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Adaptation to Climate Change:
Why is it needed and how can it be implemented?

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This paper presents ongoing research being carried out for the EU-funded ADAM project (Adaptation and Mitigation Strategies: Supporting European Climate Policy). Funded by the European Commission and coordinated by the Tyndall Centre for Climate Change Research in the UK, ADAM is an integrated research project running from 2006 to 2009 that will lead to a better understanding of the trade-offs and conflicts that exist between adaptation and mitigation policies. ADAM will support EU policy development in the follow-on stage of the Kyoto Protocol and will inform the emergence of new adaptation strategies for Europe. CEPS is one of 26 participating research institutes in the project (see http://www.adamproject.eu/).

Executive Summary

This Policy Brief provides a first overview of the state of ADAM research that was discussed during the first ADAM-CEPS seminar on 12 October 2007. It brought together academic experts, policy-makers and the civil society to discuss adaptation issues and (preliminary) ADAM research results.

The ADAM (Adaptation and Mitigation Strategies: Supporting European Climate Policy – www.adamproject.eu) project is supported by DG Research of the European Commission. Its core objective is to acquire a better understanding of the costs and benefits, trade-offs, synergies and conflicts of adaptation and mitigation policies. ADAM will support EU policy development in the next stage of the climate change negotiations and inform the emergence of new adaptation and mitigation strategies in Europe.

We first set out the rationale for public policy related to adaptation to the impacts of climatic change in the EU. Starting from the premise that the 'problem structure' of adaptation is significantly different to that of mitigation, it identifies seven objectives for public policy action: to inform the potentially vulnerable; to assist in the provision of disaster relief; to provide incentives for and enable adaptation; to mainstream climate proofing of public policy; to plan and regulate long-term infrastructural assets to reduce future vulnerabilities; to regulate adaptation 'spillovers'; and to compensate for the unequal distribution of climate impacts. A preliminary assessment of the adaptation Green Paper concludes that at least four of these seven are well-covered: information, knowledge and learning in the focus on science in the third pillar of the proposed strategy; early warning and disaster relief which is allocated to national level policy; mainstreaming climate-proofing in the extensive discussion of sectors where there is EU competence; and infrastructure planning. Three issues however are somewhat underdeveloped: facilitating adaptation in the market; regulating spillovers; and compensating for unequal distribution of climate impacts.

We then briefly introduce some of the key issues around the concepts of adaptation policy and mainstreaming before elaborating our preliminary analysis of the stakeholder engagement process. Findings point to the need for flexible and robust adaptation policies, especially in supporting local action. This involves tools and methodologies for determining and assessing risks, identification of measures of 'good' adaptation (i.e. best-practices), evaluation of alternative options, adequate funding, the identification of linkages across sectors and policy areas and the importance of creating space for learning. Overall there appears to be a general consensus from within different stakeholder communities that a systematic approach to these challenges is still in its infancy and requires additional research and other efforts.

The analysis on the economics of adaptation suggests that the economic impacts of climate change will be reduced by adaptation, primarily driven by private responses independently of government policy. In some cases, adaptation may reduce the impacts or turn climate change into an opportunity with a positive outcome. It also concludes that the principal challenges are with those (adaptation) needs that require collective action, public engagement including public finance. Adaptive capacity increases with both flexibility and economic growth and reconfirms that adaptive capacity is more restricted in small and remote communities and in the face of extreme events compared to centres with greater economic diversity and in relation to slow onset climate change. The potential for adaptation generally is large and may be fully utilised under slow and smooth changes, whereas this is more difficult to utilise in cases of climate extremes. Early, anticipatory adaptation may be more cost-effective than reactive adaptation.

Looking at the economics of extreme events, there is growing evidence of rising economic losses due to extreme weather events and even today many regions and sectors in Europe are vulnerable to natural hazards. For example flood risks have risen and in particular the new member states experience high potential losses of GDP. When projecting weather extremes into the future, risks rise considerably under a business-as-usual scenario (supporting the argument for strong climate change mitigation action). Estimated probabilistic economic vulnerabilities in Europe suggest that governments may experience serious fiscal problems if extreme events become more frequent due to climate change.

The final section elaborates on different concepts of uncertainties surrounding climate change and climate variability in the context of adaptation. It is argued that responses will depend on the range and type of uncertainty. However, uncertainty is not a good justification for postponing action since the uncertainty will probably only be resolved too late to still engage in anticipation. More importantly, effective adaptive measures will enable structural change while being sufficiently flexible to allow recalibration when uncertainties are reduced. How much flexibility to invest in needs to be resolved on a case-by-case basis, since it will come at very different costs, depending on technological and social constraints.

1. Introduction[1]

There is increasing recognition of the need for nations, communities and individuals to adapt to some level of climate change, irrespective of the level of mitigation. Adaptation is necessary to avoid or reduce the negative impacts and to explore any potential benefits of climate change. Adaptation to climate change will therefore have very important social and economic implications (as illustrated by the Stern Review, 2006).

As part of the EU response, on 29 June 2007, the European Commission (2007a) launched its Green Paper on Adaptation, building on a series of ten thematic consultation workshops in 2006, organised by the second round of the European Climate Change Programme (ECCP-2) with the remit to "define the EU role in adaptation policies so as to integrate adaptation fully into relevant European policies, to identify good, cost-effective practice in the development of adaptation policy and to foster learning".

One of the objectives of the European Commission-funded ADAM project (Adaptation and Mitigation Strategies: Supporting European Climate Policy), financed by the European Commission DG Research, is to analyse in-depth some of the issues arising in the Green Paper and the follow-up processes, notably:

a) appraise existing and future adaptation policies at EU and member state level;
b) analyse vulnerabilities to climate change for different sectors and regional scales;
c) quantify the economic costs and benefits of adaptation to climate change;
d) assess institutional barriers to adaptation and indicate possibilities to increase adaptive capacities; and
e) quantify risks and costs of extreme weather events in the EU.

