market and social aspects of discount rates should be considered.

DECISION NODE: Is there uncertainty about outcomes?

In cases where there is uncertainty about outcomes, further complications arise. The analyst may consider whether there is probabilistic information on potential outcomes. If outcomes can be represented through a probability density function, then an option can be assigned a value according to the expected outcome. However, uncertainty in outcomes raises a further issue, as both economic theory and empirical evidence indicate that people generally have preferences on uncertainty. Therefore valuation can be applied to the uncertainty in outcomes. In other words, a relevant question to consider is: How much more would people pay for an outcome that is certain than they would for an uncertain outcome, but with the same expected value? In order to address this, it is necessary to estimate a utility function for an individual respect to the outcome. In general, the utility function is shaped by diminishing marginal utility, which reflects the principle that past a certain threshold, increasing quantities of the same good bring little additional utility. Because of this the expected utility of an option will differ from the expected outcome, as outcomes which are at the tail end of an expected outcome distribution contribute little to expected utility. This is another way of saying that people are generally risk-averse, and in general prefer a certain outcome to an uncertain outcome with an equal expected value.

For example, Yohe et al. (2011) address the question of valuing adaptation options to the stochastic events related to sea-level rise in the coastal zone. They find that increases in decision-makers' aversion to risk increase the economic value of adaptations that reduce expected damages and diminish the variance of their inter-annual variability. For engineering and other adaptations that require large up-front costs and ongoing operational cost, increases in risk aversion increase the value of adaptation and therefore make implementation of these options economically efficient at an earlier date.

For a public actor, the utility functions of affected actors must be aggregated into a social welfare function. These considerations apply to situations in which outcomes can be represented probabilistically. When future outcomes cannot be represented probabilistically, valuation methods are not applicable.

While the tasks and methods discussed in this section have been applied extensively, it is important to note that they have also been subjected to substantial criticisms. The valuation tasks and methods described in this subsection are largely based on the neoclassical economics approaches of welfare economics. Criticism of these approaches has focused on the unrealistic assumptions made about actor's choice processes in order to support valuation methods. Critics point to well-documented cognitive biases in individual decision-making, so that framing effects may influence valuation (Kahneman et al. 1982). Others have criticized valuation methods for enabling trade-offs to be made between outcomes should be seen as incommensurable. There are, for example, arguments to be made against the valuation of species extinction or human suffering (Vatn 2005). In this sense, applying valuation may encompass a strong normative component, and the analyst should be aware of these issues when deciding whether to apply valuation methods.

Stockholm Hammarby wetland © Flickr/La Citta Vita

3.9 Tools for adaptation planning and implementation

Identifying adaptation needs and finding ways to address them are challenging tasks, but with the support of experts, international organizations and NGOs, many countries, regions and communities have successfully completed them. There are countless examples, from studies published in academic journals, to Least Developed Countries' National Adaptation Programmes of Action (NAPAs), to high-profile assessments of major cities in industrialized and developing countries alike.

Yet as Moser and Ekstrom (2010) and others have noted, few adaptation processes to date have reached the implementation, monitoring or evaluation stages. Often they get stuck in an earlier stage, and often finance is an issue – a subject not addressed in this guidance. But a major other factor, as Moser and Ekstrom point out, is the larger social and governance context, which can determine who supports or obstructs the process, what resources are available, and how much action is possible.

Section 2.4 discusses these challenges at length, including the need to engage stakeholders; build the case for adaptation; ensure that information is usable by the relevant actors; define the nature and scope of the work; agree on fundamental principles; set priorities, and decide how ambitious to be: whether to aim for incremental change, a more substantial shift, or transformational change.

The participatory tools described in Section 3.1 provide a good starting point for those first steps; see Sections 3.1.2.1 and 3.1.2.2 in particular for tools to help identify the key stakeholders who need to be engaged in the process, and understand their diverse perspectives and how they relate to one another. Many of the tools in Section 3.1.3 also provide useful guidance on how to engage stakeholders in community-based adaptation processes, so they're the ones who choose the adaptation measures they deem best for their needs, set priorities, make a plan, and implement the measures. This can help build a sense of ownership of the process, potentially enabling it to continue well after the intervention has ended. See, for example, the CARE Community Vulnerability and Capacity Analysis methodology, which is available in English, French, Spanish and Portuguese (Dazé et al. 2009); Oxfam International's guidance on how to empower people living in poverty to adapt (Pettengell 2010); and the Red Cross/Red Crescent vulnerability and capacity assessment guide (IFRC 2007).

Below we provide some additional guidance on effective participatory planning and implementation processes, and descriptions of tools that might be particularly useful for community-based adaptation. There is also a growing array of tools geared to local governments, businesses and organizations, and specific sectors engaging in adaptation; we have gathered those tools in Section 3.9.2.

3.9.1 Principles of effective adaptation planning and implementation

As we have discussed throughout this guidance, there is no single formula for success in adaptation: every situation is different, and in many cases, adaptation is not the main focus of activities – such as when climate concerns are "mainstreamed" into development or sectoral plans, or when "climate-proofing" is just one step in a larger planning process. When climate risks are not a major concern for stakeholders, it may even be strategic to de-emphasize the adaptation benefits of a measure; for example, restoring wetlands may be more appealing to a community for their recreational value, for the biodiversity benefits, or even to protect from existing flood risks than as protection from uncertain, future climate change risks.

This highlights the importance of understanding the context in which adaptation is to take place: societal priorities, economic interests, governance structures, etc. In order to succeed, adaptation actions need to be tailored to that context.

Equally important is that the adaptation process be participatory and inclusive. This not only means engaging the intended beneficiaries of adaptation actions, but also the people whose support and/or involvement will be needed to successfully plan and implement measures. That might include elected officials, staff in different ministries, agricultural extension officers, local planners, sectoral leaders, businesses or other constituencies; see Section 3.1.2 for tools to help you identify and "map" the different actors and how they relate to one another.

A key role of participatory processes is to help reach agreement on the scope of the work to be done, priorities, and goals – what would constitute success? Section 3.1 provides extensive guidance on how to work with stakeholders: from ethical issues, to effective facilitation, to specific techniques, methods and tools. It is also essential to have a clear set of guiding principles; for example, the Adaptation Learning Programme for Africa laid out the following guiding principles for participatory scenario planning (CARE International 2012):

- Involve all relevant stakeholders, women and men of different age, livelihood, ethnic or other groups, recognizing their roles and utilizing their specific knowledge and capacities to enable a participatory process and coordinated outcomes.
- Recognize, respect and build on both local and scientific climate knowledge.
- Encourage open discussion, dialogue and feedback among stakeholders. Use a range of participatory workshop methods to ensure discussion and reflection are open and useful to all. Pay attention to language used

to ensure everyone understands and can contribute.

- Communication should be inclusive, reaching all genders and groups (e.g. livelihood groups, land users, vulnerable groups) within the community.
- Conduct timely PSP, as soon as possible after the seasonal forecast is available, and timely communication of advisories to empower communities, local governments and other adaptation practitioners to take appropriate actions.
- Encourage participants to take their own decisions and actions as well as to support others and seek necessary support. Be ready with ideas on where this could be found.

The design of the process is very important – though it is often neglected. If a project is to be owned and moved forward by all, and if participants' adaptive capacity is to be strengthened, the process has to work well for everyone involved. That means everyone should understand their own role in the various stages, and how the pieces fit together to achieve the objectives. Visual representations of the decision-making process may help to illustrate this more clearly and to clarify expectations. Ideally there should be multiple opportunities for the key players to actively engage as the design develops. A good collaborative adaptation process also includes iterative cycles of learning and reflection that allow the group to recognize and respond to changing circumstances and unforeseen outcomes. As Pelling et al. (2008) note, it is also important to remember that very valuable interactions between individuals occur informally, in "shadow spaces", and ensure that the process provides such opportunities to connect. Figure 3.9.1 below, adapted from O'Hara and Pulhin (2006), illustrates another important aspect of effective participatory processes: multiple opportunities to reflect, reconsider assumptions and adjust as needed.

