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Chapter 6

Tools to mainstream adaptation into decision-making processes

This chapter examines the tools that can be used to mainstream, or integrate, adaptation into existing decision making and appraisal processes. Informed by countries' experiences to date, it explores how adaptation can be included within traditional decision-making tools such as cost-benefit analysis, multi-criteria analysis and cost-effectiveness analysis. It analyses the applicability of new approaches, such as real options analysis, that are designed to support decision making under uncertainty. It discusses the importance of aligning the tools used with the institutional context that they will operate in.

Key messages

- Mainstreaming requires the integration of adaptation into existing processes and decision cycles. This recognises that adaptation will often be one of many policy objectives, and not necessarily the dominant one. It also requires the identification of suitable entry points in the policy process for introducing mainstreaming, noting these will differ across sectors and national contexts.
- To effectively mainstream adaptation, there is a need for pragmatism, capacity building and support for considering climate risks. Success will often be contingent on the timing of such mainstreaming measures and the stage at which they are considered during the decision-making process.
- With greater mainstreaming, adaptation will be further integrated into existing appraisal processes. However, adaptation involves some challenges for existing methods, due to the high uncertainty involved. A suite of new decision support tools have therefore emerged that can assist better decision-making under climate change uncertainty.
- These new methods for decision-making can be resource-intensive and complex to use. These have many potential applications for major policy initiatives and investments. To support mainstreaming, the priority is to develop "light-touch" approaches that capture the core concepts of these new methods while balancing pragmatism with economic rigour.

Adaptation mainstreaming

Adaptation mainstreaming is the integration of adaptation into decision making across a range of policy areas, rather than through the implementation of standalone adaptation measures. Mainstreaming adaptation into policy-making is a continuing process, requiring the integration of climate considerations into existing policy and project cycles. A key element of this is the integration of climate risks into the decision-support tools that are used in standard policy and project appraisal. The concept of mainstreaming – of incorporating an additional factor to the decision process – is not novel to adaptation. It has been applied across a range of policy areas to address cross-cutting issues such as gender, health and environmental impacts, and these provide useful lessons (see Box 6.1 for some examples).

Drawing on countries' experiences, this chapter discusses the key entry points and processes for mainstreaming adaptation, and how new economic tools and approaches can be applied to them. However, early experience shows that many of these approaches can be resource-intensive and complex to use. There is a continuing need to develop "light-touch" approaches that are pragmatic, fit-for-purpose and consider the likely time and resources available. These should capture the conceptual aspects of these new approaches, while maintaining a degree of economic rigour, both at policy and project level.

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Box 6.1. **Existing examples of mainstreaming**

Climate change adaptation is not the first issue to face the challenge of mainstreaming: other initiatives have been successfully mainstreamed in many OECD countries, with notable examples being health, gender and the wider environmental concerns. These provide useful lessons for climate mainstreaming. In the context of health, health impact assessments provide a set of procedures, methods and tools that can help assess the potential effect of various initiatives on the health of a population and the distribution of those effects within the population. In the case of gender, it has been emphasised that mainstreaming does not simply entail increasing the number of women in certain roles; instead, it entails changing the social consciousness so that the effects of a policy for both women and men are carefully analysed before being implemented (True, 2010). This demonstrates the ultimate goal of mainstreaming in changing perceptions and practice. Organisational arrangements for mainstreaming environmental considerations are often top-down in character, whereby the (environment) ministry pushes mainstreaming throughout the generation of guidelines that are then co-ordinated between ministries (Nunan et al., 2012).

In the context of environmental mainstreaming, the OECD (2012) study on greening development highlighted specific interventions including: using multi-year development planning processes; developing key actors' technical skills; encouraging the participation of non-government actors; building functional and technical skills; and planning and targeting efforts carefully. It also provided some recommendations on how development support can deliver better capacity by: viewing capacity support for the environment as underpinning all development support; collaborating across domestic agencies; harmonising approaches among development support providers; nurturing local ownership; focussing on results; implementing best practice guidelines; and reflecting on and learning from the process.

Source: True, J. (2010), "Mainstreaming Gender in International Relations. Gender Matters in Global Politics" (New York: Routledge) L.J. Shepherd (Ed.) pp. 189-203; Nunan, F., A. Campbell and E. Foster (2012), "Environmental Mainstreaming: The Organisational Challenges of Policy Integration", Public Administration and Development 32, 262-277, *http://dx.doi.org/10.1002/pad.1624*; OECD (2012), *Greening Development: Enhancing Capacity for Environmental Management and Governance*, OECD Publishing, Paris, *http://dx.doi.org/10.1787/9789264167896-en*.

The context for adaptation mainstreaming

The multi-sectoral characteristics of climate risks and adaptation responses have significant implications for the development of mainstreaming tools. Policy measures that will affect adaptation are often implemented for non-climate reasons, with multiple objectives and ancillary costs and benefits that are material to the overall choice of the measures. It is therefore important to understand the context for an intervention and decision, including the existing policy and objectives, non-climatic drivers, and the current decision-making process. As an example, resilience may be mainstreamed as part of an urban regeneration programme, but the design of such a programme will be dominated by local economic development objectives and other drivers, such as demographic and land-use change. Mainstreaming requires a good understanding of the individual organisations, institutional networks and processes making relevant decisions. Critically, all of these will differ with each specific adaptation context.

Another characteristic with implications for adaptation mainstreaming relates to the profile of costs and benefits over time for adaptation decisions (DFID, 2014). In many cases, the most important impacts of climate change are likely to arise in the future, say 2040 and beyond. Within economic analysis, the benefits of adapting to these changes accumulate

over long time horizons, while the costs are typically incurred now. Using the public discount rates conventionally used in OECD countries, typically being between 3% and 6%, future adaptation benefits arising from climate change in the medium term and beyond are likely to be small in current terms and thus alone would rarely justify early intervention. This also has implications for the political economy of adaptation decision making, as these timescales do not always fit with political cycles or institutional time horizons. However, as noted in Chapter 3, even OECD countries have an adaptation deficit, and thus resilience to current climate variability offers a good place to start from an economic perspective.

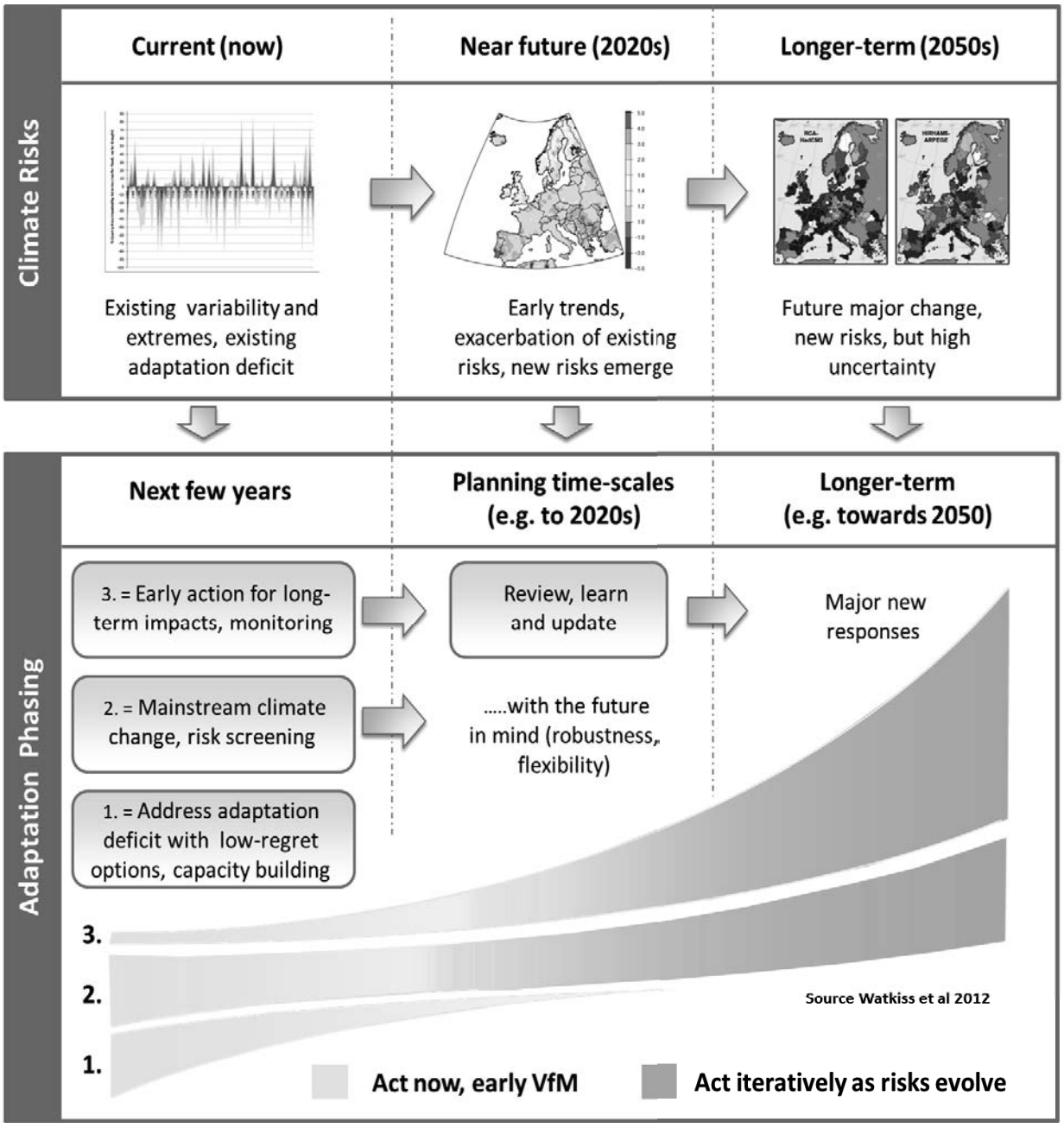
Uncertainty about how both climate and society will change over time makes it more challenging to assess the cost-benefit profile of adaptation options (UNFCCC, 2009; Hallegatte, 2009; Wilby and Dessai, 2010). The consequences of climate change will depend on what is happening to the climate itself, but also to the societies with which it interacts. Neither of these can be reliably predicted over long time horizons. In some instances, it is unclear whether warming will lead to increased or decreased precipitation. An early adaptation response to address a long-term risk (even without discounting) has the potential to misallocate resources by over-investing in risks that do not emerge, or implementing measures that are insufficient to cope with more extreme outcomes. However, inaction as a result of uncertainties could likewise lead to much greater costs in the future, as discussed in Chapter 4.