This policy brief provides a first overview of the state of ADAM research as presented and discussed on 12 October 2007 during the first ADAM-CEPS seminar on adaptation. The seminar brought together experts from academia, policy-making, and the civil society to discuss adaptation issues and (preliminary) ADAM research results. While the seminar was mainly intended to disseminate ADAM research, the discussions with stakeholders also inform ADAM research and help to identify concrete policy questions that ADAM should address. As new research results become available, new policy briefs will be published. Since the project was only launched in March 2006, research results are necessarily preliminary at the current stage. It is expected, however, that ADAM research will inform the next policy round, the White Paper and its associated Integrated Impact Assessment.

This policy brief is organised as follows. Following this Introduction, section 2 sets out the rationale for public policy related to adaptation to the impacts of climatic change in the EU. Section 3 provides evidence from a number of stakeholders and sketches the perception of various actors towards the role of European adaptation policies and climate proofing of sectoral policies. Section 4 on the economics of adaptation argues that the economic impacts of climate change will mainly be reduced by private autonomous response, while the principal challenges reside with adaptation needs that require collective action and public engagement, including public finance.

Section 5 assesses monetary and socioeconomic risks from extreme weather events in Europe and points to the evidence of rising losses due to weather extremes whilst important knowledge gaps remain to project future risks.

The final section (6) deals with different concepts of uncertainties surrounding climate change and climate variability, and argues for adaptive measures to be sufficiently flexible to allow recalibration as uncertainties are reduced with time.

Box 1. Definitions

Conceptually, a broad definition of adaptation commonly used is the 'adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities' (IPCC, 2001). As our understanding of what adaptation actually involves has improved over time, it has been recognised that adaptation can: 1) focus on either managing the impacts of the climate-related hazard, reducing exposure to the hazard, or reducing the vulnerability of elements at risk (though in reality responses may sometimes overlap in their categorisation); 2) involve a range of actors throughout society from governments down to individuals; and 3) manifest itself in many forms (the Stern Review, for instance, highlighted differences according to whether measures were anticipatory or reactive, private or public, autonomous or planned, etc.). Recent attempts to make the concept operational, and hence more relevant for practitioners, have also found that distinguishing between process (building adaptive capacity) and outcome (the delivery of actual adaptation measures) can be useful (UKCIP, cited in Tompkins et al., 2005). This is an approach that has been adopted to help structure the ADAM analysis (McEvoy et al., 2007). We offer definitions of key terms below.

[1] Contributed by Henry Neufeldt & Christian Egenhofer.

Adaptation: defined as adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities. Various types of adaptation can be distinguished, including anticipatory, autonomous and planned adaptation:

- **Anticipatory adaptation** – Adaptation that takes place before impacts of climate change are observed. Also referred to as proactive adaptation.
- **Autonomous adaptation** – Adaptation that does not constitute a conscious response to climatic stimuli but is triggered by ecological changes in natural systems and by market or welfare changes in human systems. Also referred to as spontaneous adaptation.
- **Planned adaptation** – Adaptation that is the result of a deliberate policy decision, based on an awareness that conditions have changed or are about to change and that action is required to return to, maintain, or achieve a desired state.

Adaptive capacity (in relation to climate change impacts): often referred to as the ability of a system to adjust to climate change (including climate variability and extremes) to moderate potential damages, to take advantage of opportunities, or to cope with the consequences (IPCC, 2007).

Vulnerability: the degree to which a system is susceptible to, and unable to cope with, adverse effects of climate change, including climate variability and extremes. Vulnerability is a function of the character, magnitude and rate of climate change and variation to which a system is exposed, its sensitivity and its adaptive capacity (IPCC, 2007).

Hazard: a source of risk that does not necessarily imply potential for occurrence. A hazard produces risk only if an exposure pathway exists, and if exposures create the possibility of adverse consequences (EWA, 2007).

Mainstreaming: describes the integration of policies and measures to address climate change in ongoing sectoral and development planning and decision-making, aimed at ensuring the sustainability of investments and at reducing the sensitivity of development activities to current and future climatic conditions (Klein et al., 2005).

2. The rationale for public policy: How well does the EU strategy address the objectives for public policy?[2]

The 'problem structure' of adaptation is significantly different to that of mitigation. While mitigation will typically have long-term effects on the climate – which is a global public good – many adaptation actions will have relatively short-term effects on welfare that are local and private. While there is a clear-cut case for government (and indeed international governmental) action to protect public goods like the climate system, it is less evident that governments should have a role in influencing adaptation to climate change impacts.[3] Hence, there is a need to define appropriate roles for public policy.[4]

The 2007 Commission Green Paper on Adapting to Climate Change has started to do this. It argues for a multi-level approach to the governance of adaptation, with specific roles at the European, national, regional and local levels. At the European level the main task is to integrate (or mainstream) climate adaptation in policies related to vulnerable sectors where the EU has significant competences like agriculture, fisheries, water, biodiversity, health and transport and energy networks. The Green Paper also argues that adaptation needs to be integrated into the EU's external policies, especially those oriented to more vulnerable developing countries through, for example, support for actions within the UNFCCC, such as National Adaptation Programmes of Action (NAPA). Support for scientific research to improve knowledge about climate and its impacts, and encouraging broader stakeholder involvement are also highlighted.