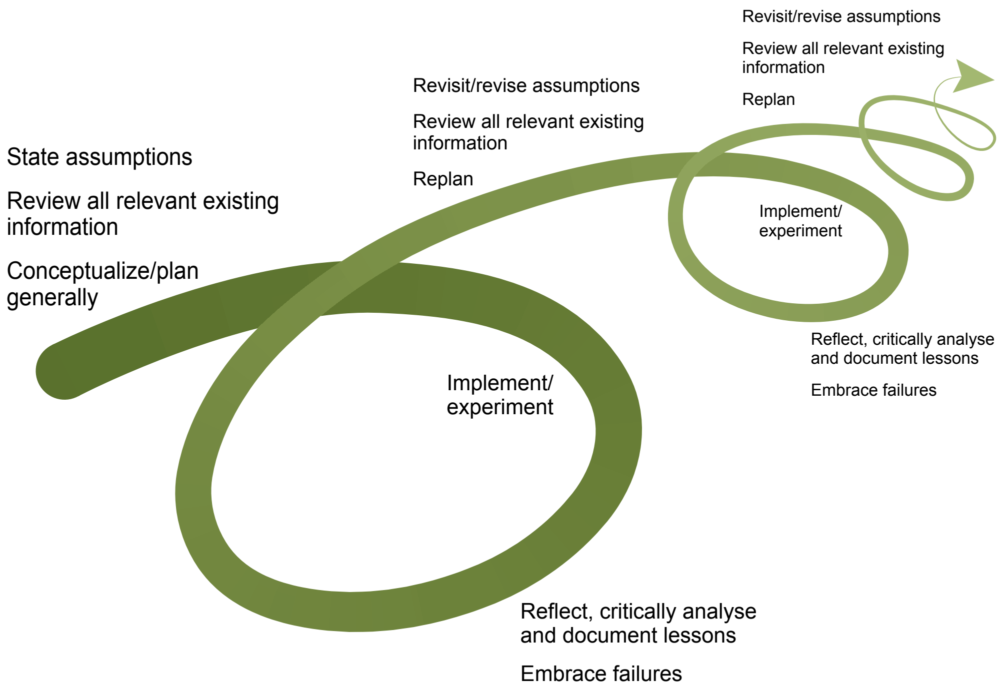

FIGURE 3.9.1 **An iterative learning approach to increase the quality of participatory action research.** Adapted from O'Hara and Pulhin (2006).

3.9.2 *General guidance and tools for adaptation planning*

As noted at the beginning of this section, many of the participatory tools and methodologies presented in Section 3.1.3 offer useful guidance on planning and implementing adaptation, especially in community settings. Three other useful resources are:

- *Designing Climate Change Adaptation Initiatives* (UNDP 2010a) is a toolkit for practitioners with the stated purpose of supporting the design of measurable, verifiable, and reportable adaptation initiatives, with step-by-step guidance for planning adaptation initiatives.
- CLIMATE-ADAPT, the European Climate Adaptation Platform, has an Adaptation Support tool that provides guidance and links to resources to assist with every step of the adaptation process, starting with basic guiding principles: **climate-adapt.eea.europa.eu/adaptation-support-tool**.
- GSDRC, a partnership of research institutes, think-tanks and consultancies, has compiled an online Topic Guide to Climate Change Adaptation that includes explanatory materials as well as a collection of guidance and tools: **www.gsdrc.org/go/topic-guides/climate-change-adaptation/adaptation-guidance-and-tools**.

Along with these fairly general resources, there is a growing array of specialized tools and materials to support adaptation planning and implementation in specific settings, such as individual cities or regions, or within individual sectors: water resources, coastal management, agriculture, etc. The two sections below list some of those specialized tools; note that some of the resources listed, especially in Section 3.9.2.2, include materials that might be useful in several different settings.

3.9.2.1 Tools for local- and regional-level adaptation planning

- ICLEI USA has compiled a Climate Adaptation Guidance website with an array of free tools, training materials and case studies for local planners: **www.icleiusa.org/climate_and_energy/Climate_Adaptation_Guidance**. A particularly valuable resource on the site is *Preparing for Climate Change: A Guidebook for Local, Regional and State Governments* (Snover et al. 2007), produced by the Climate Impacts Group at the University of Washington (U.S.) in association with ICLEI and with the participation of King County (Seattle) officials, which offers practical guidance based on the work of ICLEI's Climate Resilient Communities programme: **www.icleiusa.org/action-center/planning/adaptation-guidebook**.
- ICLEI Oceania, meanwhile, has developed a Local Government Climate Change Adaptation Toolkit that builds on the Australian Government's risk management framework and incorporates capacity-building to support adaptive management: **archive.iclei.org/index.php?id=adaptation-toolkit0**.
- The Canadian Institute of Planners has developed a website, Planning for Climate Change (**www.planningforclimatechange.ca**, in English and French) that provides a Model Standard of Practice, case studies from across Canada, and detailed guidance for planners in different settings, including small rural communities and Nunavut communities.
- The Climate Witness Community Toolkit, developed by WWW–South Pacific through a process undertaken on Kabara, Fiji, is designed to help facilitators work with communities to plan adaptation measures that they can implement themselves: **wwf.panda.org/about_our_earth/all_publications/?uNewsID=162722**.

- The Caribbean Climate Online Risk and Adaptation Tool (CCORAL) is designed to help Caribbean countries to plan climate change adaptation measures and "make more climate-resilient decisions": **ccoral.caribbeanclimate.bz**.
- The Institute for Tribal Environmental Professionals at Northern Arizona University has developed Tribes & Climate Change, a website that includes an adaptation resource guide with materials that might be particularly useful to Native American tribal leaders developing and implementing adaptation plans: **www4.nau.edu/tribalclimatechange/resources/adaptation.asp**.

3.9.2.2 Sector-specific tools

- The U.S. Environmental Protection Agency has compiled a list of adaptation planning tools and resources for public officials, including specialized tools for public health, coastal planners, water resources managers, and officials in specific regions: **www.epa.gov/climatechange/impacts-adaptation/adapt-tools.html**.
- The Georgetown Climate Center Adaptation Clearinghouse has assembled packages of key resources, expert organizations, assessments and sample plans for adaptation in transportation, public health, coasts and water, as well as links to state and local adaptation plans, law and governance materials, and other resources: **www.georgetownclimate.org/adaptation/clearinghouse**.
- The Ecosystem-Based Management Tools Network has compiled an Climate Change Tools Matrix – a five-page spreadsheet – of commonly used, low-cost tools to support adaptation planning, with both generic tools and specialized tools for coastal and land use planners: **www.ebmtoolsdatabase.org/resource/climate-change-tools-matrix**.
- NatureServe and the Ecosystem-Based Management Tools Network have compiled a guide called Tools for Coastal Climate

Tonle Sap lake fishing, Cambodia ©SEI/Roengchai Kongmuang

Adaptation Planning, targeted at practitioners and decision makers involved in coastal zone management, natural resource management, protected area and habitat management, watershed management, conservation, and local planning in the coastal U.S.: **connect.natureserve.org/toolkit/ebm-tool-network/climate-adaptation-planning-tools**.

3.9.2.3 Planning tools for businesses and organizations

- UKCIP has developed BACLIAT (**www.ukcip.org.uk/bacliat**), the Business Areas Climate Assessment Tool, to help businesses identify current and future climate risks and address them. The tool is built as a series of workshops with background information and step-by-step guidance. A "Speed BACLIAT" spreadsheet tool is also available. The Costings tool, also from UKCIP, can be used by both private- and public-sector decision-makers to get a better sense of the economic implications of climate change and adaptation measures: **www.ukcip.org.uk/costings**.
- Another UKCIP tool, CLARA, the Climate Adaptation Resource for Advisors, is designed to help advisors to small and medium enterprises help them understand climate risks, make the business case for action, and implement adaptation measures; the factsheets can also be accessed directly by businesspeople: **www.ukcip.org.uk/clara**.
- UKCIP's Adaptation Wizard is designed to help organizations evaluate their vulnerability to climate change, identify key climate risks, and develop a climate change adaptation strategy. The website includes several case studies, as well as a guide to all the information, tools and resources developed by UKCIP; see **www.ukcip.org.uk/wizard**.

3.9.3 Other planning and implementation tools

Many of the challenges that arise in adaptation processes are not unique, and in fact, many tools used in adaptation today are based on methodologies first used in the development realm, such as "action research" approaches (see Section 3.1.3). Unlike the tools described in Section 3.9.2, the resources listed below were not expressly designed for adaptation, but they have been used successfully as part of adaptation processes. In addition, see Section 2.5.7.1 for a description and an example of logical frameworks, and see Hovland (2005) for several more options, including guides to stakeholder and social network analysis and "problem tree" analysis.

- Participatory mapping has been widely used for more than 20 years in both industrialized and developing countries, as a way to visualize local communities' relationship to the landscape, as well as the social, cultural, economic and historical context. Thus, it is a common approach to gathering local knowledge and initiating a dialogue about issues of interest to the community. The International Fund for Agricultural Development (IFAD) has published an in-depth guide, available as a free download; see Corbett (2009).
- "Mental model" approaches have been used in organizational settings to ensure that team members have a collective vision of the task or issue at hand, so they can solve it more effectively (Langan-Fox et al. 2000). They are also seen as useful when multiple stakeholders with different perspectives are assigned to plan and manage a process together; while mental modelling may not bring them to full agreement, it can help them identify differences and commonalities and thus enhance collaboration and collective decision-making (Du Toit et al. 2011). The Climate Change Collective Learning and Observatory Network

Ghana has used mental models to assess how community members understand climate change, and outlined the process on its website; see CCLONG (n.d.).