Earlier frameworks presented adaptation responses as a set of building blocks or a spectrum of options (McGray, Hammill and Bradley, 2007; Klein and Persson, 2008). These included differentiated activities such as: addressing current vulnerability, building adaptive capacity, mainstreaming climate risks, and preparing for and tackling longer-term challenges. More recent updates of these frameworks have made them decision-led, and aligned types of activities and decisions to iterative frameworks (e.g. Ranger et al., 2010; Watkiss and Hunt, 2011). Each activity (or building block) is a different problem type, requiring different types of information, and varying methods of economic appraisal (Li, Mullan and Helgeson, 2014).

An example of such a decision-led framework is summarised in Figure 6.1. The evolution of climate change is presented at the top of the figure, as a process that starts with current climate variability and evolves over time with increasing uncertainty (Watkiss, 2014). In response, the bottom of the figure outlines three different types of adaptation response, which together address the economic and uncertainty challenges. All three types need to be considered together in an integrated adaptation strategy. The use of an adaptation pathway approach can capture and link the different activities together over time (Downing, 2012):

- First, it prioritises early actions that address the current adaptation deficit and help to build resilience for the future, particularly in the short-term when there is limited climate change apparent. This involves early capacity building and the introduction of low- and no-regret actions, which lead to immediate economic benefits (for examples, see Chapter 3). Such actions are grounded in current policy and can often use existing decision support tools.
- Second, there is early action to integrate adaptation into current decisions or activities with long life-times, such as infrastructure or planning. This requires alternative information sources and methods to the first bullet, because of the need to consider future climate change uncertainty. It also recognises that there is a need to consider options in a different way to normal appraisal, such as considering low-cost options, flexibility or robustness to address future uncertainty.

Figure 6.1. **Iterative climate risks and adaptation**



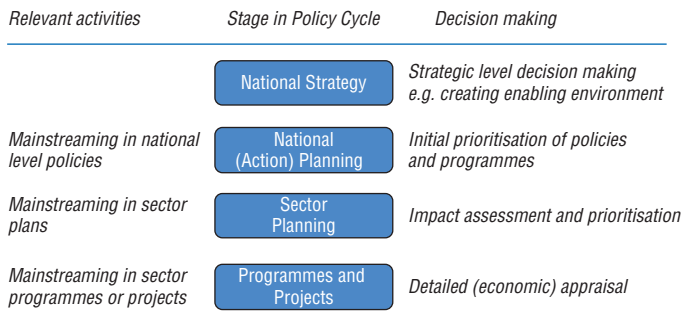
Source: Watkiss (2014).

- Finally, there is a need to consider the potential major impacts of climate change, noting the possible long timescales and high uncertainty. The consideration of these longer-term issues involves important challenges and usually requires new approaches or thinking built around adaptive management. This entails learning from early activities, identifying iterative portfolios that can be brought forward or delayed according to how the future develops, and implementing early actions to address irreversibility, lock-in and encourage transformation.

Mainstreaming entry points and examples

An important component of the mainstreaming process is to find relevant entry points (OECD, 2009), that is, to identify opportunities in the national, sector or project planning process where climate risk considerations can best be integrated. This requires an understanding of the linkages between climate change adaptation and national or sector development priorities. It is also important to consider how these linkages cascade through to implementation, as well as how they are situated within the institutional and political contexts. Figure 6.2 outlines the main levels at which adaptation can be integrated into decision making at the national level. Relevant activities are shown on the left side, with decision making steps on the right. For each level, there will be an entry point for mainstreaming adaptation, i.e. the point for the initial screening and prioritisation of policies or projects. A critical part of the integration process is therefore to identify these entry points and to look for opportunities on how best to include adaptation.

Figure 6.2. **Mainstreaming steps and entry points**



Enabling adaptation mainstreaming at the national level

At the national level, strategic decisions are taken that create the enabling environments for public- and private-sector actors, as well as communities and individuals. In the climate change context, there are now a large number of national OECD climate change strategies and a growing number of national adaptation action plans (see Mullan et al., 2013; Wilby, 2012; EEA, 2014).

In the United Kingdom, the government's approach is for climate change adaptation to be mainstreamed across all policy areas. To facilitate this process, the first UK climate change risk assessment, published in 2012, was followed up with a detailed analysis of adaptation, as part of the Economics of Climate Resilience study and the National Adaptation Programme (Frontier, 2013; HMG, 2013a; HMG, 2013b). The adaptation method for this (Watkiss and Hunt, 2011) used iterative adaptive management, drawing on the example of the Thames Estuary 2100 project (EA, 2009; 2011). It focused on mainstreaming at the sector level, working with the individual departments across government. It included a pathway analysis for a number of key risks to identify entry points and activities within existing policies and areas. The UK has also invested heavily in capacity support and in the development of tools, initially with the UK Climate Impacts Programme, and more recently with the Climate Ready team at the Environment Agency, to provide support to other policy areas for the mainstreaming approach.

Another example is the Dutch Delta programme, which has the mandate to create a strategy for the long-term protection of the coast and its hinterland (Deltacommissie, 2008).

This programme not only considers flood protection, but also includes fresh water supplies, and the wider interactions between life and work, agriculture, nature, recreation, landscape, infrastructure and energy, with a strong emphasis on sustainability. It uses an iterative adaptive management approach that prepares for the future and considers decisions in a timely fashion to plan investments (Delta Programme, 2011). It also considers short-term measures that increase adaptability (flexibility) and resistance to extreme events (robustness), to make it possible to delay reaching tipping points. Most recently, the development of adaptation plans has also been extended to consider dynamic adaptation pathways (Delta Programme, 2014; Haasnoot et al., 2013). The Netherlands has also produced a comprehensive tool for dealing with climate adaptation issues ("*handreiking ruimtelijke adaptatie*").

While recognising different circumstances between countries, lessons can be learned from the practices in developing countries. In the climate change context, developing countries have adopted a range of approaches to mainstreaming adaptation in national development strategies. For example, developing countries already include "environment" as a cross-cutting theme in their national development vision, national development plans (e.g. medium-term plans, five year plans or poverty reduction strategies), and sector development plans. In a few countries, these activities are being integrated, or at least tracked, in the national budget allocation process and in sector budget activities. Such initiatives can be extended to include climate. An example is Rwanda, which has integrated climate change (with environment) as one of seven cross-cutting issues in national development and sector development planning (Republic of Rwanda, 2012). Rwanda is also including related indicators into its budgeting process and public financial management. Some other lessons from mainstreaming practices in developing countries are heighted in Box 6.2.

Mainstreaming adaptation at programme and project levels

Existing safeguard mechanisms, such as environmental impact assessment (EIA), provide a natural entry-point for considering whether projects are vulnerable to climate change or could exacerbate climate risks elsewhere. Although originally designed to prevent negative impacts on the environment, the EIA process has the benefit of being a familiar and well-established part of the policy making process in OECD countries (Agrawala et al., 2010). It will, however, only capture those policies that are subject to environmental impact assessments, such as infrastructure construction. Moreover, it may require revision of the legal framework to include climate risks.

More generally, climate risk screening can be applied as a step in the policy-making process to identify where policies, programmes or projects may be particularly vulnerable to climate change. This has emerged strongly in relation to investment projects funded by the international finance institutions and multilateral development banks. For example, the African Development Bank (AfDB, 2011) has introduced a Climate Safeguard System that includes a traffic light system, or scorecard, to identify which projects may be particularly vulnerable to climate risk. These projects may then require a more detailed evaluation to consider integration of climate aspects into design and implementation. These evaluations tend to have a strong focus on enhancing the climate resilience of infrastructure or major investments.

A complement to the identification of high-risk policies, projects and programmes is the integration of adaptation into existing policy and project appraisal guidance. This entails the modification of existing appraisal guidance to also cover climate change or to support the consideration of some of the additional aspects and challenges of adaptation.

Box 6.2. **Mainstreaming practices in developing countries**

In a developing country context, mainstreaming activities usually follow a slightly different path than in developed countries, with different entry points, reflecting the differences in national strategic planning. Many developing countries are producing National Adaptation Plans (NAP). The UN guidance for the development of NAPs outlines the need for mainstreaming in developing such plans. This is critical because of the strong overlap with existing development activities (LDC Expert Group, 2012). In this context, there is a different set of entry points for mainstreaming, outlined in the table below (UNDP/UNEP, 2011) that often operate through different organisational leads. This structure closely parallels that outlined for environmental mainstreaming more generally (OECD, 2012).