2.1 Adaptation challenges for markets and policy

Adaptation is defined as changes made by individuals, organisations and governments to reduce the damages (or increase the benefits) from climate change. But achieving efficient adaptation[5]

[2] Contributed by Frans Berkhout.

[3] Of course, there may also be a range of private or local co-benefits to mitigation (including, for instance, cost savings or health co-benefits by switching to more sustainable energy), just as there can be longer-term and societal benefits to adaptation actions (including, for instance, increased resilience of regional food supplies through a switch to drought-resistant crops), but these will typically not be the primary objective of the mitigation or adaptation action.

[4] A variety of rationales have been given for public policy related to climate adaptation. Klein & Tol (1997) argue that public policy related to adaptation should have four objectives: increasing robustness of infrastructures; increasing flexibility and adaptability of vulnerable managed systems; reversing trends that increase vulnerability; and improving awareness and preparedness.

[5] IPCC (2001) argues that adaptation has three aspects: reducing risks of climate damages; developing capacity to cope with damages that are unavoidable; and being able to exploit new opportunities. Adaptation is efficient if the costs of adaptation are smaller than the benefits in terms of reduced damages or increased returns (Mendelsohn, 2006).

by private actors alone turns out to be difficult due to a series of information, market and policy failures partly but not only as a result of some public goods characteristics, e.g. the inequitable distribution of climate impacts and the spillovers that adaptation can generate (see also sections 3 and 5). Finally, there are many conditions under which markets do not operate (such as for jointly-consumed goods like biodiversity), or operate only partially. In all of these cases government policy has a clear role. The literature has identified the following problems:

- *Uncertainties about climate change impacts and the benefits of adaptation*: Uncertainty affects the assessment not just of climate-related damages, but also of the benefits of adaptation.
- *Constraints on adaptation*: Much adaptation will draw on resources (including capital, knowledge, technology, consent) not held by the adapting agents themselves. While some of these resources will be available through the market, there are also likely to be constraints – partly as a result of uncertainty.
- *Role of the market in adaptation*: Mendelsohn (2006) argues that markets will tend to encourage efficient adaptation in sectors whose goods are traded, such as agriculture, forestry, construction, energy and tourism. In contrast, markets will not be effective in encouraging efficient adaptation for jointly-consumed goods like biodiversity. Here government has a role in encouraging adaptation. See also section 5.
- *Adaptation spillovers*: The benefits of an adaptation to climatic changes may not be exploited entirely by the agent making the change. There may be other beneficiaries from the knowledge and experience that an innovator has invested in. These 'spillovers' can lead systematically to a socially sub-optimal level of investment in adaptation, generating a rationale for policy and legal interventions.
- *Unequal distribution of climate change impacts*: It is clear that the impacts of climate change will be unequally distributed across world regions and between social groups. This is partly because vulnerability to climate change impacts will to a large extent be conditioned by a host of other stresses related to poverty, health status and conflict.

2.2 Roles for policy in adaptation

Drawing on the insights and arguments above, we argue for seven objectives for public policy action: to inform the potentially vulnerable; to assist in the provision of disaster relief; to provide incentives for and enable adaptation; to mainstream climate-proofing of public policy; to plan and regulate long-term infrastructural assets to reduce future vulnerabilities; to regulate adaptation 'spillovers'; and to compensate for the unequal distribution of climate impacts.

1. *Information, knowledge and learning*: Governments have played a major role in sponsoring climate science and in the provision of tools such as global, regional and national climate scenarios.
2. *Early-warning and disaster relief*: Most governments have in place plans, organisations and resources to alert people to weather-related disasters and to cope with the consequences, at home and abroad.
3. *Facilitating adaptation in the market*: There are strong 'public good' arguments for investing in scientific and technological resources that may be widely adopted in response to climate change.
4. *Mainstreaming climate-proofing*: Large areas of public policy applies to climate-vulnerable sectors, either because they are collective goods (like nature conservation) or because the state has a clear role through regulation or ownership (like water). In these sectors government will play part of the role in enabling or encouraging adaptation.
5. *Infrastructure planning and development*: Water, transport and energy infrastructures are likely to be influenced by changing climate, as is the distribution of settlements, especially in coastal and fluvial flood plains. Modification of infrastructures and of spatial plans in response climate impacts is another area in which governments will play a major role.
6. *Regulating adaptation spillovers*: Unregulated, it is likely that the most vulnerable social groups will end up bearing many of the new social and economic risks that arise as a result of climate change.
7. *Compensating for the unequal distribution of climate impacts*: The notion of compensation is by now well-entrenched in public health and environmental policy. Where the cause of damage can be well-defined, compensation can be dealt with between individuals, but where it cannot be clearly established, governments need to play a role.

2.3 Assessing the EU strategy

In the 'four pillars' of EU adaptation policies identified in the 2007 Green Paper, at least four of

these seven are well-covered: information, knowledge and learning in the focus on science in the third pillar of the proposed strategy; early warning and disaster relief which is allocated to national level policy; mainstreaming climate-proofing in the extensive discussion of sectors where there is EU competence; and infrastructure planning. But three of these issues play a less prominent role: facilitating adaptation in the market; regulating spillovers; and compensating for unequal distribution of climate impacts (although the latter is partially covered in the discussion of integrating adaptation into the EU's external actions, pillar 2).

3. Adaptation policies and mainstreaming[6]

This section briefly introduces some of the key issues around the concepts of adaptation policy and mainstreaming before elaborating on preliminary analysis of the stakeholder engagement process.[7] Findings point to the need for flexible and robust adaptation policies, especially in supporting local action. This involves tools and methodologies for determining and assessing risks, identification of measures of 'good' adaptation (i.e. best-practices), evaluation of alternative options, adequate funding, the identification of linkages across sectors and policy areas and the importance of creating space for learning. Overall there appears to be a general consensus from within different stakeholder communities that a systematic approach to these challenges is still in its infancy and requires additional research and other efforts.