- The Johari Window technique, developed by the psychologists Joseph Luft and Harry Ingham in 1955, is used to explore the differences in how people perceive themselves vs. how others perceive them, and gaps in knowledge on both sides. For a short explanation, see **www.businessballs.com/johariwindowmodel.htm**. It can also be used to highlight differences in people's perspectives and preconceptions about an issue. For an example focused on climate change perceptions in Western Australia, see Gray (2009).
- Soft Systems Methodology, designed by Peter Checkland in the 1960s, grew out of general systems theory, which views everything in the world as part of an open, dynamic, and interconnected system with the various parts of this system interacting with each other, often in a nonlinear way. It is a way to explore complex situations with different stakeholders; numerous goals; different viewpoints and assumptions; and complicated interactions and relationships. By acknowledging these perspectives it becomes possible to explore potential interactions and impacts of any changes. For an in-depth guide, see Checkland and Scholes (1999); for a short, free guide, see Williams (2005). ■

3.10 Methods for monitoring and evaluating adaptation

3.10.1 Introduction

Monitoring and evaluation (M&E) are key components of the adaptation process. They help ensure that adaptation measures are implemented as planned, that they produce the anticipated results, and that they are indeed (or still) the right things to do – given the high degree of uncertainty about future climate, socioeconomic conditions, and the resulting climate risks. They also provide crucial lessons about what does and doesn't work, building local knowledge and adaptive capacity and, to the extent that findings are shared more broadly, expanding global knowledge about adaptation. Monitoring and evaluation also help ensure that adaptation finance is being used as effectively as possible – not a small issue given the huge gap between estimated adaptation needs and available finance (see, e.g., Smith et al. 2011; The World Bank 2010b). And from both funders' and the intended beneficiaries' perspectives, monitoring and evaluation are crucial for transparency and accountability (Klein 2011).

That is a broad range of needs to meet through a single process, and although adaptation practitioners, funders and researchers have now been designing, analysing and testing M&E frameworks for several years, this is still a relatively new field for climate adaptation. (Development, however, offers several lessons.) Moreover, as discussed in Section 2.5, the time-scale of adaptation benefits – potentially years or decades after the end of a programme or intervention – makes it difficult to gauge the outcome of a measure. Often, at best, we can quantify outputs (e.g. number of farmers trained in conservation-agriculture techniques, or number of hectares planted with drought-resistant maize), but amid ever-shifting conditions, we may never know by exactly how much, if at all, an intervention reduced the impacts of climate change. Less-quantifiable benefits, such as improved problem-solving capacity among local stakeholders, more-effective local institutions, or increased attention to climate change among government officials, are even more difficult to monitor and evaluate, much less compare across different settings. In this context, it may take several decades before we truly know what constitutes "successful adaptation", and how best to measure it. Thus, a recent review of M&E frameworks by UKCIP and the SEA Change Community of Practice argues:

> Monitoring and evaluation of [adaptation] can and should serve not only to document and demonstrate the effectiveness of interventions, but also to generate knowledge, learning, and evidence to inform this emerging area of policy and programming. M&E presents a crucial opportunity for generation and dissemination of applied research in a new field. (Bours et al. 2013, p.59)

As Bours et al. (2013) note, existing M&E methods range from fairly theoretical and technical frameworks, often developed in academia, to practical, step-by-step guides geared to people working on community-based adaptation and disaster risk reduction. Which tools will be most appropriate for a specific project will depend on the nature of the work being done – does it involve building a dike, for example, or building the capacity of farmers to adapt to climate change? Several of the frameworks, tools and methods presented here are on the more practical end of the spectrum discussed by Bours et al. (2013). In choosing an approach, it may be useful to look for several common traits of effective M&E systems:

- They start with a clear, agreed-upon understanding of what constitutes success, and how to measure it;
- They start with a clear, agreed-upon understanding of who is responsible for what – who is accountable for meeting each of the different goals or targets;
- They track progress over the course of the project, rather than just looking at the end result;
- They consider not just *what* is done or achieved, but *how* it is done – the quality of the process as well as the content;
- They question assumptions, asking not only, "Are we doing things right?" but also "Are we doing the right things?"
- They recognize that not everything can be measured, and include qualitative assessments as well;
- They consider different perspectives on "success" – for example, a funder may be satisfied by a project's outcome, but the intended beneficiaries may see no positive change, or gender inequalities may have led to only men benefiting from an intervention, but not women;
- They are flexible, allowing for adjustments over the course of the project, and not overly burdensome, ensuring that M&E does not take up an excessive share of available resources.

Given that, as discussed above, M&E is closely linked to learning and knowledge generation, it may be helpful to read Section 3.11, on tools for learning and reflection, along with this one. Section 3.1, on participatory processes, and Section 3.8, on adaptation planning, may also provide useful context about the role of stakeholders in defining the scope of a project, its intended outcome(s), and measures of success, and in monitoring the project once it is under way.

Finally, we should mention three useful online resources:

- The European Union's CLIMATE-ADAPT website provides a short but handpicked list of resources for adaptation M&E;

see **climate-adapt.eea.europa.eu/adaptation-support-tool/step-6**.

- The Clim-Eval platform (**www.climate-eval.org**) is the online home of a global community of practice that aims to establish standards and norms, support capacity development, and share good practices in climate change and development evaluation. Members come from government and development cooperation agencies, civil society organizations, and academia. The website includes an electronic library, a blog, videos, news about M&E developments, and other resources.
- The website of the Global Environment Facility's Evaluation Office includes M&E guidance and discussions (not all adaptation-specific), and many examples; see **www.thegef.org/gef/eo_office**.

3.10.2 Critical reviews and principles for adaptation M&E of adaptation

Several efforts have been made in recent years to survey the landscape of adaptation M&E approaches around the world and distil lessons and guiding principles. Several are discussed in Section 2.5.4, and we do not replicate that material here – though there is some overlap. Along with the UKCIP/SEA Change review discussed above (Bours et al. 2013), other useful reviews include:

Monitoring and Evaluation for Adaptation: Lessons from Development Cooperation Agencies, from the OECD (Lamhauge et al. 2012), analyses the treatment of M&E in 106 adaptation project documents across six bilateral development agencies. It finds that results-based management, and logical frameworks (see Section 2.5.7 and Section 3.10.4 below) are the most common approaches used for adaptation. The analysis stresses the importance of clearly differentiating between outcomes, outputs and activities, and combining qualitative, quantitative and binary indicators. It also notes that the baselines for these indicators should include the effects of future climate change, particularly for projects with long-term implications, but acknowledges that significant challenges in setting those baselines and in attributing longer-term outcomes to interventions.

Making Adaptation Count, by GIZ and the World Resources Institute (Spearman and McGray 2011), provides an overview of M&E for adaptation, drawing links to results-based management and the Aid Effectiveness Agenda (OECD 2005). It then reviews early efforts at adaptation M&E and draws lessons about the highly contextual nature of adaptation, the value of diversity in evaluating adaptation, and the need to explicitly state, at the outset, the assumptions being made about future conditions. Spearman and McGray also identify three principles of effective adaptation M&E systems: design for learning; manage for results; and maintain flexibility in the face of uncertainty.

The UNFCCC Subsidiary Body for Scientific and Technological Advice (SBSTA) reviewed Parties' submissions about adaptation M&E best practices as well as an array of project documents and other sources. The synthesis report (UNFCCC 2010) identifies distinct roles for monitoring – to enable planners and practitioners to improve adaptation efforts by adjusting processes and targets – and evaluation – a process for systematically and objectively determining the effectiveness of an adaptation measure in the light of its objectives. It also distinguishes two key elements of assessing effectiveness: 1) have the objectives and targets been achieved, and 2) can this be attributed to the measure taken? The SBSTA also proposed a framework for adaptation M&E, shown in Figure 3.10.1, which further distinguishes between outputs (measureable products and services), outcomes (the short-term and medium-term effects of a measure), and impacts (long-term effects on specific groups or systems). For best results, the SBSTA suggested, monitoring and evaluation should be done at three stages: during implementation, immediately after conclusion, and some years after conclusion.