Possible entry points for mainstreaming in national strategic planning policy in developing countries

Planning level	Entry point
National government and cross sector ministries	• National development vision (long-term) • Poverty reduction strategy • National development plan (e.g. 5 years) • National budget allocation process or review
Sector ministries	• Sector development plans • Sector master plans • Sector budgets
Sub-national authorities	• Decentralisation plans • District plans • Subnational budgets

Source: LDC Expert Group (2012), *National Adaptation Plans. Technical guidelines for the national adaptation plan process*, Bonn: UNFCCC secretariat. Bonn, Germany. December 2012. Available at: *http://unfccc.int/NAP*; UNDP /UNEP (2011), *Mainstreaming Climate Change Adaptation into Development Planning: A Guide for Practitioners*, UNDP-UNEP Poverty-Environment Initiative, Nairobi; OECD (2012), *Greening Development: Enhancing Capacity for Environmental Management and Governance*, OECD Publishing, Paris, *http://dx.doi.org/10.1787/9789264167896-en*.

For example, in the United Kingdom, supplementary "Green Book" guidance was published to support policy makers in accounting for adaptation in economic policy appraisal. This recommended an iterative adaptive management approach and provided guidance on options appraisal, including real options analysis.

A further approach is to update engineering or design standards to account for climate change. This has been done for flood protection standards in Denmark, Germany, Australia and the United Kingdom (Wilby and Keenan, 2012). However, caution is needed to ensure that the benefits of such actions justify the additional costs, especially given future discounting of uncertain benefits and the context specific nature of adaptation.

Enabling conditions for mainstreamed decision making

Mainstreaming does not occur in a vacuum, and it is essential to understand and integrate adaptation within the existing socio-institutional landscape. For mainstreaming to be effective, entry points must be identified. Further, mainstreaming approaches need to align to the policy and institutional landscape, and consider existing processes or guidance, such as project cycle steps and appraisal documentation already in place. Since mainstreaming will be country, sector and even organisation specific, this cautions against the development of generic tools for mainstreaming adaptation.

Pragmatism is essential as any tools or guidance need to fit with the resource, time, capacity and expertise available for policy or project analysts, otherwise there is a danger that they will not get used. As an example, the UK supplementary guidance on adaptation recommends the use of real options analysis (HMT, 2009), but this proved challenging to apply outside of the context of infrastructure projects. This may mean a focus on providing information and processes that are fit for purpose, rather than perfect, particularly given the potential complexity of climate change and uncertainty analysis.

The stage at the decision-making process when adaptation is considered is critical. It is important to ensure that the mainstreaming activities come early enough in the process to influence the decision, or are targeted at key windows or "intervention opportunities" (Ballard, 2014) (see Box 6.3 for some examples). This is particularly important when there are long-lived decisions or defined policy opportunities for change.

Box 6.3. **The issue of timing and intervention opportunities**

Mainstreaming activities often need to occur early in the process if they are to be influential. An example is climate risk screening of infrastructure or investment decisions. First, there is a need for strategic issues to be identified early on, either in relation to the sector strategy or the overall investment portfolio. For example, if there are major climate risks at the river basin level, these are more difficult to address at the individual project level; instead, a strategic risk screening (e.g. within the strategic environment assessment or investment strategy) at the outset could identify such risks. Second, the analysis of climate risks and mainstreaming activities needs to occur early in the project cycle, such as at the concept or early design stage, or at the latest during the detailed design phase. The analysis should ideally be aligned to approval milestones. The inclusion of adaptation considerations at the environmental impact assessment stage, for example, is usually too late to have a major influence on project design.

For some decisions or investments, there may be very narrow and critical windows of opportunity to influence decisions. Moser and Ekstrom (2010) highlight "non-climatic windows of opportunity" such as land-use plan updates, infrastructure replacement and building renovations. Paradoxically, it may be that natural – or climate change – disasters provide opportunities to reduce further, longer-term risks since stakeholders are galvanised to act. For example, *ex post* reconstruction following a disaster such as Hurricane Katrina has resulted in an urban development patterns more cognizant of the possibility of such climate risks occurring in the future (O'Brien et al., 2012).

Source: Moser, S.C. and J. Ekstrom (2010), "A framework to diagnose barriers to climate change adaptation", Proceedings of the National Academy of Sciences of the United States of America, Vol. 107(51), *http://dx.doi.org/10.1073/pnas.1007887107*; O'Brien. K. (2012), "Global environmental change II: From adaptation to deliberate transformation", *Progress in Human Geography*, Vol. 36 (5), *http://dx.doi.org/10.1177/0309132511425767*.

In practical terms, the path from identifying potential entry points and providing tools through to implementing mainstreaming is often challenging. Achieving this requires involving a diversity of users and stakeholders, finding relevant champions, building partnerships and providing support networks. Such support networks will be particularly important as mainstreaming moves from a central unit (e.g. located in the environment ministry) out to other ministries. The complexity of decision support tools needs to be aligned to the capacity, time availability, capability and interest of sectors in switching from other tasks to climate mainstreaming. It is also critical to complement tool

development with capacity development. This support must be complemented by good co-ordination and assistance. An example is the "Handbook for Local Elected Officials on Climate Change" used in Canadian municipalities to develop strong leadership on adaptation mainstreaming (Vaughan, 2012).

It is useful for decision makers to also identify opportunities that can be created by implementing adaptation, rather than focusing only on the risks and amelioration actions. For example, establishing development zones connected to ports with efficient transport may incentivise infrastructure development in areas away from the coasts (Hallegatte, 2011). The New Brunswick Climate Change Action Plan 2014-20 in Canada, for example, provides discussion of such alternatives and clearly specifies the importance of ensuring that adaptation to climate change is incorporated into every-day decisions within the province (Province of New Brunswick, 2014).

Enhancing the understanding of the barriers or constraints to adaptation can help to move from an idealised model of adaptation planning to the reality of how it plays out in practice. The UK experience provides some useful lessons (Cimato and Mullan, 2010; Frontier Economics, 2013; HMG, 2013b) These lessons include the need to identify key barriers to effective adaptation (including market, policy, behavioural and governance failures), to build organisational adaptive capacity, and to introduce enabling actions that are likely to lead to more effective adaptation (see Box 6.4 for details on each of these barriers).

Box 6.4. **Barriers to adaptation**

Barriers or constraints to adaptation are factors that make it harder to plan and implement adaptation actions (IPCC, 2014). Barriers will make adaptation less efficient or less effective. Alternatively, they may require changes that lead to missed opportunities or higher costs (Moser and Ekstrom, 2010). In 2013, the UK government in its National Adaptation Programme identified the main barriers to socially efficient adaptation as market failures, policy failures, governance failures and behavioural barriers (HMG, 2013b):

- **Market failures** can occur e.g. due to lack of information, the presence of externalities and public goods, information asymmetry and misaligned incentives. Economic theory applied to adaptation (e.g. Fankhauser, Smith and Tol, 1999; Mendhelson, 2000; Cimato and Mullan, 2010), as well as empirical observations (Mendelsohn, 2000; Osberghaus et al., 2010a; Wing and Fisher-Vanden, 2013) indicate that such actions will not receive appropriate levels of private investment. For example, Lee and Thornsbury (2010) point out that under different market structures (monopoly, oligopoly or perfect competition), the ability of investors to reap the benefits of adaptation will vary, and therefore also their incentives to invest in it.
- **Policy failures** occur when conflicting policy objectives co-exist (which is often) and there are not appropriate mechanisms for addressing these trade-offs (Frontier Economics, 2013). For example, urban development objectives may not take into account the vulnerability of assets and human systems to climatic stresses. Also, when policies result in market distortions (e.g. price or income subsidies), people will under- or over-adapt depending on how their adaptation choices will translate into income changes (Fankhauser, Smith and Tol, 1999).
- **Governance failures** refer to ineffective institutional decision-making processes, e.g. when the current structure of institutions and regulatory policies is poorly aligned to account for adaptation objectives (Craig, 2010; Spies, 2010; Stillwell et al., 2010; Stuart-Hill

Box 6.4. **Barriers to adaptation** *(cont.)*

and Schulze, 2011; Eisenack and Stecker; 2012; Huntjens et al., 2012; Herrfahrdt-Pähle, 2013). Adaptation typically requires multiple actors and institutions with different objectives, jurisdictional authority and levels of power and resources. The complexities of governance networks can constrain adaptation (see Klein et al., 2014). Overlapping mandates of government entities tend to create conflicts and slow adaptive responses. Further, lengthy bureaucratic processes and lack of transparency are an impediment to fiscal planning and access to finance, particularly relevant for developing countries (Setz et al., 2008). Poor – or lack of – leadership (Moser and Ekstrom, 2010), lack of a clear mandate, and the short-term political cycle can also represent barriers to effective decision making (Lehmann et al., 2012). Corruption within institutions also undermines adaptation efforts (Lesnikowski et al., 2013; Schilling et al., 2012).

- **Behavioural barriers** are concerned with the observed inability of individuals to take what appear to be rational decisions (i.e. to maximize their net benefits or utilities) and with their cognitive limitation in attempting to achieve their goals. This limitation manifests itself as inertia, procrastination, and the use of time-inconsistent discounting (see Simon, 1999; Jones, 1999; Cimato and Mullan, 2010). Social values and beliefs can also support or hamper adaptation (Jones and Boyd, 2011; Stafford-Smith et al., 2011; Adger et al., 2012) in so far as they frame how societies develop rules and institutions to govern risk, and to manage social change and the allocation of scarce resources (Ostrom, 2005).

Further, individuals, institutions and the natural environment will clearly adapt within the boundaries of their adaptive capacity (see Oberlack and Neumarker, 2011; Stern, 2006; Kuch and Gigli, 2007; Osberghaus et al., 2010b; Hallegatte, Lecocq and de Perthuis, 2011), and physical and biological constraints. Gender, age, education, access to infrastructure and finance, and access to markets and technology are all elements that determine the adaptive capacity of social systems. Natural systems' ability to adapt will be possible within certain climatic thresholds, and can be hampered by other non-climatic stresses (Klein et al, 2014; Cimato and Mullan, 2010), and the presence of physical barriers (e.g. the lack of corridors for species migration).