3.1 Adaptation policies

As the impacts of climate change have become more evident (e.g. EEA, 2006), several countries in Europe have started to plan for and implement measures to adapt to anticipated climate change and variability. A series of stakeholder interviews[8] across sectors have confirmed that progress on adaptation is still at an early stage, even though EU market structures are considered well developed and capacity to adapt is high compared to other regions in the world (Stern, 2006).

There are a number of initiatives that address both impacts and adaptation in some EU member states. These include Finadapt[9] in Finland, Klimaat voor Ruimte[10] (climate changes spatial planning) in the Netherlands, and several in the United Kingdom – particularly the UK Climate Impacts Programme (UKCIP).[11] UKCIP has been set up to help organisations and individuals assess how they might be affected by climate change, and to prepare for impacts. Practically, a number of practical tools have been developed including a so-called UKCIP adaptation wizard, a risk, uncertainty and decision-making framework, and a specific methodology for costing the impacts of climate change.

At the EU level, the profile for adaptation has gradually increased. First, the European Commission's 2005 Communication, *Winning the battle against climate change*, set out that the Commission should explore "the role of the EU in reducing vulnerability and promoting adaptation" and that "EU climate policy should aim to reduce vulnerability of European society and economy to the adverse effects of climate change and improve its resilience". In 2007, the European Commission (2007b) Communication *Limiting Global Climate Change to 2 degrees Celsius: The way ahead for 2020 and beyond*; stated that: "Measures to assist countries to adapt to the unavoidable consequences of climate change will have to be an integral part of the future global climate agreement. The need to adapt to the impacts of climate change should be taken into account in public and private investment decisions. Building on the implementation of the EU Action Plan on climate change and development (which was to have been reviewed in 2007) the EU should enhance its alliance-building with developing countries in the areas of climate change adaptation and mitigation. The EU should also strengthen the implementation of the EU Action Plan on climate change in the context of development cooperation." The importance of adaptation has also been acknowledged by the European Council.

As all EU policies – not only those that are directed towards avoiding climate change – have a potential impact on adaptation by affecting vulnerability or the ability to adapt, it is not yet clear where the field "EU adaptation policy" starts and where it ends. As a first step, this would point to a need to identify the areas where EU policy competencies in general and law and measures in particular, can have significant

[6] Contributed by Darryn McEvoy & Paul Watkiss.

[7] McEvoy et al. (2008).

[8] Some exerpts from the ADAM stakeholder interviews (McEvoy et al., 2007): "Evidence of best practice is limited because the adaptation agenda is so new" (Town and Country Planning Association) and "we are currently in the process of moving from the development of an adaptation strategy to a period where we will see actual delivery of measures on the ground" (City of London Authority).

[9] http://www.ymparisto.fi/default.asp?contentid=165496&lan=en

[10] http://www.klimaatvoorruimte.nl/

[11] http://www.ukcip.org.uk/

influence on Europe's citizens. A greater understanding of interactions between different policies and sectors, and potential spillover effects will ultimately be a prerequisite for mainstreaming climate change considerations across all EU policies.

Box 2. Adaptation to reinforce the mitigation agenda: an example

As a practical example, urban greenspace benefits adaptation by providing valuable cooling and infiltration functions whilst contributing to social agendas, and even reinforcing the mitigation agenda by reducing energy use through the shading of buildings. These 'win-win' situations provide important opportunities for delivering adaptation, even if not directly motivated for this purpose. Alternatively, there may be policy barriers as illustrated by the potential conflict between mitigation and adaptation measures – urban densification seen as good for mitigation but acting against adaptation objectives (McEvoy *et al*, 2006). A better understanding of opportunities and barriers will undoubtedly assist more effective decision-making and the informed development of an overarching strategic framework at EU level.

3.2 Mainstreaming

In addition to the emergence of adaptation policy frameworks, there is a recognition that there is a need to consider how best to address adaptation objectives through existing institutional mechanisms. This is increasingly described as 'mainstreaming'. The concept was first put forward and explored at the World Summit on Sustainable Development (Johannesburg, 2002), and in early usage is most commonly associated with the integration of climate change considerations into development assistance. More recently it has been applied to wider policy contexts, i.e. strategies for adaptation needing to be embedded within existing horizontal and sectoral policies and institutional frameworks.

Emphasis on existing policies, rather than relying on the design and implementation of independent adaptation policies results also from the cross-cutting nature of adaptation to climate change. The Adaptation Green Paper highlights that 'certain sectors (e.g. agriculture, water, biodiversity, fisheries, and energy networks) are largely integrated at EU level through the single market and common policies and it makes sense to integrate adaptation goals directly into them'. It also discusses the need to 'integrate adaptation when implementing and modifying existing and forthcoming legislation and policies', and that 'when preparing their programmes for Community support, Member States should integrate adaptation activities'. There is also a further pragmatic consideration in that there is no single legal basis at the EU level for climate change actions, nor a dedicated budget line. Both tend to be wrapped in a range of existing provisions and funds. The Green Paper refers to the need for integration, e.g. discussing integration of adaptation activities in key sectoral policies, though critically there is little consideration of the mechanisms, or the proposed 'roadmap', that would help to promote mainstreaming.[12]

There are signs of progressive mainstreaming across a number of important sectors:

- The European Commission is working on a Communication on water scarcity and droughts which is closely linked to climate change and adaptation. Likewise, the proposed legislation on the assessment and management of floods will focus on prevention, protection and preparedness'.
- For the agricultural sector, the Green Paper outlines that community support plays an important role in food production, the maintenance of rural landscapes, and the provision of environmental services. There is a need as part of current reforms (e.g. of the Common Agricultural Policy - CAP) to move towards a framework for the sustainable development of EU agriculture. The Green Paper states that 'future adjustments of the CAP and the 'Health check' of 2008 could provide opportunities to examine how to better integrate adaptation to climate change in agriculture support programmes.
- In the area of energy, the Green Paper outlines that the Commission has a role, and is currently working towards a Strategic Energy Technology Plan, which will consider adaptation. In the urban context, a key energy issue is in relation to buildings. The Commission will start work on revising the relevant regulatory framework in the near future, in particular the Directive on energy performance of buildings.
- For transport, the Green Paper outlines that 'new transport infrastructure and related transport means should be made climate proof from the early design phase'.
- In relation to crosscutting themes, 'Climate-proofing must be integrated into the

[12] A similar criticism can be levelled at national Governments, as indicated through one interviewee's comments that there is 'obviously a need for better coordination of response and for the Government to get its own house in order' (in reference to the UK).

Environmental Impact Assessment (EIA) Directive and the Strategic Environmental Assessment (SEA) Directives.

- Again, in relation to water resources, there is a recognition that the Water Framework Directive (WFD) is a powerful tool for introducing climate change impacts into water resources management and river basin planning (see: the main conclusion of Time to Adapt — Climate Change and European Water Dimension, held as part of the German EU presidency's activities). The concept of mainstreaming was also discussed in the recent EEA report (2007) 'Climate change and water adaptation issues'.
- The Green Paper also acknowledges that EC funding programmes are an important component of promoting climate change adaptation, stating that there will be an examination of 'how climate proofing can be reflected and made operational in the programmes and projects adopted under the Cohesion Fund, Regional Development Fund, pre-accession instruments, Trans-European Networks Programmes, and infrastructure measures under the Rural Development Fund'. Ensuring that climate change considerations are adequately incorporated into these important funding streams will be a critical constituent of any future EU adaptation strategy, in particular the White Paper on adaptation, to be published in 2008.

3.3 Preliminary findings from the 'actor-based' analysis: implications for the Green Paper

This section draws together some of early findings, based on preliminary policy analysis and an initial round of interviews with key stakeholders across a variety of different sectors (as well as those responsible for cross-sectoral policy). Due to the focus of the research, the emphasis is on the 'process' of adaptation, and the building of adaptive capacity. A number of initial findings can be presented.

3.3.1 Climate risks go mainstream

Many of the interviewees felt that they no longer had to deal with sceptics in the same way as in the past. Climate change science is more or less accepted now, and resistance to change is in retreat. It was acknowledged that there is a need to think differently about the management of climate risk, for example expressed as "change management rather than climate change". Interviewees noted a shift in the business perspective from viewing climate change as an environmental risk, and thus marginal, to a corporate risk, central to the business with a similar importance to geopolitical or health and safety risks.

3.3.2 Promising policy areas for EU mainstreaming

A preliminary screening analysis suggests that EU policy has the potential to mainstream adaptation across most policy areas, covering most major sectors (see Appendix 1). The most important areas for mainstreaming (i.e. where the EU has important competencies, and the ability to influence) are thought to be for agriculture and water sectors. There are also potentially important influences in relation to coasts/marine systems, tourism, health, biodiversity, built environment and infrastructure. Further afield, there is also the potential to affect non-EU vulnerability through foreign/development policy and through trade, i.e. with external EU areas.

3.3.3 Initial focus is on institutional capacity, not on adaptation measures

For all interviewees, identification of processes was easier than outcomes, i.e. highlighting the important role that institutional capacity has to play in 'enabling' future adaptation to take place. As such, it was noted that it would be important to understand how learning occurs in organisations (and individuals), the role of champions in individual organisations, and how different institutional structures facilitate, or hamper, adaptation. A common message was for responsibility (and possible liability) to be more clearly defined. It was acknowledged that the perception of risk and decision-making cultures of sectors and organisations has a strong influence on whether climate-related activity is likely to be proactive or reactive.

3.3.4 Adaptation as a learning process

Across all the interviews, access to the latest scientific knowledge and best practice, and ensuring responses are evidence-based, was seen as extremely important for organisations to adapt (the forthcoming ADAM adaptation catalogue was seen as a potentially valuable addition to the knowledge base by those interviewed). As such, platforms for knowledge transfer were seen as critical. In addition to having access to knowledge, a common thread that weaves throughout all the interviews is the importance of 'learning to adapt', and ultimately to better understand how learning occurs in different organisations (seen as a crucial component of the

adaptation process). Indeed, there is a lot we can learn from other contexts, sectors and systems on how to do this well (knowledge already exists in relation to the conditions that best support effective learning, e.g. a comfortable space, lack of urgency, etc.). Peer-to-peer learning through networks, well facilitated meetings, training events, etc. was seen by some as a good way to share practical information about experiences, overcoming barriers and detailing best practice (as well as providing required support for decision-makers).

Box 3. Examples of actors' risk perception

Two examples of actors who see the risks of climate change as very real are the Greater London Authority and the Association of British Insurers. London is seen as potentially at risk from all the major climate-related hazards and is therefore pro-active in developing a comprehensive adaptation policy. The authority recognises that climate risks are likely to affect most aspects of business, as well as being an environmental issue. The insurance industry is also particularly pro-active (and seen as having a key role to play in the adaptation agenda) and is increasingly willing to engage with government, business and others, in order to more effectively manage climate risks. They also have considerable power to influence adaptation activity. For instance, the Association of British Insurers (in its role as an umbrella group for the insurance sector) has negotiated with the UK Government and committed to continue the provision of flood insurance, on the condition that investment is made to ensure adequate climate proofing of planned developments.