The SBSTA review also provides a fairly detailed overview of the progress to date in applying M&E frameworks to adaptation in different countries, including the kinds of indicators that are being used – with a detailed comparison of the UK and Finland – as well as programme- and project-level applications of M&E under different funders. One notable finding is how expensive a thorough M&E system can be: for example, the M&E budget of the four-year Pacific Adaptation to Climate Change project implemented by the United Nations Development Programme and the Secretariat of the Pacific Regional Environment Programme is $410,000 USD. Given that such costs would be prohibitive for many community-based adaptation projects, UNDP has developed a simplified tool to monitor and evaluate locally driven adaptation projects.

Monitoring Adaptation to Enhance Food Security, from the CGIAR Research Program on Climate Change, Agriculture and Food Security (Chesterman and Ericksen 2013), explores how food security outcomes are being addressed in adaptation M&E. It finds that most available documents only outline frameworks, but do not report specific experiences, which makes it difficult to summarize best

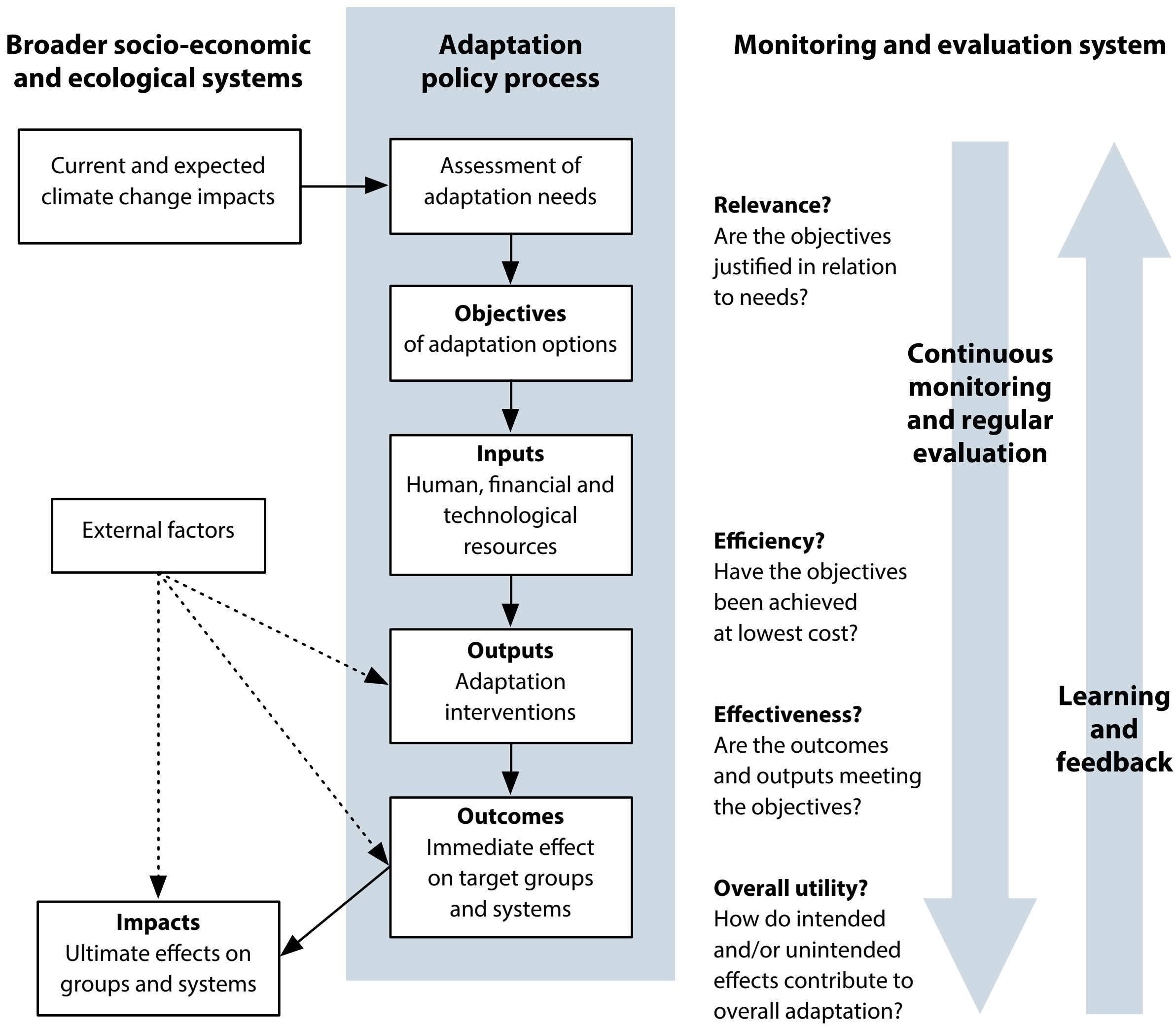

FIGURE 3.10.1 **A proposed framework for adaptation M&E** (UNFCCC 2010).

practices or identify the most reliable indicators to use. It offers six recommendations:

- Agree on a common framework or outcome pathway with clear and agreed outcomes.
- Use scenarios to handle the necessary planning under uncertainty, combined with ex-ante assessments of adaptation investments and interventions to identify robust strategies.
- Engage in ongoing monitoring using a clear "logic" model to track progress of the "robust strategies" on the ground, ensuring that the model is explicit about what constitutes success.
- Take a learning approach to M&E with stakeholders at multiple institutional levels.
- Encourage data-sharing across projects doing M&E, to contribute to the growing body of knowledge about the most effective agriculture and food security interventions.
- Develop and use a tool for managing or evaluating impact given inevitable tradeoffs among food system outcomes.

3.10.3 Practical guidance for adaptation M&E

As should be clear from the preceding overview, there are many examples of M&E frameworks and tools, but relatively few provide step-by-step guidance. Here we describe two which do, aiming to meet the needs of practitioners in particular.

The AdaptME toolkit (Pringle 2011), **www.ukcip.org.uk/adaptme-toolkit**, was developed in response to a growing demand for practical support in evaluating adaptation progress and performance, and can be used with the UKCIP Adaptation Wizard (**www.ukcip.org.uk/wizard**) or separately. It includes three modules:

Fundamentals:

- What is the purpose of my evaluation?
- What am I evaluating?
- What logic and assumptions underpin the intervention I will be evaluating?
- Who should I involve in the evaluation?
- How should I communicate the findings?

Adaptation challenges:

- What challenges might I face when evaluating adaptation performance?
- What limitations are placed on my evaluation?
- How do I evaluate the unintended and unexpected?

Measuring performance:

- Measuring progress and performance;
- Establishing evaluation criteria: indicators and metrics.

CARE International's *Participatory Monitoring, Evaluation, Reflection and Learning for Community-based Adaptation* manual (Ayers et al. 2012) provides a detailed overview of key adaptation and M&E concepts, then outlines a five-step process for designing an M&E strategy:

- Step 1: Select a facilitator;
- Step 2: Select team members in partnership with the community;
- Step 3: Develop indicators;
- Step 4: Measure baselines;
- Step 5: Finalize the M&E plan, budget and resource allocation.

For each step, it provides advice, key questions to ask, and suggested tools to apply – which are described in detail in a separate section. It also provides real-life examples, such as a visioning exercise from a project in Nepal that used the phases of the moon to guide community members through setting baselines for different indicators (p.49).

The manual also explains what to do with the information collected through the M&E process, recommending that it be fed into a continuous learning and reflection process that asks questions such as: What changes are occurring? What is working well? What is not working well? How have changes in context influenced results? Do we need to do anything to adjust our plans in light of changing contexts? As the data are gathered, they can be used to revise adaptation plans and indicators and targets as needed, and they should also be fed into reporting. One suggested way to do the latter is to hold regular "feedback meetings" to discuss the findings and their implications with stakeholders.

3.10.4 Common evaluation methods and additional tools

The CARE International manual described above (Ayers et al. 2012) describes a wide array of participatory tools that can be used at different stages of the M&E process. Here we describe a handful of tools from development and other contexts that are being applied to adaptation M&E. We begin with relatively general tools, then list a few more narrowly focused tools. For additional resources, see Section 3.1 of this guidance, especially Section 3.1.5, on participatory analytical tools.