Source: Bones and Boyd (2011); Cimato and Mullan (2010); Craig (2010); Eisenack and Stecker (2012); Fankhauser, Smith and Tol (1999); Frontier Economics (2013); Hallegatte, et al. (2011); Herrfahrdt-Pähle (2013); HMG (2013b); Huntjens et al. (2012); Jones (1999); Klein et al. (2014); Kuch and Gigli (2007); Lee and Thornsbury (2010); Lehmann et al. (2012); Lesnikowski et al. (2013); Mendhelson (2000); Moser and Okstrom (2010); Oberlack and Neumarker (2011); Osberghaus et al. (2010a); Osberghaus et al. (2010b); Ostrom (2005); Schilling et al. (2012); Setz et al. (2008); Simon (1999); Spies (2010); Stafford-Smith et al. (2011); Stern (2006); Stillwell et al. (2010); Stuart-Hill and Schulze (2011); Wing and Fisher-Vanden (2013).

Recent plans for mainstreaming adaptation have started to use iterative climate risk management approaches, with examples in both OECD and non-OECD economies. Iterative approaches identify different activities compared to older adaptation impact assessment studies, with a greater focus on capacity building and enabling steps. They also provide a stronger economic justification for early intervention and longer-term action (post 2030), noting the latter is often missed in more traditional sector mainstreaming. As an example, the use of an iterative approach identified the long-term risks of climate change for the Ethiopian coffee industry, even though this was not a short-term focus for vulnerability (FDRE, 2014). Iterative approaches also provide a framework for review and evaluation. However, these approaches require detailed analysis and capacity to implement.

Decision support tools for mainstreaming

Standard public policy and project appraisal involves a systematic decision-making process: understanding the problem; identification of options; appraisal of options (and implementation approach); planning and implementation; and finally monitoring and evaluation. This approach is often formalised through guidance on impact assessment or economic appraisal and evaluation, for both policy and project decisions. Earlier impact-assessment driven studies of adaptation did not consider this broader appraisal framework, and instead largely considered adaptation, external to established processes. However, in recent years, there has been a shift towards adaptation assessment more closely aligned to the policy implementation cycle above, e.g. the UN PROVIA initiative.[2]

In terms of the standard policy or project cycle, there are two points where decision support tools are particularly important; i) for shortlisting options and ii) for prioritising the shortlisted options. The process of identifying a shortlist of options (e.g. scoping or feasibility) includes, for instance, identifying focus areas for a national plan or strategy, or a broad list of options for an individual policy or project. The prioritisation of options can be as part of detailed policy or project appraisal, based on the characteristics of climate change and other risks, as well as economic and social considerations. In the adaptation context, there is an emerging community of practice and useful examples for shortlisting and prioritisation, outlined below.

Identifying and shortlisting options

There are standard methods for shortlisting options, which may take the form of scoping economic analysis, simple attribute analysis and ranking, or stakeholder consultation and expert elicitation. These are common to most policy or project cycles, and can thus be included within a mainstreaming perspective. In the national context, most adaptation examples have been part of national or sector action planning. Similar approaches can also be taken at the project level. The aim of these processes has been to filter options down to a manageable shortlist of priorities, which can then be appraised.

Previous studies have considered a large number of methods for these early tasks, often looking at economic and other criteria to shortlist options. A key innovation of these recent approaches is that they include criteria that are of direct relevance to adaptation: for example, urgency, no- or low-regret characteristics, co-benefits, alongside the standard consideration of costs and benefits. Practical examples include the national Routeplanner exercise in the Netherlands (Van Ierland et al., 2006; De Bruin et al., 2009).

More recent assessments of adaptation actions have started to use iterative climate risk management in the scoping and initial prioritisation phase. A key advantage of this is that it identifies options with different time scales and levels of uncertainty, which can help with the phasing of responses. These include options that are beneficial, even without considering future climate change. An example is enhanced disaster risk management, which address the current adaptation deficit and helps to build future resilience. It also includes early options that build "resilience" into infrastructure development or planning processes, where there are long life-times, as well as options that introduce iterative planning and monitoring for the long-term.

Tools for appraising options

The methods outlined in the preceding paragraphs are, or can be, used to effectively incorporate climate risks into wider development policies, programmes and projects. The

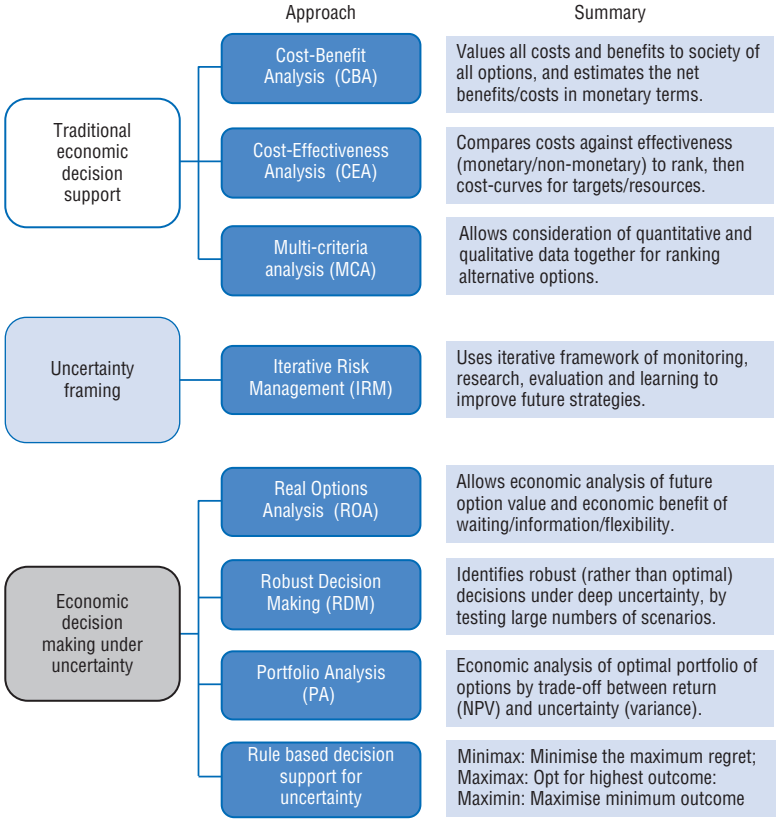
subsequent selection and prioritisation of shortlisted options can then be assisted by the use of a variety of decision support methods and tools. Indeed, a principal focus of policy and project analysis for adaptation to date has been on the appraisal stage, specifically the prioritisation of adaptation options. There are, however, a number of distinctive factors that are important to consider when supporting decision making on adaptation. For example, there are no simple common metrics to compare and prioritise different adaptation interventions because of the highly site- and context-specific nature of adaptation. This contrasts with mitigation options, which target a common burden (greenhouse gas emissions), that can be prioritised in terms of the cost of abating a tonne of CO_2 equivalent, using cost-effectiveness analysis. The analysis of adaptation options therefore involves additional steps to assess the impacts and to assess potential benefits, noting that many impacts are in non-market sector benefits (e.g. health, ecosystems), and that many adaptation options are non-technical in nature. There are several techniques for incorporating non-market benefits in cost-benefit analysis, but this can be a resource intensive process. This further complicates the quantification and valuation of different options.

Adaptation appraisal also has to consider the dynamic and changing nature of climate change over time, including the inter-dependencies in climate risks. The issue of future climatic (and socio-economic) uncertainty also has to be incorporated since it affects both the selection of adaptation options and the decision-framework used for prioritisation (see Chapter 4 for further discussions). Due to these diverse challenges, the most common techniques used in policy appraisal (e.g. cost-benefit analysis and cost-effectiveness analysis) have limitations in coping with adaptation. This is consistent with the latest report by the Intergovernmental Panel on Climate Change (IPCC), which highlights that "economic thinking on adaptation has evolved from a focus on cost-benefit analysis and identification of 'best economic' adaptations to the development of multi-metric evaluations" and that "economic analysis is moving away from a unique emphasis on efficiency, market solutions, and benefit-cost analysis of adaptation to include consideration of non-monetary and non-market measures; risks; inequities; behavioural biases; consideration of ancillary benefits and costs" (Chambwerra et al., 2014).

There is a growing evidence base and body of practical experience of the use of decision support approaches for adaptation appraisal. These include conventional decision-support methods, notably cost-benefit analysis, cost-effectiveness analysis and multi-criteria analysis. These also include approaches that allow for consideration of uncertainty, notably real options analysis, robust decision making, portfolio analysis and iterative risk management (see MEDIATION, 2013 and Watkiss et al., 2014 for a detailed description and review of these methods and their application to adaptation). The different methods summarised in Figure 6.3 are categorised as: traditional economic tools, uncertainty framing, and economic decision making under uncertainty. The latter two categories build on the principles in the first category and are distinct either because they introduce a dynamic component (e.g. for iterative risk management and real options analysis), they use a different/additional criterion (robust decision making or portfolio analysis), or do not rely on probabilistic data (rule-based methods).

Whilst these tools have primarily been developed in the context of project-level appraisal, in principle they can be used to inform the development of policy initiatives at the national and sectoral levels. However, these tools serve principally as an organising framework at those levels, often with semi-quantitative versions due to limited data

Figure 6.3. **Decision support tools for adaptation**



Source: Updated from Watkiss, P. et al. (2014), "The use of new economic decision support tools for adaptation assessment: A review of methods and applications, towards guidance on applicability", *Climatic Change*, *http://dx.doi.org/10.1007/s10584-014-1250-9*.

availability. They do, nonetheless, provide a good guide to the economic merits of the initiatives. At the project level, where data are available, they can be applied more quantitatively. Examples of adaptation applications are summarised in Table 6.1.