3.3.5 Better stakeholder engagement with policy

As noted in the interviews: 'adaptation responses can benefit significantly from effective, and iterative, stakeholder engagement'. This suggests the need for improved interactions between the policy, stakeholder, and scientific communities (quote: in many instances policy makers are unaware of what is actually happening at the 'coal-face', a result of liaising predominantly with other policy makers). Therefore, mobilising local experiences was viewed as a key asset for identifying options and relevant indicators. The BKCC programme (Building Knowledge for a Changing Climate) in the UK (and successor programme, Sustaining Knowledge for a Changing Climate) was suggested as an example of best practice, both in linking science, policy and stakeholders, and in providing practical tools for robust decision-making. Although there is clearly an increased awareness of climate change, it was also noted that there is a perceived gap between theory and practice and that converting awareness into practical actions is a common problem. It was argued that further advanced level training for professionals will ensure that the climate change information / guidance is put to most effective use (the importance of educating those in key positions).

3.3.6 Costs and benefits

Not surprisingly, the economic dimension of adaptation was considered very important by several of those interviewed. It was felt that decision-makers need more detailed information on the costs and benefits of alternative adaptation measures, as this will be an important influence for both private and public investment. Existing lack of knowledge of the costs and benefits of adaptation options was seen as a potential barrier to implementation. Other wider economic issues were also discussed, for example in relation to difficulties in assigning values to natural resources correctly (leading to economic disincentives that may act against responses). Similarly, even though climate change has been identified as a major threat to society, there was concern that inadequate resources to fund adaptation activity was a major barrier (both in financial terms and the presence and development of an adequate skills base).

3.3.7 Common themes identified by stakeholders

Contributions from experts and stakeholders seem to suggest the following:

- Any adaptation framework – irrespective of the governance level it will be set at – will need to incorporate tools and mechanisms that *enable adaptation activity* i.e. ensuring flexibility and support for local level action. As we would expect, and as we know from other policy areas, meaningful local participation can benefit the development of risk assessment in addition to promoting the legitimacy of decision-making, and the effective implementation of adaptation measures.
- Adaptation can be considered as a process or outcome. If it is seen as process, education, information and awareness become crucial in building adaptive capacity. The interviews point to the importance that stakeholders attach to enhance learning via mechanisms or platforms that promote the transfer of knowledge between science, stakeholders, and policy makers. If adaptation is seen as output, key issues are the

clarification of what "good" adaptation actually is or should be but also how to measure it and evaluate different options.

- Moving towards the implementation of adaptation measures, results were quite predictable and included the importance of adequate resourcing to ensure that the adaptation agenda is supported or the need to identify different possible 'points of entry' in promoting adaptation (e.g. during major policy reviews, or new internal or external policy initiatives) to avoid golden (policy) opportunities being missed.
- Stakeholders confirmed that "adapting to climate change" requires integration across different policy 'silos' (see mainstreaming section). Yet, governments in general have difficulties in formulating and implementing integrated approaches. Adaptation could have positive implications for other policy fields such as social/environmental justice and improving quality of life. Policy makers should attempt to identify those areas with synergies between adaptation and other policies, particularly sustainable development.
- A key challenge for the EU – as it is for governments in general – is to ensure that adaptation is adequately integrated into policies and funding regimes, recognising that this can impact both EU and non-EU vulnerabilities.
- As a final point, stakeholders also identified the need for more innovative use of incentives and rebates (for example, Germany: permeable paving, Australia: water saving initiatives) not only to promote the implementation of adaptation measures but also the "process" through awareness raising and local support.

4. The economics of adaptation[13]

The analysis on the economics of adaptation suggests that the economic impacts of climate change will be reduced by adaptation, primarily driven by private responses autonomous of government policy. In some cases, adaptation may reduce the impacts or turn climate change into an opportunity with a positive final outcome. It also concludes that the principal challenges are with those (adaptation) needs that require collective action, public engagement including public finance. Adaptive capacity increases with both flexibility and economic growth. The preliminary analysis reconfirms an expected result that the adaptive capacity is more restricted in small and remote communities and in the face of extreme events compared to centres with greater economic diversity and in relation to slow onset climate change. The potential for adaptation generally is large and may be fully utilized under slow and smooth changes, whereas this potential is more difficult to utilize in cases of sudden changes. Early, anticipatory adaptation may be more cost-effective than reactive adaptation.

4.1 The role of economics

The economics of adaptation has several roles. It can assist in achieving a given level of adaptation in the most cost-effective way. Under a wider analysis, it can be used to compare the benefits and costs of adaptation, to ensure that the benefits of the adaptation measure outweigh the costs, and can help prioritise alternative adaptation options. Finally, under a formalised cost-benefit analysis, it can be used to achieve the optimal level of adaptation. So far, the economics of adaptation is a relatively unexplored field of research with few results.

The literature distinguishes between autonomous *direct* adaptation and autonomous *indirect* adaptation. Autonomous *direct* adaptation can be described as changes that market participants or individuals make as part of their economic behaviour when confronted with climate change. This means that a change in the climate triggers responses of market participants or individuals , e.g. to change inputs or their behaviour in order to continue producing the same output or satisfying the same needs as before the change.[14] It is likely that direct autonomous adaptation will constitute a major part of the adaptation that will take place under climate change. The role and importance of autonomous direct adaptation depends critically on how developed the markets are. Thus, in less developed countries, and in particular in informal sectors, opportunities for autonomous direct adaptation are restricted, and the actors thereby become more vulnerable to climate change.