- *Ten Steps to a Results-Based Monitoring and Evaluation System,* from the World Bank (Kusek and Rist 2004), available as a free download in English, Spanish, French, Chinese and Vietnamese, is an in-depth guide to M&E in a variety of contexts. The handbook is primarily targeted to officials facing the challenge of managing for results, especially in developing countries, and presents a strategy that it says is already being used by seasoned programme managers in developed countries and international organizations to gain insight into their performance and make improvements. The book can be used alone, or in conjunction with workshop materials developed at the World Bank, "Designing and Building a Results-Based Monitoring and Evaluation System: A Tool for Public Sector Management" (available from the SEA Change website, **www.seachangecop.org/node/1350**). The handbook starts with a "Readiness Assessment" and then takes readers through steps to design, manage and ensure the sustainability of their M&E system.
- Results-based management is a way of managing whereby an organization ensures that all of its processes, products and services contribute to the achievement of desired results. It depends on clearly defined accountability for results, and requires systematic monitoring, self-assessment and reporting on progress. Managing to achieve results is not new, but results-based management provides improved focus and prioritization of all of an organization's work, systematically linking activities carried out by all units at all locations and under all funding sources. For an overview, see UNDP (2002), or the Global Environment Facility's guide: **www.thegef.org/gef/about_RBM**. For an application of RBM to adaptation (combined with logical frameworks), see the Adaptation Fund's project-level RBM and baselines guidance (Adaptation Fund 2011)
- Logical frameworks are an analytical, presentational and management tool which can help planners and managers to analyse the existing situation during activity preparation, establish a logical hierarchy of means by which objectives will be reached; identify the potential risks to achieving the objectives and to sustainable outcomes; establish how outputs and outcomes might best be monitored and evaluated, if desired; present a summary of the activity in a standard format, and monitor and review activities during implementation. For a brief overview and an example, see Section 2.5.7.1, or **portals.wdi.wur.nl/ppme/index.php?Logical_Framework_Approach**.
- Outcome mapping was developed by the International Development Research Centre (IDRC) in Canada as a methodology for

planning, monitoring and evaluation that focuses on what contributes to outcomes made by development interventions, rather than trying to specifically attribute the change to a particular intervention. The approach is grounded in an understanding of development as a complex and non-linear process that involves multiple actors, some of whom work for, and some who work against, change. Outcome Mapping has a lot to offer in the evaluation of adaptation interventions as it gets away from assumption made in impact-based methods, that it is possible to make simple cause and effect links, when the context of most adaptation processes are open and complex systems with the attendant unexpected and unintended consequences associated with this. For a wealth of resources on this approach, go to the Outcome Mapping Learning Community, **www.outcomemapping.ca**.

- Most significant change is a participatory form of monitoring and evaluation that asks the people involved in or affected by a project to identify what they consider to have been the most significant change resulting from the project. For an introduction, see the tools section of Ayers et al. (2012), or Section 2.5.7.4 of this guidance.
- Appreciative inquiry is a method of change management that can be used at many levels to understand whole systems, organizations, networks and teams. It emphasizes inquiry into strengths rather than focusing on weaknesses and problem-solving. The basic approach is to find out what is going well, what conditions support that success, visioning what might be, and creating participatory dialogues about how visions might be achieved; see **www.iisd.org/ai**.
- *Auditing Community Participation: An Assessment Handbook,* from the Joseph Rowntree Foundation (Burns and Taylor 2000), was written to help assess levels of community involvement in area regeneration initiatives in the UK, but it is more widely applicable. It provides tools and appraisal exercises for measuring the history and patterns of participation; the quality of participation strategies adopted by partners and partnerships; the capacity within partner organizations to support community participation; the capacity within communities to participate effectively; and the impact of participation and its outcomes.

Flooding in Bangladesh © Flickr/Amir Jina

3.11 Tools for learning and reflection

Adaptation has been called a process of "learning within the unknowable" – a term coined by Flood (1999a; 1999b) to explain how our human minds must learn to deal with the complexity and uncertainty of social and natural systems. "We are faced with learning within the unknowable," he writes. "We learn our way into a mysterious future" (Flood 1999a, p.251). As has been emphasized throughout this guidance, learning is at the core of adaptation: as each cycle is completed, the knowledge it has generated feeds into the next round of analysis, action, and learning. Thus, *learning to learn* – from our own experiences, and from others' – is crucial to successful adaptation, and helping people at all levels to become better learners and critical thinkers is an important aspect of building adaptive capacity. However, relatively little effort is typically put into understanding *what needs to be learned, by whom,* and *how* (Armitage et al. 2007). Concepts, assumptions and approaches to learning have been applied in "vague and uncritical ways" (ibid.); there is a need for more specific learning goals.

From a practical perspective, *what* needs to be learned is closely linked to specific questions in monitoring and evaluation. For example, if a project has set out to reduce crop losses due to heat stress, perhaps by introducing new heat-resistant varieties, the M&E process should shed light not only on how well the project was implemented, but on whether planting those heat-resistant varieties actually reduces crop losses – the "Are we doing the right thing?" question discussed in Section 3.10. Yet another step in the process would be to explore in more detail why the heat-resistant varieties did or did not work – for example, whether rainfall or humidity levels are important, or whether these varieties require, say, more fertilizers or pesticides. The deeper the inquiry, the more learning that can result.

Who learns can also vary greatly. Quite often, as discussed in Section 3.1, participatory processes are front-loaded in the adaptation cycle: stakeholders are asked to provide information, and maybe to express their preferences in appraising adaptation options, but after that, there is often no follow-up.

Coastal erosion and inefficient erosion reduction measures at Cape Town, South Africa.

Yet if stakeholders' adaptive capacity is to grow, they need to learn with the project team. Thus, as noted in Section 3.10.3, CARE International's manual for M&E and learning in community-based adaptation (Ayers et al. 2012) recommends having regular "feedback meetings" to share M&E results with stakeholders, and to use an array of participatory tools to support collective learning. From there, learning can be taken to a larger scale by sharing insights (formally, e.g. in a report or peer-reviewed journal article, or informally, on a site such as weADAPT – see Section 3.11.13). This can allow for deeper learning by comparing multiple experiences and distilling best practices, and can also support replication and scaling-up of successful approaches.

How learning occurs will depend, in part, on *who* is learning, but a growing body of research shows there is a large gap between knowledge and practice (see, e.g., Klein and Juhola 2013; Lonsdale 2013). Closing this gap requires greater awareness of what makes "usable knowledge" (Haas 2004; see Section 2.4.4), and part of it involves understanding behavioural and institutional barriers (see Sections 3.5 and 3.6). At the same time – and especially within the organizations and communities that are actively engaged in adaptation – there is a need to create conditions that support learning. Pasteur (2004), writing about development agencies, identifies three key aspects of creating a "learning organization":

- **Guiding ideas:** A shift in fundamental assumptions may be needed; several approaches may work, such as an "open learning model" or a complex systems approach, but the key is to be more open and experimentalist, holistic and pragmatic, and encourage greater collaboration.
- **Theory, methods and tools:** The guiding ideas need to be supported by new practical tools and approaches, such as "action learning" (see Section 3.1.6), and changes to current practices – from how workshops are run, to accountability and reporting systems.
- **Innovations in infrastructure:** Decentralized structures allowing for greater participation, flattened hierarchies, and small units that communicate and interact well with one another are likelier to foster learning; strong hierarchies, and "silo" mentalities discourage it.
- **Skills and capabilities:** Skills such as effective listening, dialogue and communication may not come naturally to people and are typically not part of professional training; awareness-raising and skill development in these areas will likely be needed.

3.11.1 Emotional and relational aspects of learning

Work in the 1970s onwards has explore how people can, with support, evolve as learners from a position of being dependent on others to "hand down the truth" to becoming aware of multiple perspectives and having the confidence to state their own views and challenge assumptions. This kind of evolution is an important aspect of building adaptive capacity and encouraging autonomous adaptation; in the long run, the people exposed to climate hazards cannot depend entirely on others' help and expertise to avoid the worst impacts.

Learning is not a neutral process. Both research and experience tell us that people have great attachment to their ideas, opinions and ways of seeing the world, and having these challenged can feel very threatening. This is one reason why effective facilitation is so important in participatory processes: it can help create "safe" spaces for people to speak openly, exchange ideas and experiences, and learn together and from one another. (See Section 3.1 for an in-depth discussion of facilitation and tools for facilitators.) Another way to look at what enables learning to occur in participatory processes is provided by Collins and Evans (2002), who distinguish between three categories of expertise:

- **No expertise:** Insufficient knowledge to engage in even a cursory discussion of the topic;
- **Contributory expertise:** Ability to contribute to the knowledge base on the topic, either with abstract/generalizable knowledge (e.g. science), or with local/practical knowledge;
- **Interactional expertise:** Able to not only contribute to the knowledge base in one form or the other, but also "interact interestingly" with those possessing the other form.