Table 6.1. **Examples of appraisal methods used in the adaptation context**

Tool	Published example applications
Cost-Benefit Analysis (CBA)	A South African case study examined the benefits and costs of avoiding climate change damages through structural and institutional options for increasing water supply in the Berg River Basin in the Western Cape Province (AIACC, 2006). In Germany, cost-benefit analysis was applied to assess 28 adaptation options (Tröltzsch et al., 2012).
Cost-Effectiveness Analysis (CEA)	Boyd, Wade and Walton (2006) undertook a detailed application of cost-effectiveness for water resource zones and the potential adaptation response to reduce household water deficits from future climate change in the United Kingdom. Tainio et al. (2013) investigated the cost-effectiveness of alternative conservation measures that could maintain the biodiversity of Finnish semi-natural grasslands under a changing climate.
Multi-criteria analysis (MCA)	Van Ierland et al. (2006) applied MCA to assess adaptation options for the Netherlands as part of the Routeplanner national study. This used a qualitative MCA, which included various adaptation criteria. A quantitative MCA was used in the Thames Estuary 2100 project (EA, 2009; EA, 2011) as part of a broader study looking at future coastal flood defences for London. The MCA was used to include qualitative criteria (e.g. environment and heritage) alongside formal economic cost-benefit analysis.
Real Options Analysis (ROA)	Jeuland and Whittington (2013) applied real option analysis for a water resource planning case study (large water storage projects) in Ethiopia along the Blue Nile. Van der Pol et al. (2013) looked at optimal dike investments under uncertainty with learning about increasing water levels.

Table 6.1. **Examples of appraisal methods used in the adaptation context** *(cont.)*

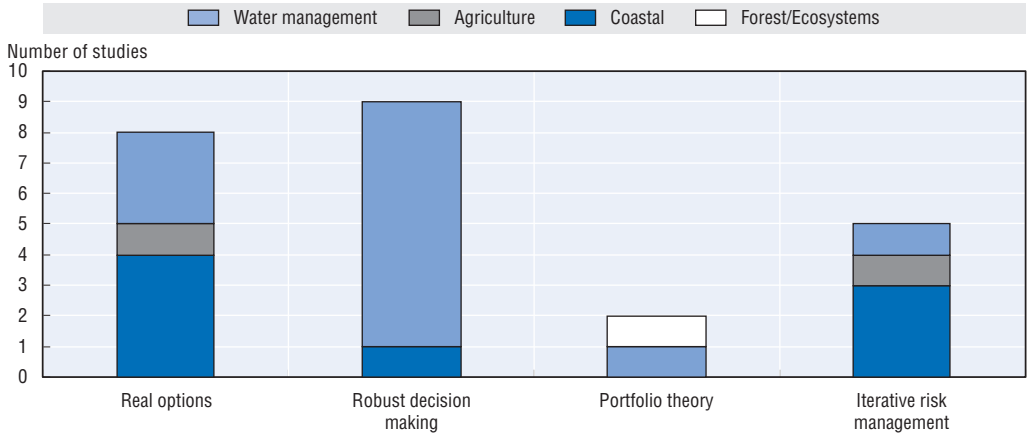
Tool	Published example applications
Robust Decision Making (RDM)	A comprehensive, formal application of RDM was undertaken by Lempert and Groves (2010) for Southern California's Riverside County Inland Empire Utilities Agency (IEUA). Dessai and Hulme (2007) present an example of the application for RDM to look at climate uncertainty for water supply management in the United Kingdom.
Portfolio Analysis (PO)	Crowe and Parker (2008) use portfolio analysis to investigate genetic material that could be used for the restoration or regeneration of forests under climate change futures. Hunt (2009) applied portfolio analysis to a case of local flood management in the United Kingdom, looking at portfolios of hard and soft options.
Iterative Risk Assessment (IRM)	The Thames Estuary 2100 project (EA, 2009; EA, 2011; Reeder and Ranger, 2011) developed a tidal flood-risk management adaptation plan for London using an iterative planning approach and adaptation pathways, with a detailed monitoring and evaluation strategy.

Source: ECONADAPT (2015), "The Costs and Benefits of Adaptation", results from the ECONADAPT Project, ECONADAPT consortium, *http://econadapt.eu/*.

Appraisal review findings and lessons

Analysis of conventional as well as of new appraisal support tools and discussion with practitioners reveals some interesting lessons. A recent review (ECONADAPT, 2015) sought to identify applications of new decision-support tools. It found that the number of economic applications of the new tools to adaptation remains low, in both absolute terms and relative to the use of conventional tools such as cost-benefit analysis and cost-effectiveness analysis. Applications were concentrated in sectors such as water management, coastal management and agriculture (Figure 6.4). These applications are predominantly stand-alone assessments, rather than as part of mainstreamed assessments.

Figure 6.4. **Applications of new decision support tools for adaptation**



Source: ECONADAPT (2015), "The Costs and Benefits of Adaptation", results from the ECONADAPT Project, ECONADAPT consortium, *http://econadapt.eu/*.

Most economic applications are academic studies, often focused on technical adaptation, with less application in direct project or policy appraisals (ECONADAPT, 2015). The more applied studies include the application of iterative risk assessment in national policy appraisal in the Netherlands (iterative management for the Delta Programme, 2014) and in Ethiopia (the National Climate Resilience Strategy: FDRE, 2014). Iterative risk assessment has also been implemented at the project level with the application to the London Thames Estuary 2100 project (EA, 2009; EA 2011). Robust decision making has been applied to water management in the Colorado river (Groves et al., 2013), flood risk management in Ho Chi Minh

City in Viet Nam (Lempert et al., 2013) and coastal resilience planning in Louisiana (Groves and Sharon, 2013). Real options analysis has been applied in practice in the context of mitigation, but has yet to inform practical adaptation decisions. Real options analysis has also focused on sea level rise, which is easier to assess due to its slow-onset nature and known direction of change. Its advantage over cost-benefit analysis (to which it should be seen as a complement) is that it explicitly accounts for learning and adjustment of the adaptation investment over time, as climate – and other – uncertainties are resolved.

Analysis of these applications show that there are no hard or fast rules on when to use which tool, yet certain tools lend themselves more to specific contexts or sectors. The type of adaptation problem (and objective) will therefore shape the choice of the decision-support tool used. Importantly, none of these decision-support tools is universally applicable to all adaptation problems and they each have particular strengths for certain types of decisions and applications. The principal criteria on which these tools can be evaluated include: availability of probabilistic climate impact data; availability of monetary values for non-market impacts; and importance of climatic uncertainty to main decision variables. Some indicative analysis is presented in Table 6.2.

Table 6.2. **Attributes and application of decision support methods for adaptation**

Decision-support tool	Strengths	Challenges	Applicability	Potential use
Cost-Benefit Analysis (CBA)	Well known and widely applied.	Valuation of non-market sectors/ non-technical options. Uncertainty limited to probabilistic risks/ sensitivity testing.	Most useful when climate risk probabilities are known and sensitivity is small.	To identify low- and no-regret options. As a decision-support tool within iterative climate risk management
Cost-Effectiveness Analysis (CEA)	Analysis of benefits in non-monetary terms.	Single headline metric difficult to identify and less suitable for complex or cross-sectoral risks. Low consideration of uncertainty	As above, but for non-monetary sectors (e.g. ecosystems) and where social objectives exist (e.g. acceptable risks of flooding).	As above, but for market and non-market sectors where benefits are not monetised.
Multi-Criteria Analysis (MCA)	Analysis of costs and benefits in non-monetary terms.	Relies on expert judgement or stakeholders, and is subjective, including analysis of uncertainty.	When there is a mix of quantitative and qualitative data. Can include uncertainty performance as criteria.	As above, as well as for scoping options. Can complement other tools and capture qualitative aspects.
Iterative Risk Assessment (IRA)	Iterative analysis, monitoring, evaluation and learning.	Challenging when multiple risks acting together and thresholds are not always easy to identify.	Useful for long-term and uncertain challenges, especially when clear risk thresholds exist.	For appraisal over medium-longer term. Also applicable as a framework at policy level.
Real Options Analysis (ROA)	Value of flexibility, information.	Requires economic valuation (see CBA), probabilities and clear decision points.	Large irreversible decisions, where information is available on climate risk probabilities.	Economic analysis of major capital investment decisions. Analysis of flexibility within major projects.
Robust Decision Making (RDM)	Robustness rather than optimisation.	High computational analysis (formal) and large number of model runs.	When uncertainty is large. Can use a mix of quantitative and qualitative information.	Identifying low- and no-regret options and robust decisions for investments with long life-times.
Portfolio Analysis (PA)	Analysis of portfolios rather than individual options.	Requires economic data and probabilities. Issues of interdependence.	When number of complementary adaptation actions and good information.	Project based analysis of future combinations. Designing portfolio mixes as part of iterative pathways.

Source: Adapted from Watkiss, P. et al. (2014), "The use of new economic decision support tools for adaptation assessment: A review of methods and applications, towards guidance on applicability", *Climatic Change*, *http://dx.doi.org/10.1007/s10584-014-1250-9*.

As mentioned above, policy-level assessments are more likely to make use of the established tools that provide a framework for more aggregated analysis. Nonetheless, iterative risk frameworks and robust decision making also have high potential for programme and sector analysis though they are more widely used at the project level. At the project level, tool selection will be influenced by data availability and the level of uncertainty. Several approaches, such as real options and portfolio theory, require subjective probabilistic inputs at a minimum, but perform better when objective probabilistic inputs are available. Suitable probabilistic climate projections are not available for all geographic regions.