[13] Contributed by Asbjørn Aaheim & Anita Wreford

[14] Examples are e.g. i) if more fertiliser is required per unit of land in order to produce the same crop "after" climate change, the farmer will consider the possibility of using more land or a little more of both, ii) If climate change is negative for crops and positive for cattle, the composition of the agricultural product of a country will become more dominated by cattle and less by crops, iii) More rainy days makes more people travel by car rather than walk or bicycle. A more humid climate will therefore increase the use of cars even if the transport needs are the same; iv) An increase in days with "extreme heat" has the costs of an increase in hospital admittances. However, the consumers, who are potential patients, will adapt by purchasing more cooling equipment in order to avoid heat stress in the future.

Autonomous *indirect* adaptation is a result of the market effects spurred by climate change. In other words, impacts of climate change in one sector have a knock-on effect in other sectors, affecting prices and therefore production. Commodities and services heavily dependent on the utilisation of natural resources will be particularly vulnerable, because the availability of natural resources is sensitive to the climate. These sectors clearly include agriculture, forestry and fisheries. Other sectors of possible interest are transport and tourism.

Box 4. Economics of timber production

For example, it is expected that the productivity of forests will increase under climate change, at least in the northern hemisphere. In economic terms, this means that the cost of supplying timber goes down. However, due to the global interactions between supply and demand, the final outcome to the owners of the forests is negative: Higher productivity in forested land implies that the rent collected on harvest is reduced because the prices go down. Those who gain are the consumers, who are spread all over the world, since timber is a world traded commodity. In other words, what appeared to be good news to forest owners became good news to the world consumer, while the owners ended up facing a loss (Aaheim et al., forthcoming).

Neither direct nor indirect autonomous adaptation are subject to policy making in general. However, being a result of predicted behaviour among economic agents, possible undesirable consequences may need policy interventions. For example, adaptation requires accelerated turnover of the capital stock. Hence, the economic agents need time, perhaps decades, to adapt. The new investments will also be made with an additional source of uncertainty, namely how and to what extent the climate will continue to change. Thus, autonomous adaptation works best under a slow and smooth change of climate. The main challenges occur in cases of sudden changes.

4.2 Adaptation under local restrictions

In an ideally competitive market, the potential for autonomous adaptation is significant. Capital moves freely across borders and labour is mobile and it does not matter where services are produced or demanded as long as they are produced. The real situation is more constrained. A local community whose economic activities depend heavily on climate-dependent activities, such as tourism, will be more severely affected than larger communities where these activities constitute a small share. The effect of the closure of businesses, in terms of social costs on a small community, is much more significant than in a larger community, where customers are likely to be recruited from a larger variety of activities, thereby making them less vulnerable. Policies that generally contribute to more flexible economies will moreover enhance the adaptive capabilities. For example, education makes it easier to move and actually get a job and increases the ability to change the structure of the economy into a less climate dependent direction.

4.3 Public action and implementation of adaptation measures

The economics of autonomous direct adaptation assumes that private actors undertake adaptation measures to the extent that the cost they pay on the margin equals the expected marginal reduction of the damage that they themselves feel responsibility for. This may however not be true.

- First, measures to protect and prevent against negative impacts benefits the collective without being subject to the control of single agents and/or measures are subject to economies of scale. Hence, there is a lack of incentives to single agents to implement them. An example for this are dikes. Cost-benefit analysis repeatedly shows that the benefits of dike building outweigh the (construction) costs, at least in densely populated areas that have been studied. Similar measures include building to prevent river flooding, building standards aiming at resisting storms, protection walls against land-slides etc. However, there are few, if any, systematic assessments of such options in relation to climate change.
- Second, even if incentives for the individuals exist, public authorities may nevertheless take the responsibility, especially in the case of natural hazards. Damages caused by natural hazards in most EU member states are subject to combined response of different parties, usually justified by ethical arguments: people should not bear an extra burden for being exposed to natural hazards. As a result, however, individuals lose incentives to take appropriate actions to protect and prevent, for example when developing areas subject to a hazard risk. This creates the "moral hazard" effect, for example excess development in risky areas. The damages under climate change will therefore also exceed the damage that reflects the accepted level of security in a society.

Finally, it should not be forgotten that there is an increasing role of private insurances, which will be

crucial to discourage exposure to risk, e.g. by not providing insurance to homes built in exposed areas.

4.4 Transaction costs

Often unaccounted for, transactions costs are made of up the costs associated with searching for information, searching for partners in collective action, drawing up and enforcing contracts, and building up networks and social capital. The most advanced analysis of the transaction costs of implementing policies designed to bring about public benefits have been undertaken in agriculture and land use. It has been shown in the agricultural sector that farmers failed to adopt voluntary conservation practices in Europe even where they were being paid to do so because of the perceived high transaction costs in setting up the contracts with government agencies (Falconer, 2000). Such policies for land use may well be part of adaptation to climate change and, with significant uncertainties about local climatic conditions and changes in variability, it may well be that transactions costs for adaptation policy implementation may be high.

A distinction can also be made between anticipatory vs. reactive adaptation, i.e. adaptation that occurs before or after the impacts of climate change are observed. There can be circumstances when an anticipatory intervention is less costly and more effective than a reactive action (a typical example is that of flood protection). There are some studies that show that reactive responses are not always cost-effective or adequate, and that the transactions costs associated with adaptation policy implementation may be high. However, it is increasingly agreed that in order to prevent major damages, a purely reactive strategy will not be sufficient (especially larger and more complex adaptation measures need to be planned in advance). This will need to be tested for EU member states across various sectors. ADAM will undertake this work in the future.