Such interactional expertise might enable a project manager presenting M&E data to stakeholders to elicit valuable feedback from those stakeholders that enhances overall learning – say, observations about characteristics of heat-resistant crop varieties that might have contributed to their success or failure, to go back to the earlier example. It might allow a scientist to challenge local people's assumption that groundwater salinization was entirely due to sea-level rise, by showing how a new well-drilling technique reduced saltwater intrusion. Or it might allow local farmers to challenge the merits of a "successful" intervention – say, if they knew the heat-resistant crop varieties would be prohibitively expensive for them without the financial support provided by an adaptation project.

Carolan (2006) builds on Collins and Evans' work by adding one more category, "public expertise", of expertise, the ability to gauge public sentiment and values and incorporate them into the decision-making process. This, he notes, is particularly valuable when dealing with environmental risks, "once we begin to move from questions of what 'is' to 'what should be done' ".

Pelling and High (2005a; 2005b), meanwhile, emphasize the importance of social capital to build the relationships and trust that are essential for mutual and collective learning (see a related discussion in Section 3.9.1). In a case study of a dairy farmers group in New Zealand (see Pelling and High 2005b), they find that by working closely together over several years, the farmers have become quite effective at learning from one another and from external sources and built up confidence in their ability to proactively adapt to climate change. At the same time, Pelling and High note, "this solid base of trust is won at the expense of excluding others", so the group is not helping to raise the adaptive capacity of farmers outside it.

3.11.2 Adaptation as social learning

Closely linked to the discussion above is the concept of adaptation as social learning – learning on a larger scale than just individuals or groups, up to a societal scale, as a result of social interactions and processes (Reed et al. 2010). Through social learning, successful adaptation strategies and lessons from individual projects and actions become part of the collective knowledge base, building adaptive capacity across entire organizations, communities or sectors. Both the adaptation and resilience literatures have thus emphasized the importance of fostering social learning (see, e.g., Pelling and High 2005b; Pahl-Wostl et al. 2007; Collins and Ison 2009) and of creating opportunities to support it, such as "deliberative workshops" (McCrum et al. 2009). Social learning is also an important part of "adaptive co-management", an emerging approach to managing complex social-ecological systems that combines the principles of adaptive management (see Section 3.7.6) with vertical and horizontal collaboration (Armitage et al. 2008).

Pahl-Wostl et al. (2007) describe the social network of stakeholders as "an invaluable asset for dealing with change", and argue that social learning not only increases adaptive capacity, but also leads to sustained processes of attitudinal and behavioural change through interaction and deliberation.

Such a perspective is at the core of HarmoniCOP, a European project focused on participatory river basin management, which used the key message of "learning together to manage together" (HarmoniCOP 2005). Importantly, Pahl-Wostl et al. note that the governance structure "has a strong influence on the nature of multiparty cooperation and social learning processes", citing empirical analyses that show that centralized political and economic systems, privatization, commercialization of the environment, rigid bureaucratic systems, and political secrecy and poor public access to information can impede social learning. Johannessen and Hahn (2013), meanwhile, stress that even when social learning does occur – as they find in the context of flood risk management in Kristianstad, Sweden's most flood-prone municipality – it can fail to effect change if it goes against a well-established paradigm (in this case, the notion of being safe behind embankments), and if it is not supported by national-level policies and governance systems.

Lonsdale et al. (2010) note that social learning can also be enhanced by rethinking how organizations themselves operate and engage with others: their priorities, how staff are expected to spend their time, and what is valued and rewarded. Sometimes, they write, organizations' stated goals do not match their practices, as when staff are encouraged to make connections with the community but are not given time to do so. Lonsdale et al. (2010) go on to identify several characteristics of an organization with a learning culture:

- It recognizes, supports and is able to benefit from formal and informal structures.
- It is open to innovation both in terms of the way it is managed and in operational activities.
- It supports creative thinking, innovation and exploration of change from the personal to organizational level, allowing this to contribute to more formal governance and accountability structures.
- It encourages and supports learning from experience at various levels (e.g. through attention to what is being learned, e.g. facts and skills, incorporation of learning from evaluations, support for action learning sets and other enquiry processes, etc.) towards improving practices, policies and programmes.
- It recognizes that attention needs to be paid to all stages of the learning cycle (experience, reflection, conceptualization, planning and implementation) for learning to occur and change to happen.

They also identify several "indicative attributes" of learning organizations:

- Actively seeking new ideas and other ways of working, including examples from outside the organization;
- Dissonant information that does not fit with current practice and thinking and experience is not seen as taboo but welcomed and actively explored;
- Creation of and support for "informal space" to experiment and innovate, and support for dialogue processes that enhance collaboration rather than debate and argument;
- Support for processes of learning and enquiry, such as action learning sets, learning histories, appreciative inquiry at all levels of the organization;
- Mistakes are seen as an opportunity to learn;
- Ethos of professional development and providing support for individuals who act as champions or agents of change;
- Practice of actively examining accepted ways of doing things and creating novel management systems to facilitate adaptation;
- Willingness to explore new and innovative adaptation options;
- Ability to retain institutional learning and knowledge.

3.11.3 Tools for learning and reflection

Quite a few of the tools and resources discussed in previous sections of this guidance, especially Sections 3.1 and 3.10, can support collective learning and reflection; CARE International's manual for M&E and learning in community-based adaptation (Ayers et al. 2012), discussed above and in Section 3.10, provides a particularly useful step-by-step approach. In addition, appreciative inquiry (**www.iisd.org/ai**), also listed in Section 3.10, should be useful in many settings. Below are some more resources to support learning and reflection:

- weADAPT, an adaptation knowledge-sharing platform, invites users to share their own knowledge and experiences and to network with others working on similar issues, individually or through "initiatives" (communities of practice); see **www.weadapt.org**.

Irrigation, Kibwezi © SEI

- *Tools for Knowledge and Learning: A Guide for Development and Humanitarian Organisations* (Ramalingam 2006), available as a free download in English and Spanish, is a comprehensive and well explained collation of tools that can be applied to adaptation processes.
- Learning for Sustainability is a knowledge portal geared to people seeking to improve collaboration and social learning in the context of environmental decision-making. It provides an annotated guide to a range of online resources, including papers, handbooks, tips, theory and techniques in a number of related fields; see **learningforsustainability.net**.
- *The Barefoot Guide to Learning Practices in Organisations and Social Change* (Barefoot Collective 2013) is a free practical resource for leaders, facilitators and practitioners involved in social change who want to improve and enrich their learning processes. This guide is the joint effort of a group of development practitioners from across the globe, and includes topics such as community mobilizing and development, adult learning, funding, evaluation, facilitation, and creative writing. There is also a Companion Booklet with practical ideas and tips for designing and facilitating learning processes.
- Learning journals can be used as a tool for individual reflection. Reflective diaries/learning journals/portfolios are records kept on a regular, often daily, basis by people undergoing a learning process and are commonly used in action research and other reflective approaches. In learning two kinds of reflection are important: reflection as a group and reflection as an individual. Journals can regularly capture moments of dissonance, confusion, surprise, etc., and help identify patterns and start challenging assumptions and biases. Smith (2013) provides a useful introduction in a free blogpost.

Panorama of Guadiana River in Spain, detail © Flickr/Federico Martínez Montero

4 Example cases

Adaptation situations can be described by means of characteristics (see Section 1.3), which have an indication on the identification of the critical task to be addressed. In Section 2, the relationship between specific characteristics of an adaptation challenge and the critical task indicated was illustrated through decision trees. In this section, we provide three case studies of how that approach can be applied. Each case study begins with a narrative description of the situation, which describes the adapting actors, the climate hazards and the geographic location. Next, the key characteristics of the situation are analysed in order to identify critical tasks. Finally, a schematic diagram is presented which illustrates the sequence of questions to be addressed within a given case.

It should be noted that the characteristics of an adaptation situation may be known from the outset, or they may be discerned through the application of a method. The characteristics of the situation may also change, because adaptation action is taken, or for other reasons (e.g. changes in socio-economic or political conditions). In these case studies, the situations are initially characterized on the basis of the knowledge available at the outset. As critical tasks are performed, the knowledge they generate may lead to additional tasks, which are shown in sequence in the diagrams.

We describe two sorts of cases in this section: two adaptation research cases, and one adaptation policy case. In general, one can say that adaptation research cases, as they aim at generating knowledge, are more closely related to the first stage of the adaptation cycle, identifying adaptation needs, while adaptation policy cases are likelier to stretch into the second stage, identifying adaptation options, and beyond – and may even start at that stage, building on research that has identified specific needs. As discussed in Sections 2.5 and 3.9, relatively few adaptation projects to date have made it to the implementation stage or later – though at the community level, especially, several have. Here, however, we focus on adaptation research and policy cases in the first three stages of the adaptation cycle.