While existing decision support tools, including cost-benefit analysis, can be used for studies that are focused on current climate variability, adaptation interventions are often in areas that are difficult to value, and usually involve a lack of quantitative information. In such cases, cost-effectiveness, multi-attribute analysis (or multi-criteria analysis) may be more practical, notwithstanding the limitations of these approaches. For the analysis of short-term decisions with long life-times and longer-term challenges, a greater focus on new decision support tools is warranted. Robust decision making has broad application for current and future time periods. When investments are nearer term (especially high up-front capital investments), and where there is an existing adaptation deficit, real options analysis is a potentially useful tool. For long-term applications in conditions of low current adaptation deficit, iterative risk assessment may be more applicable. Importantly, while the tools are presented individually, they are not mutually exclusive.

It is worth noting that the differences between the tools are not limited to data and capacity constraints but may have a material impact on the order of prioritisation of adaptation options. Klijn, Mens and Asselman (2014) demonstrate that applying robust decision making results in a different order from cost-benefit analysis, and cost-benefit analysis produces a different order from cost-effectiveness analysis.

A key message, however, is that all the new methods are resource-intensive and can be technically complex. This constrains their formal application to large investment decisions or major risks, which are priority projects for adaptation. These issues are likely to limit future application in the mainstreaming context, especially in developing countries, but also in OECD countries, as shown by early implementation experience (HMT, 2008). The translation into sectoral contexts, with analysts who may not have extensive knowledge of climate projections and uncertainty, is likely to be difficult.

A critical question is therefore whether the concepts in these approaches to uncertainty can be used in "light-touch" approaches that capture their conceptual aspects, while maintaining a degree of economic rigour, both at policy and project level. This would allow a wider application in qualitative or semi-quantitative analysis. Possible elements include the broad use of decision tree structures from real options analysis, the concepts of robustness testing from robust decision making, the shift towards portfolios of options from portfolio analysis, and the focus on evaluation and learning from iterative risk assessment for long-term strategies. There has been some progress advancing these types of "light-touch" applications (Hallegatte et al., 2012; Ranger et al., 2013). However, more research needs to be undertaken to better understand how and where the trade-offs between quantitative analysis and pragmatic application can be made.

Additional issues with mainstreaming and appraisal

The discussion and the tools above are predominantly focused on the challenges of timing and uncertainty. However, as outlined in Chapters 3 and 4, there are a number of other methodological challenges with adaptation. These include assumptions regarding the choice of discount rate, equity weighting or distributional issues and risk preferences. They also include issues of baselines, analysis of non-technical options, issues of scale and aggregation, and transferability of benefits and costs. These challenges potentially apply at both the policy and programme levels, as well as the project-level. The larger scale and the increased number of actors may also mean that the appraisal and implementation processes and the monitoring of outcomes become more challenging, with differing views on how to best address these issues.

These additional issues can potentially complicate the process of mainstreaming. For instance, discounting means that longer-term benefits have less weight in the decision-making process than those occurring now. While this takes account of preferences, and allows the effective allocation of resources, it can reduce the attractiveness of more sustainable options, for example, it usually takes several years for the benefits of sustainable agriculture to become apparent (Berger and Chambwera, 2010). Discounting can make it difficult to justify early action to address longer-term major impacts. While declining discount rates are already recommended for use in some OECD countries, they are likely to have relatively modest impacts compared to the use of constant values. The shift to iterative risk management, and the consideration of the value of information, learning and option values, along with analysis of robustness and flexibility, helps to capture the economic justification for appropriate early actions.

Box 6.5. **Discounting and discount rates**

Discounting is used to compare costs and benefits arising at different point in time. The higher the discount rate, the lower the weight placed on costs and benefits arising in the future.

The market rate(s) of interest will be the most relevant in undertaking financial appraisal of projects by the private sector. The market rate of interest arises because individuals attach less weight to a benefit or cost in the future than they do to a benefit or cost now. Impatience, or "pure time preference", is one reason why the present is preferred to the future. Historically, 6-20% effectively represents a typical range for the market rates of interest – the lower end of the range being more common in OECD countries and the higher end being common in less developed countries.

The social discount rate attempts to measure the rate at which the utility of consumption falls over time for society and is therefore distinct from the market interest rate, which is determined by individual preferences expressed in financial markets. Social discount rates, as used by the public sector, tend to be lower than market interest rates – a range of 3% to 12% is typical.

It should be noted that when long time periods need to be considered, as in the context of climate change, the effect of discounting is to weight present values over future values so that the damages associated with climate change become very small. For example, with a horizon of around 100 years, a discount rate of 4 percent implies that damage of USD 100 at the end of the period is valued at USD 8 today.

Some conclusions can be drawn regarding the practical consequences for discounting as applied to adaptation. First, market rates will apply to those investment decisions that are made by private sector actors. These rates may be expected to constrain investments in adaptation to climate change.

Second, where adaptation investments in the public sector are likely to have lifetimes of less than 30-40 years, standard public sector discount rates will be appropriate. Consequently, and as with private sector adaptation, near-term climate change impacts will be most important in determining the selection of adaptation options. This outcome is likely to be exacerbated by the fact that impacts in the distant future are much more uncertain, so reducing the influence they have on adaptation option selection.

Third, investments in adaptation that have long life-times (for example, over 40 years) may be more appropriately discounted at declining rates, as in the example given above. However, for the sake of consistency, it is important that other, non-adaptation, public sector investments are subject to the same discounting profile.

A further issue relates to the distributional patterns of climate change, which disproportionately affects poor and vulnerable groups (IPCC, 2014). Some studies highlight that, in the context of adaptation, cost-benefit analyses do not always capture inequality and impacts on the most vulnerable, as it focuses on more valuable assets and groups (e.g. Cartwright et al., 2013). There is also a question of how costs and benefits can be balanced where one community or stakeholder benefits and another loses. It is possible to take these factors into account in appraisal by using equity (distributional) weights or looking at the distributional effects of policies or projects, and it may be advantageous to use these more frequently than is currently the case. Finally, it remains an open question as to what extent the costs of adaptation (e.g. a flood protection scheme) should be borne by the beneficiaries of the measure and to what extent they should be shared across a larger population group (Fankhauser and Soure, 2012). Different societies will come to different conclusions based on their social welfare function.

The challenges above are not unique to adaptation. This is because the concepts of mainstreaming would suggest compatibility with existing systems, processes and guidance. Most policy and project appraisal guidance has recommended approaches for baseline setting, and the analysis of non-market and qualitative benefits. Further, while discount rates and equity weights are potentially a contentious issue, existing guidance and decisions on these will already exist in the policy or project appraisal context. To illustrate, if existing appraisal practice recommends declining discount rates (e.g. HMT, 2009) or intergenerational rates (HMT, 2008), then these should also be applied to adaptation decisions: if not, then it is unlikely that adaptation alone will lead to a change of practice. Similarly, if equity weights are not currently used, e.g. in existing cost-benefit analysis, then it is unlikely that adaptation will be the trigger to change organisational practice and the current practice of qualitative analysis of distributional consequence of policies is likely to continue. However, as more experience of adaptation mainstreaming develops, it may be necessary to re-examine existing systems, to see if they adequately address these issues.

Notes

1. The views expressed in this publication are the sole responsibility of the authors and do not necessarily reflect the views of the European Commission. The European Community is not liable for any use made of this information. The project and this review also benefited from co-funding from Canada's International Development Research Centre, as part of the project "The Economics of Adaptation and Climate-Resilient Development" – however the views expressed are entirely those of the study team and do not necessarily reflect the views of IDRC.
2. Programme of Research on Climate Change Vulnerability, Impacts and Adaptation (PROVIA) is a global initiative which aims to provide direction and coherence at the international level for research on vulnerability, impacts and adaptation. Provia was supported by the Mediation Project (Methodology for Effective Decision-making on Impacts and AdaptaTION). This project provided scientific and technical information about climate change impacts, vulnerability and adaptation options, including the adaptation learning cycle, methods, decision support and information (Hinkel and Bisaro, 2013).

References

Adger, W.N. et al. (2012), "Cultural dimensions of climate change impacts and adaptation", *Nature Climate Change*, Vol. 3, *http://dx.doi.org/10.1038/nclimate1666*.

AfDB (2011), *Climate Screening and Adaptation Review & Evaluation Procedures*, African Development Bank Group, Tunis.

Agrawala, S. et al. (2010), "Incorporating Climate Change Impacts and Adaptation in Environmental Impact Assessments: Opportunities and Challenges", *OECD Working Paper, http://dx.doi.org/10.1787/19970900*.

AIACC (Assessments of Impacts and Adaptations to Climate Change) (2006), "Estimating and Comparing Costs and Benefits of Adaptation Projects: Case Studies in South Africa and The Gambia", Final Report Submitted to AIACC, the International START Secretariat, Washington, DC.

Ballard, D. (2014), "CAFCA – Climate Adaptation Financing Coastal Areas", *Method Paper*.

Berger and Chambwera (2010), "Beyond cost-benefit: Developing a complete toolkit for adaptation decisions", *IIED Briefing Note*, International Institution for Environment and Development, London.

Boyd, R., S. Wade and H. Walton (2006), *Climate Change Impacts and Adaptation: Cross-Regional Research Project(E)*, Defra, UK.

de Bruin, K. et al. (2009), "Adapting to climate change in the Netherlands: An inventory of climate adaptation options and ranking of alternatives", *Climatic Change*, Vol. 95(1-2), *http://dx.doi.org/10.1007/s10584-009-9576-4*.

Cartwright, A. et al. (2013), "Economics of climate change adaptation at the local scale under conditions of uncertainty and resource constraints: the case of Durban, South Africa", *Environment and Urbanization*, No. 6, *http://dx.doi.org.10.1177/0956247813477814*.