We should note that in the case of adaptation policy cases, at least some of the methods used may be prescribed by the policy context (see also Section 1.3). For example, the application of cost-benefit analysis to adaptation options may be required by national legislation. Where the choice of methods is stipulated by the policy context, we point this out.

4.1 Research cases

4.1.1 Guadiana river basin

In the upper and middle Guadiana river basin, in Spain, climate change is expected to reduce water availability through reduced precipitation and more frequent droughts. Climate projections indicate that river flow could decrease by 11% by 2030, increasing water stress in the basin and resulting in more frequent droughts (CEDEX 2011; Junta de Extremadura 2013). Agriculture in the Guadiana is highly sensitive to climate conditions. Temperature increases will affect crop yields, and less water availability will make agricultural systems more dependent on irrigation, both potentially affecting farmers' incomes.

In the upper Guadiana, irrigation systems use groundwater, which is more resilient to prolonged droughts than the surface waters also used for irrigation in the middle Guadiana. However, there are larger storage capacities in the middle Guadiana, which could potentially reduce the impacts of decreasing precipitation. The aquifer from which farmers in the upper Guadiana draw water also maintains an internationally significant wetland. Climate change impacts, reducing precipitation,

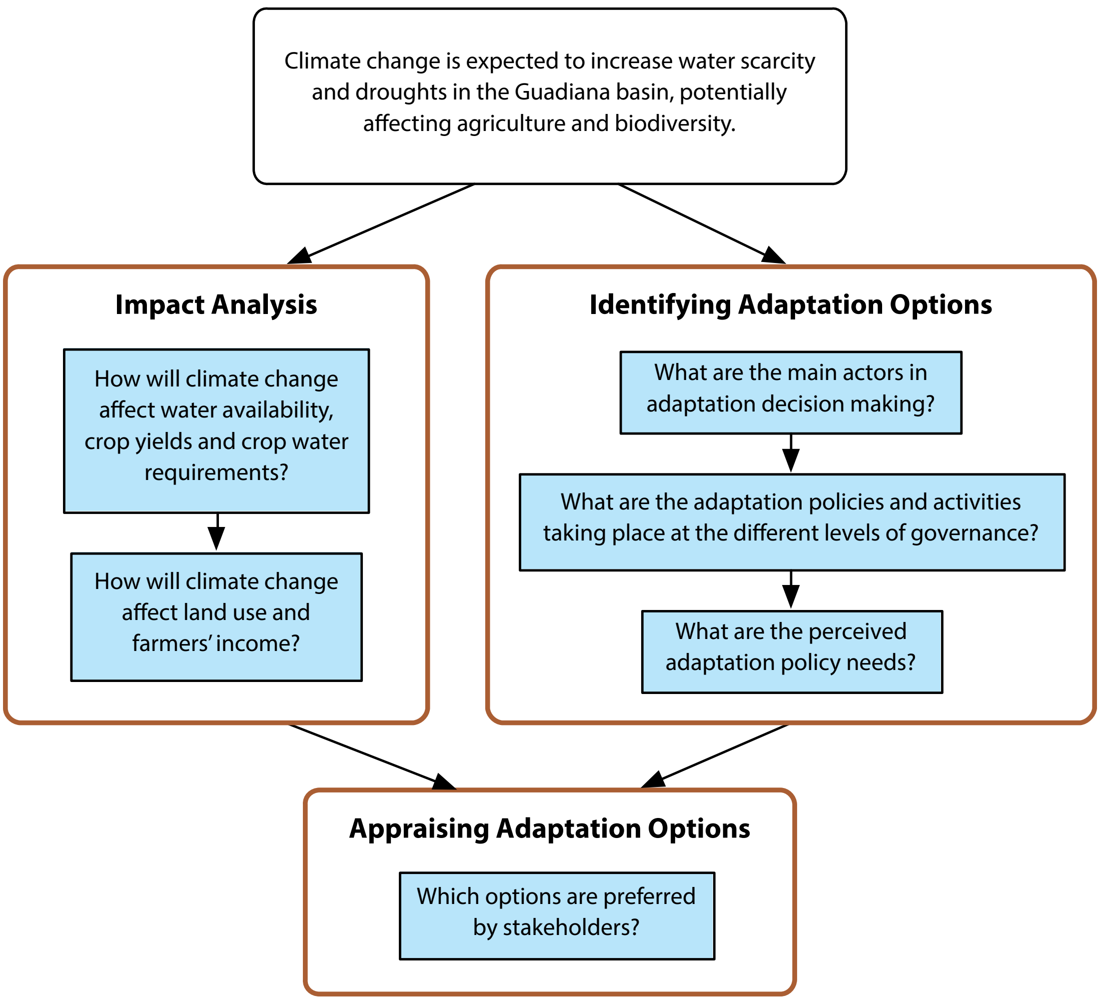

FIGURE 4.1.1 **Schematic diagram of the Guadiana case study in the MEDIATION Project.**

may exacerbate the environmental problems linked to water resources over-exploitation, e.g. biodiversity loss through wetland loss from decreasing groundwater levels.

Reducing pressure on the aquifer is thus an important consideration in adapting agricultural production to increasing drought frequency. Because adaptation options affect groundwater extraction from a shared aquifer for agricultural production, private actors are interdependent, and the adaptation situation involves public actors influencing collective adaptation. Further, because adaptation options considered include long-term water infrastructure investments, the long term is important to adaptation decision-making.

Figure 4.1.1 shows a diagram of the Guadiana case study, with three stages of analysis. On the left is the impact analysis, which asked questions about future climate changes and their impacts on water resources, crop yields and farmers' income. These questions have been addressed by projecting residual impacts with water and crop models (Varela-Ortega et al. 2013). The methods applied to address these tasks are described in Section 3.2.

In the Guadiana, adaptation options affect levels of groundwater extraction from a shared aquifer for agricultural production. Collective action is therefore an important component of adaptation options. For example, improving the technical efficiency of water management through regulation or market-based instruments would require collective action for successful implementation. Understanding of the institutional context and how this supports or constrains collective action is therefore a salient challenge to address. The second type of assessment, the right branch in the diagram, therefore focuses on identifying adaptation measures by understanding the institutional context. The sequence of tasks (formulated as questions) addresses the actors involved, the policies undertaken that are relevant to adaptation in the agricultural and water sectors, and perceived adaptation policy needs. The case study team in the Guadiana applied social network mapping techniques to identify linkages and gaps between key organizations for adaptation, as reported in Varela-Ortega et al. (2013).

Further, this line of inquiry may address the question of why droughts have negatively impacted farmers in the past. For example, 2005 was particularly bad for crop yields in the Guadiana. Such a line of inquiry assesses potential and actual capacity from the farmers' perspective, and explores the causes of impacts from current climate variability. Such questions are raised with the aim of identifying cognitive and institutional barriers to adaptation which can be addressed by measures which do not require further knowledge about climate impacts (Sections 3.5 and 3.6).

Finally, a third stage of analysis addresses the question of appraising adaptation options. This is especially challenging in the Guadiana because outcomes of interest are thus broader than only economic productivity, and include the ecological conditions of the wetland (Varela-Ortega et al. 2013). The case study team also applied an analytical hierarchy process to appraise different water management options, including increasing storage capacity, changing crop varieties and developing an insurance system. This method allowed stakeholders to consider multiple criteria of options over longer time scales. The approach was favoured over a formal robust decision-making analysis, given the timeframe of the case study, because of the resource-intensive nature of projecting adaptation options over longer time-scales and multiple scenarios.

4.1.2 Drought impacts in Serbian agriculture

In central Serbia, increasing drought impacts threaten the agricultural production of smallholder farmers. Irrigation canals are in poor condition, having fallen into disrepair following land reform and fragmentation of the land base during the post-communist transition. The restoration and maintenance of the irrigation system, which requires collective action due the shared nature of the irrigation canals, would reduce the impacts of current climate variability and future climate change. Therefore, understanding the influence of institutions in supporting and constraining collective action is a salient challenge.

The case study team carried out semi-structured interviews and workshops in order to identify key institutions influencing collective action in the irrigation system, and report on this in Bisaro et al. (2013). Corruption encountered in past experiences with agricultural cooperatives and government officials has led to a lack of trust and eroded social capital, making coordinated action more difficult. Accessing government support and economic incentives requires farmers to register their farms. However, there is a very low rate of farm registration, particularly among small-scale farmers. This has created barriers to farmers acting collectively to maintain the irrigation infrastructure. The team thus found that the institutions affecting farm registration and property taxes are key to understanding conditions and opportunities for collective action.

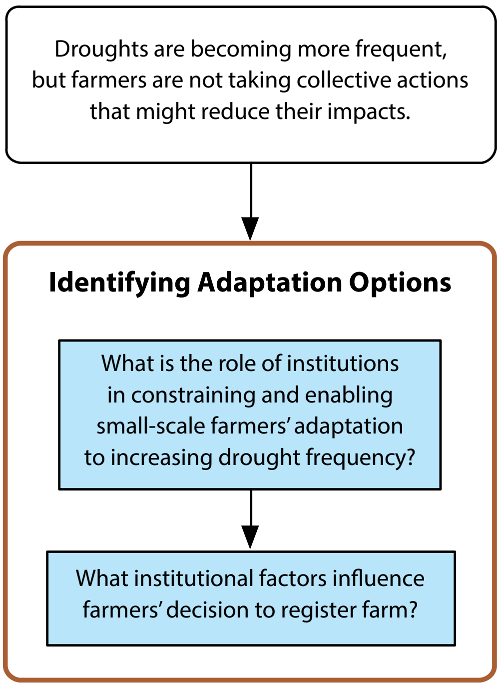

FIGURE 4.1.2 **Schematic diagram of the Serbian case study in the MEDIATION Project.**

Figure 4.1.2 is a diagram was developed based on case study work in the MEDIATION project.

The analysis focused on understanding barriers to collective adaptation options. Institutional analysis was applied and provided insight into why existing irrigation systems are not collectively maintained or improved, and into possible measures for improving this. Results of the institutional analysis identified farm registration, and the factors influencing it, such as farm size and social benefits, as key barriers to collective action. The conclusion was that cross-sectoral planning to address specific legal and procedural barriers is needed, combined with building stakeholder networks, and should be informed by further research to understand and explain the role of the identified barriers.

In the case study, an initial decision was made to focus on identifying adaptation measures rather than impact analysis, due to pragmatic criteria such as the availability of data and resources to carry out a regionally downscaled impact projection (see Section 2.1.1). Available knowledge of large-scale trends in climate and existing risks from climate variability instead motivated an institutional analysis, which may inform the design of "no-regrets" options facilitating collective action for irrigation system restoration and maintenance.

4.2 Policy case

4.2.1 Climate change and ground-level ozone in the UK

Ground-level ozone, a major air pollutant, is created when nitrogen oxides and volatile organic compounds from traffic fumes, industrial processes and other sources react together in the presence of sunlight. Ozone pollution is a known problem in the UK, primarily in the southeast, and during heat waves, when ozone production increases, it adversely affects human health, especially among people with cardiovascular and respiratory problems, and is associated with premature deaths. Future climate change projections for the UK suggest that heat waves may become more frequent and severe.

There are already policies in place to address current ozone, in European, national and local air quality legislation and measures. Previous impact studies have estimated that around 800 to 1,500 additional ozone-related deaths by 2020 per year may be expected due to climate change. Further, impact studies estimate the increase of annual mean ozone from climate change could increase concentrations by 7–33% and 5–20% in urban and rural areas, respectively, for the 2080s.

Projection of future ozone concentrations from climate change is extremely uncertain, however. Ozone concentrations depend on air quality and mitigation policy. Moreover, physical processes linking climate change to ozone formation are not well understood. Other variables, such as age distribution, are important determinants of health impacts, as are health levels and public health policies. There is further a large degree of uncertainty on the physical impact levels, because it is not known if ozone is a threshold pollutant – meaning that health impacts might increase severely, and non-linearly, above a given concentration level.

The immediate risk – of ozone on health – is an existing problem. It is associated with some threshold issues, but these thresholds are dominated by other factors (existing and planned pollution control). The impact of ozone on health is episodic in nature, thus also related to changes in extremes as well as general trends of warmer weather.

The Climate Change Act (2008) created a framework to build the UK's ability to adapt to climate change. It requires the Secretary of State to implement a National Adaptation Programme, and to lay before Parliament an assessment of the risks posed to the UK by climate, the Climate Change Risk Assessment (CCRA), with an update every five years. Supporting this work is an Economics of Climate Resilience study, which is assessing the costs and benefits of adaptation, the scale of the challenge, and the benefits of acting, and identifying priorities. The focus is on what the government needs to do to respond to the climate risks identified, and how much this will cost.

Of particular relevance for the policy background for the UK is that there is an existing framework for action on adaptation, and all government departments have published an initial Departmental Adaptation Plans (DAPs), setting out how they are assessing and managing the risks from climate change (together with their plans for mitigation). These policy frameworks are relevant and determine, to an extent, the formulation of air pollution policy which takes into account adaptation to climate change.

The following diagram has been developed based on expert consultations.

The critical tasks identified involve the three stages of identifying adaptation needs, identifying adaptation measures, and appraising adaptation options. Due to the scale of the analysis, financial considerations and available resources, it was

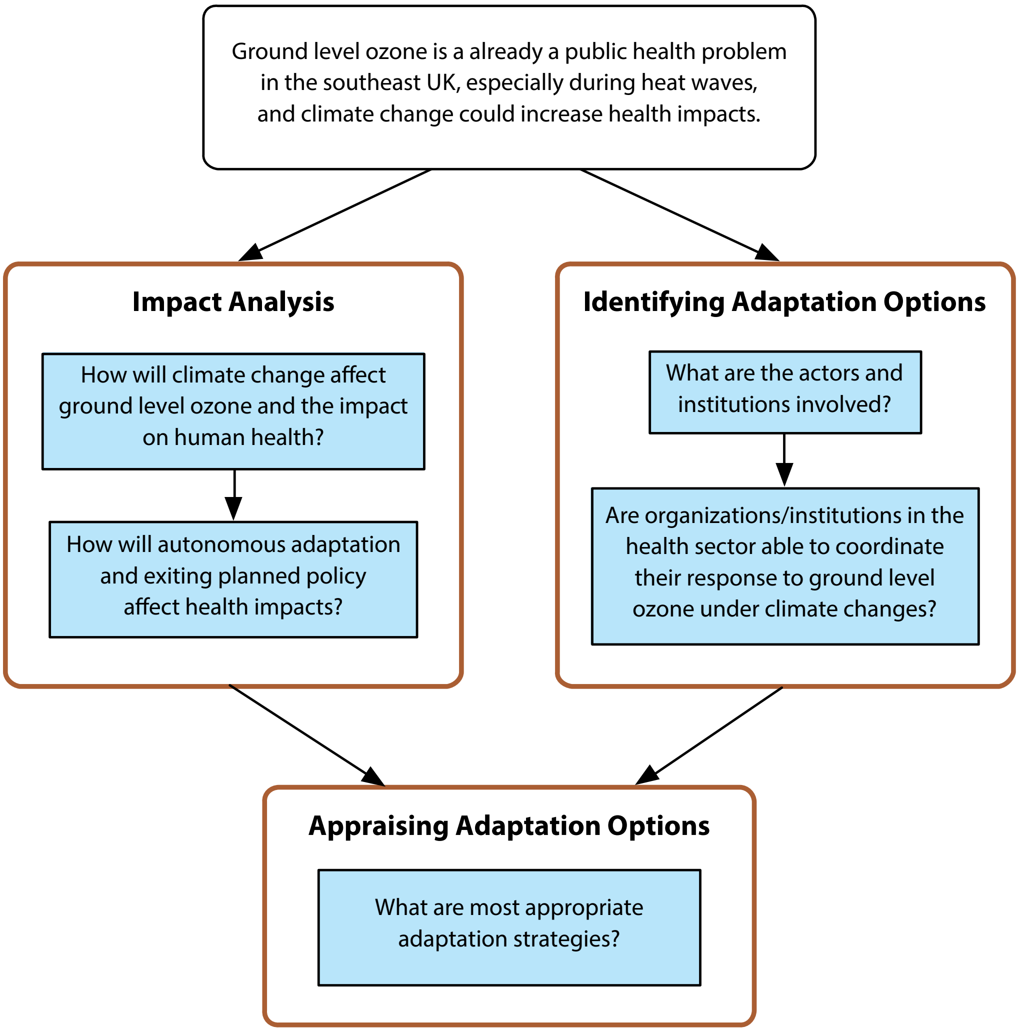

FIGURE 4.2.1 **Schematic diagram of the UK ozone and climate change policy case.**

considered appropriate to carry out an impact analysis. Potential impact was carried out in order to identifying the level of climate risk presented, while residual impact projection then aimed at better representing autonomous adaptive behaviour. In order to include the influence of other policies in relevant sectors, an institutional analysis through governance description was carried out.

Then, a self-assessment method was applied by public actors to assess their awareness and ability to co-ordinate a cross-sectoral response to the health impacts of ozone, particularly with respect to future increases in temperatures and heat wave frequency from climate changes. Deciding on a preferred adaptation option involving public and private stakeholders is a planned future step.

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