Chambwera, M. et al. (2014), Economics of adaptation. In: *Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects*. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, pp. 945-977.

Craig, R.K. (2010), "'Stationarity is Dead' – Long Live Transformation: Five Principles for Climate Change Adaptation Law", *Harvard Environmental Law Review*, Vol. 34(1).

Crowe K.A. and W.H.Parker (2008), "Using portfolio theory to guide reforestation and restoration under climate change scenarios", *Climatic Change*, Vol. 89, *http://dx.doi.org/10.1007/s10584-007-9373-x*.

Cimato, F. and M. Mullan (2010), "Adapting to Climate Change: Analysing the Role of Government", *Defra Evidence and Analysis Series*, Paper No. 1, Defra, London.

de Bruin, K. et al. (2009), "Adapting to climate change in The Netherlands: an inventory of climate adaptation options and ranking of alternatives", *Climatic Change*, Vol. 95(1-2), *http://dx.doi.org/10.1007/s10584-009-9576-4*.

Deltacommissie (2008), *Working together with water. A living land builds for its future*, Findings of the Deltacommissie, DeltaCommissie, The Hague.

Delta Programme (2014), *Working on the delta: Promising solutions for tasking and ambitions*, The Delta Programme, The Hague.

Delta Programme (2011), *Working on the delta: Investing in a safe and attractive Netherlands, now and in the future*, The Delta Programme, The Hague.

Dessai S. and M. Hulme (2007), "Assessing the robustness of adaptation decisions to climate change uncertainties: A case study on water resources management in the East of England", *Global Environmental Change*,Vol. 17(1), *http://dx.doi.org/10.1016/j.gloenvcha.2006.11.005*.

DFID (2014), *Early Value-for-Money Adaptation: Delivering VfM Adaptation using Iterative Frameworks and Low-Regret Options*, UK Department for International Development, London.

Downing, T.E. (2012), "Views of the frontiers in climate change adaptation economics", *Wiley Interdisciplinary Reviews: Climate Change*, Vol. 3(2), *http://dx.doi.org/10.1002/wcc.157*.

EA (2011), "Thames Estuary 2100: Strategic Outline Programme", Environment Agency (UK), Bristol.

EA (2009), "Thames Estuary 2100 Plan Technical Report – Appendix H: Appraisal in TE2100", Environment Agency (UK), Bristol.

ECONADAPT (2015), "The Costs and Benefits of Adaptation", results from the ECONADAPT Project, ECONADAPT consortium, *http://econadapt.eu/*.

EEA (2014), *National adaptation policy processes in European countries: 2014*, European Environment Agency, Copenhagen.

Eisenack, K. and R. Stecker (2012), A framework for analyzing climate change adaptations as actions. *Mitigation and Adaptation Strategies for Global Change*, 17, 243-260.

Fankhauser, S. and R. Soare (2012), "Strategic Adaptation to Climate Change in Europe", *EIB Working Papers* 2012 / 01.

Fankhauser, S., J.B. Smith and R.S.J. Tol (1999), "Weathering climate change: Some simple rules to guide adaptation decisions", *Ecological Economics*, Vol. 30(1), *http://dx.doi.org/10.1016/S0921-8009(98)00117-7*.

Frontier Economics (2013), "The Economics of Climate Resilience CA0401", Frontier Economics Ltd, Ecofys UK Ltd, Irbaris LLP. *http://randd.defra.gov.uk/Default.aspx?Module=More&Location=None&ProjectID=18016* (accessed 16 March 2015).

Groves, D.G. and C. Sharon (2013), "Planning Tool to Support Planning the Future of Coastal Louisiana", *Journal of Coastal Research*, Special Issue 67 – Louisiana's 2012 Coastal Master Plan Technical Analysis, *http://dx.doi.org/10.2112/SI_67_10*.

Groves, D.G. et al. (2013), *Adapting to a Changing Colorado River. Making Future Water Deliveries More Reliable Through Robust Management Strategies*, Prepared for the US Bureau of Reclamation and conducted in the Environment, Energy and Economic Development Program within RAND Justice, Infrastructure and Environment, Santa Monica.

Haasnoot, M. et al. (2013), "Dynamic adaptive policy pathways: A method for crafting robust decisions for a deeply uncertain world", *Global Environmental Change*, Vol. 23(2), *http://dx.doi.org/10.1016/j.gloenvcha.2012.12.006*.

Hallegatte, S. (2009), "Strategies to adapt to an uncertain climate change", *Global Environmental Change*, Vol. 19(2), *http://dx.doi.org/10.1016/j.gloenvcha.2008.12.003*.

Hallegatte, S. (2011), "How Economic Growth and Rational Decisions Can Make Disaster Losses Grow Faster Than Wealth", *Policy Research Working Paper* 5617, World Bank, Washington, DC.

Hallegatte, S. et al. (2012), "Investment Decision Making Under Deep Uncertainty: Application to Climate Change", *Policy Research Working Papers*, No. 6193, World Bank, Washington, DC, *http://dx.doi.org/10.1596/1813-9450-6193*.

Hallegatte, S., F. Lecocq and C. de Perthuis (2011), "Designing climate change adaptation policies: An economic framework", *Policy Research Working Paper Series*, No. 5568, World Bank, Washington, DC, *http://dx.doi.org/10.1596/1813-9450-5568*.

Herrfahrdt-Pähle, E. (2013), "Integrated and adaptive governance of water resources: the case of South Africa", *Regional Environmental Change*, Vol. 13(3), *http://dx.doi.org/10.1007/s10113-012-0322-5*.

Hinkel, J. and A. Bisaro (2013), "Methodological choices in problem-oriented adaptation research: a diagnostic framework", *Regional Environmental Change*, MEDIATION Special Issue.

HMG (2013a), *The National Adaptation Programme: Making the country resilient to a changing climate*, HM Government, London.

HMG (2013b), *The National Adaptation Programme Report: Analytical Annex*, Economics of the National Adaptation Programme, HM Government, London.

HMT (2009), *Accounting for the Effects of Climate Change: Supplementary Green Book guidance*, HM Treasury, London.

HMT (2008), *Intergenerational wealth transfers and social discounting: Supplementary Green Book guidance*, HM Treasury, London.

Hunt, A. (2009), "Economic Aspects of Climate Change Impacts and Adaptation in the UK", PhD Thesis, University of Bath.

Hunt, A. and P. Watkiss (2011), "Climate change impacts and adaptation in cities: a review of the literature", *Climatic Change*, Vol. 104(1), *http://dx.doi.org/10.1007/s10584-010-9975-6*.

Huntjens, P. et al. (2012), "Institutional design propositions for the governance of adaptation to climate change in the water sector", *Global Environmental Change*, Vol. 22(1), *http://dx.doi.org/10.1016/j.gloenvcha.2011.09.015*.

IPCC (Intergovernmental Panel on Climate Change) (2014), *Climate Change 2014: Impacts, Adaptation, and Vulnerability*, Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change, Cambridge University Press, Cambridge and New York.

Jeuland, M. and D. Whittington (2013), "Water Resources Planning under Climate Change: A 'Real Options' Application to Investment Planning in the Blue Nile", *Environment for Development. Discussion Paper Series*, No. 13-5.

Jones, B.D. (1999), "Bounded Rationality", *Annual Review of Political Science,* Vol. 2: 297-321, *http://dx.doi.org/10.1146/annurev.polisci.2.1.297*.

Jones, L. and E. Boyd (2011), "Exploring social barriers to adaptation: insights from Western Nepal", *Global Environmental Change*, Vol. 21(4), *http://dx.doi.org/10.1016/j.gloenvcha.2011.06.002*.

Frontier Economics (2013), "The Economics of Climate Resilience CA0401: Synthesis Report", Frontier Economics, IRBARIS and Ecofys, London.

Klijn, F., M.J.P. Mens and N.E.M. Asselman (2014), "Robustness analysis for flood risk management planning: On risk-based decision making beyond simple economic reasoning, exemplified for the Meuse River (Netherlands), *Paper presented at the 6th International Conference of Flood Management*, September 2014, Sao Paulo.

Klein, R.J.T. et al., (2014), Adaptation opportunities, constraints, and limits. In: *Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects*. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change.

Klein, R.J.T. and Å. Persson (2008), "Financing Adaptation to Climate Change: Issues and Priorities", European Climate Platform (ECP), *Report* No. 8.

Kuch, P.J. and S. Gigli (2007), *Economic Approaches to Climate Change Adaptation: And their role in project prioritisation and appraisal*, GTZ (ed.), Climate Protection Programme in Developing Countries, Eschborn.

Least Developed Countries (LDC) Expert Group, 2012, *National Adaptation Plans, Technical guidelines for the national adaptation plan process*, Bonn: UNFCCC secretariat, Bonn, Germany, December 2012. Available at: *http://unfccc.int/NAP*.

Lee S. and S. Thornsbury (2010), "The effect of market structure on adaptation to climate change in agriculture", Contributed paper at the IATRC Public Trade Policy Research and Analysis Symposium "Climate Change in World Agriculture: Mitigation, Adaptation, Trade and Food Security", June 27-29, Universität Hohenheim, Stuttgart.

Lehmann, P. et al. (2012), "Understanding barriers and opportunities for adaptation planning in cities", *UFZ Discussion Papers*, No. 19/2012.

Lempert, R.J. et al. (2013), "Ensuring Robust Flood Risk Management in Ho Chi Minh City", *Policy Research Working Papers*, No. 6465, World Bank, Washington, DC, *http://dx.doi.org/10.1596/1813-9450-6465*.

Lempert, R.J. and D.G. Groves (2010), "Identifying and evaluating robust adaptive policy responses to climate change for water management agencies in the American west", *Technological Forecasting and Social Change*, Vol. 77(6), *http://dx.doi.org/10.1016/j.techfore.2010.04.007*.

Lesnikowski, A.C. et al. (2013), "National-level factors affecting planned, public adaptation to health impacts of climate change", *Global Environmental Change*, 23(5), *http://dx.doi.org/10.1016/j.gloenvcha.2013.04.008*.

Li, J., M. Mullan and J.Helgeson (2014), "Improving the practice of economic analysis of climate change adaptation", *Journal of Benefit Cost Analysis*, Vol. 5(3), *http://dx.doi.org/10.1515/jbca-2014-9004*.

McGray, H., A. Hammill and R. Bradley (2007), *Weathering the Storm: Options for Framing Adaptation and Development*, World Resources Institute, Washington, DC.

MEDIATION (2013), Decision Support Methods for Climate Change Adaption, *Technical Policy Briefing Notes*, MEDIATION project (Methodology for Effective Decision-making on Impacts and AdaptaTION). Available at *http://mediation-project.eu/output/technical-policy-briefing-notes* (Accessed, March 2015).

Mendelsohn, R. (2000), "Efficient adaptation to climate change", *Climatic Change*, 45,583-600.

Moser, S.C. and J. Ekstrom (2010), "A framework to diagnose barriers to climate change adaptation", *Proceedings of the National Academy of Sciences of the United States of America*, Vol. 107(51), *http://dx.doi.org/10.1073/pnas.1007887107*.

Mullan, M., et al. (2013), "National Adaptation Planning: Lessons from OECD Countries", *OECD Environment Working Papers*, No. 54, OECD Publishing, Paris, *http://dx.doi.org/10.1787/5k483jpfpsq1-en*.

Nunan, F., A. Campbell and E. Foster (2012), *Environmental Mainstreaming: The Organisational Challenges of Policy Integration*, Public Administration and Development 32, 262-277 *http://dx.doi.org/10.1002/pad.1624*.

Oberlack, C. and B. Neumarker, (2011), "Economics, institutions and adaptation to climate change", *The Constitutional Economics Network Working Papers*, No. 04-2011.

O'Brien. K. (2012), "Global environmental change II: From adaptation to deliberate transformation", *Progress in Human Geography*, Vol. 36 (5), *http://dx.doi.org/10.1177/0309132511425767*.

OECD (Organisation for Economic Co-ordination and Development) (2012), *Greening Development: Enhancing Capacity for Environmental Management and Governance*, OECD Publishing, Paris, *http://dx.doi.org/10.1787/9789264167896-en*.

OECD (2009), *Integrating Climate Change Adaptation into Development Co-operation: Policy Guidance*, OECD Publishing, Paris, *http://dx.doi.org/10.1787/9789264054950-en*.

Osberghaus, D. et al. (2010a), "The role of the government in adaptation to climate change", *Environment and Planning C: Government and Policy*, Vol. 28(5), *http://dx.doi.org/10.1068/c09179j*.

Osberghaus et al. (2010b), "Individual Adaptation to Climate Change: The Role of Information and Perceived Risk", *ZEW Discussion Paper No. 10-061*, Zentrum für Europäische Wirtschaftsforschung (ZEW) GmbH, Centre for European Economic Research, Mannheim, Germany.

Stern, N. et al. (2006), *The Economics of Climate Change*, HM Treasury, London.

Ostrom, E. (2005), *Understanding institutional diversity*, Princeton University Press, Princeton.

Province of New Brunswick (2014), *New Brunswick Climate Change Action Plan 2014-2020*, Province of New Brunswick.

Ranger, N., T. Reeder and J. Lowe (2013), "Addressing 'deep' uncertainty over long-term climate in major infrastructure projects: four innovations of the Thames Estuary 2100 Project", *European Journal of Decision Process*, 1:233-262, *http://dx.doi.org/10.1007/s40070-013-0014-5*.

Ranger, N. et al. (2010), "Adaptation in the UK: a decision-making process", *Policy Brief*, Grantham Research Institute on Climate Change and the Environment and Centre for Climate Change Economics and Policy.

Reeder, T. and N. Ranger (2011), "How do you adapt in an uncertain world? Lessons from the Thames Estuary 2100 project", *World Resources Report Uncertainty Series*, WRI, Washington, DC.

Republic of Rwanda (2012), *Economic Development And Poverty Reduction Strategy 2013-2018*, Published by the Republic of Rwanda, Kigali, Rwanda.

Schilling, J. et al. (2012), "Climate change, vulnerability and adaptation in North Africa with focus on Morocco", *Agriculture, Ecosystems and Environment*, Vol. 156, *http://dx.doi.org/10.1016/j.agee.2012.04.021*.

Simon, H.A. (1999), "The potlatch between economics and political science", in Alt, J.E., M. Levi and E. Ostrom (eds.), *Competition and cooperation: Conversations with Nobelists about economics and political science*, Cambridge University Press, Cambridge.

Spies, T.A. et al. (2010), "Climate change adaptation strategies for federal forests of the Pacific Northwest, USA: Ecological, policy, and socio-economic perspectives", *Landscape Ecology*, Vol. 25(8), *http://dx.doi.org/10.1007/s10980-010-9483-0*.

Stafford-Smith, M. et al. (2011), "Rethinking adaptation for a 4 °C world", *Philosophical Transactions of the Royal Society*, Vol. 369, *http://dx.doi.org/10.1098/rsta.2010.0277*.

Stern N. et al. (2006), *The Economics of Climate Change*, HM Treasury, London.

Stillwell, A.S., M.E. Clayton and M.E. Webber (2011), "Technical analysis of a river basin-based model of advanced power plant cooling technologies for mitigating water management challenges", *Environmental Research Letters*, Vol. 6, *http://dx.doi.org/10.1088/1748-9326/6/3/034015*.

Stuart-Hill, S. and R.E. Schulze (2010), "Does South Africa's water law and policy allow for climate change adaptation?", *Climate and Development*, Vol. 2(2), *http://dx.doi.org/10.3763/cdev.2010.0035*.

Tainio, A. et al. (2014), "Conservation of grassland butterflies in Finland under a changing climate", *Regional Environmental Change*, *http://dx.doi.org/10.1007/s10113-014-0684-y*.

Tröltzsch, J., H. Lückge and C. Sartorius (2012), *Kosten und Nutzen von Anpassungsmaßnahmen an den Klimawandel: Analyse von 28 Anpassungsmaßnahme in Deutschland* [Costs and benefits of climate adaptation measures. Analysis of 28 adaptation measures in Germany], *Climate Change*, No. 10/2012, UBA, Dessau.

True, J. (2010), *Mainstreaming Gender in International Relations. Gender Matters in Global Politics* (New York: Routledge), L.J. Shepherd (ed.), pp. 189-203.

UNDP (United Nations Development Programme)/UNEP (United Nations Environment Programme) (2011), *Mainstreaming Climate Change Adaptation into Development Planning: A Guide for Practitioners*, UNDP-UNEP Poverty-Environment Initiative, Nairobi.

UNFCCC (2009), "Potential costs and benefits of adaptation options: A review of existing literature", *FCCC/TP/2009/2*, United Nations Framework Convention on Climate Change, Bonn.

van der Pol, T.D., E.C. van Ierland and H.P. Weikard (2013), "Optimal dike investments under uncertainty and learning about increasing water levels", *Journal of Flood Risk Management*, Vol. 7(4), *http://dx.doi.org/10.1111/jfr3.12063*.

van Ierland, E.C. et al. (2006), *A qualitative assessment of climate change adaptation options and some estimates of adaptation costs,* Routeplanner subprojects 3, 4 and 5, Wageningen UR.

Vaughan, H. (2012), *Leadership & Legacy: Handbook for Local Elected Officials on Climate Change*, ICLEI-Local Governments for Sustainability (Management) Inc.

Watkiss, P. (2014), *Design of Policy-Led Analytical Framework for the Economics of Adaptation*, Deliverable 1.2 of the ECONADAPT project. ECONADAPT, *http://econadapt.eu/*.

Watkiss, P. and A. Hunt (2011), "Method for the UK Adaptation Economic Assessment" (Economics of Climate Resilience), *Final Report to Defra*, May, Deliverable 2.2.1.

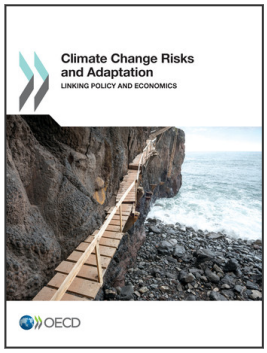
Watkiss, P. et al. (2014), "The use of new economic decision support tools for adaptation assessment: A review of methods and applications, towards guidance on applicability", *Climatic Change*, *http://dx.doi.org/10.1007/s10584-014-1250-9*.

Wilby, R.L. and S. Dessai (2010), "Robust adaptation to climate change", *Weather*, Vol. 65(7), *http://dx.doi.org/10.1002/wea.543*.

Wilby, R.L and R. Keenan (2012), "Adapting to flood risk under climate change", *Progress in Physical Geography*, Vol. 36(3), *http://dx.doi.org/10.1177/0309133312438908*.

Wilby, R.L. (2012), "Frameworks for delivering regular assessments of the risks and opportunities from climate change: An independent review of the first UK Climate Change Risk Assessment", *Final Report to the Committee on Climate Change*, Loughborough University.

Wing, I.S. and K. Fisher-Vanden (2013), "Confronting the challenge of integrated assessment of climate adaptation: a conceptual framework", *Climatic Change*, 117(3), *http://dx.doi.org/10.1007/s10584-012-0651-x*.



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