4.5 Research gaps and policy challenges

Little research exists specifically quantifying the costs and benefits of adaptation. Some studies attempt to address adaptation in a generic sense, for example PESETA, Stern, IPCC, however few provide comprehensive estimates of economic costs or benefits across sectors. Increasing sectoral literature is emerging, particularly on the costs of adaptation to sea-level rise. Considerable research exists in the health sector on the costs of climate change (e.g. Bosello et al. 2006), particularly for extreme events. However, the costs of adaptation are less well understood.

Studies in the agricultural sector tend to assume either perfect autonomous adaptation or no adaptation at all. ADAM has identified a need for research to compare the costs of adaptation with the costs of not adapting for most if not all potentially affected sectors. We come back to the earlier assumption that efficient markets are best suited to facilitate adaptation actions. However, to establish efficient markets may be challenging, particularly in cases of possible sudden changes, where proper adaptation strategies require planning. For example, extreme events represent sudden changes that may be subject to incomplete insurance markets. The costs are seldom shared according to the risks of those exposed, with a resulting lack of incentives for adaptation. Policies may instead create incentives that encourage mal-adaptation, i.e. increasing vulnerability. There is a need to study alternative incentive structures in this area.

Moreover, better insights into the public good character of adaptation measures would be helpful to improve the efficiency of adaptation. Public goods are measures for which the benefits are shared by many actors. Identification of public goods is helpful in defining cases where public authorities ought to develop adaptation strategies, and in what cases adaptation may be left to private actors. Generally, public good measures will be underfinanced if left to private intiatives. But there are also examples of adaptation measures initiated by private investors where side effects are ignored, thereby increasing the vulnerability of others.

Maladaptation, i.e. “any changes in natural or human systems that inadvertently increase vulnerability to climatic stimuli” or “adaptation that does not succeed in reducing vulnerability, but increases it instead” IPCC (2001) can lead to the following effects (Downing et al., 2005):

- Inefficient use of resources compared to other options (e.g. the principle that all actions should be climate-proof through adaptation would be an extremely expensive tax on current investment that is unlikely to provide good value for society as a whole);
- Ineffective (e.g. relying on scenarios of future climatic risks that are not subsequently realised and actions that have no other benefits);
- Displacing vulnerability (from one actor to another) and/or
- Reducing the possibility for future adaptation.

5. Assessing monetary and economic risks from extreme weather events in Europe[15]

There is growing evidence of rising economic losses due to extreme weather events and even today many regions and sectors in Europe are vulnerable to natural hazards. For example flood risks have risen and particularly the new Member States experience high potential losses of GDP. When projecting weather extremes into the future, risks rise considerably under a business-as-usual scenario (supporting the argument for strong climate change mitigation action). On the other hand there are important knowledge gaps, particularly concerning the assessment of monetary and wider socioeconomic risks to extreme events. ADAM research attempts to narrow the gap for better adaptation decisions by: a) mapping asset risks to flooding and droughts (other hazards are being included over time) in Europe for today and future climates (direct risks); and b) estimating economic vulnerabilities due to natural hazards for the public and different sectors in Europe (indirect risks). Estimated probabilistic economic vulnerabilities in Europe suggest that governments may experience serious fiscal problems if extreme events become more frequent due to climate change.

5.1 Spatial and probabilistic assessment of extreme event risks

The escalating increase in disaster losses from floods, droughts, and other climate-related disasters both in developed and developing countries has been a major concern over the last years. There is mounting evidence of a significant climate-change signal in natural disaster events, for example, increasing extreme precipitation at mid- and high-latitudes (Schönwiese et. al, 2003), extreme floods and droughts in temperate and tropical Asia, severe dry events in the Sahel and southern Africa (IPCC, 2007), and increases in tropical cyclone activity in the Atlantic and the Pacific region (Emanuel, 2005).

In Europe, wide ranging impacts of changes in current climate have been documented: retreating glaciers, longer growing seasons, shift of species ranges, and health impacts, e.g. due to the 2003 heat wave of unprecedented magnitude causing 70,000 premature deaths (EU DG ENV, 2007). There is a continuity and consistency between the observed changes and those projected for future climate change. Negative impacts will include increased risk of inland flash floods, and more frequent coastal flooding and increased erosion (due to storms and sea-level rise). Furthermore, climate change is expected to magnify regional differences in Europe's natural resources and assets. In the North, reduced demand for heating, less winter deaths, increased crop yields, longer vegetation season, extension of agricultural land areas, increased forest growth, tourism-friendly increase of the Baltic Sea temperature, and increasing water power are projected. In Southern Europe, climate change is projected to worsen conditions (high temperatures and drought) in a region already vulnerable to climate variability, and to reduce water availability, hydropower potential, and, in general, crop productivity. As climate change continues, negative impacts are likely to outweigh its benefits (IPCC, 2007).

Already today many regions and sectors in Europe are vulnerable to increasing disaster risks because of a lack of resources to implement cost-effective loss-reduction and risk-transfer measures, and their consequent inability to recover in a timely way to disaster events. The number of disastrous weather and climate-related events in Europe per year doubled over the 1990s compared with the previous decade, while non-climatic events such as earthquakes remained constant. Until 2004, four of the five years with the largest economic losses have occurred since 1997 (EEA, 2004).

Furthermore, as discussed in the green paper these "direct risks" will have important ripple economic effects ("indirect risks") on economic sectors, such as agriculture and the insurance industry, as well as the public sector. Yet, the knowledge base on disaster impacts and risks is heterogeneous. As put forward in the fourth assessment report of the IPCC (2007) and the EU Adaptation Green Paper, risk management methods and tools are not sufficiently developed to adequately address this. Knowledge exists mainly on the risks (exposure, sensitivity and impacts) from sudden and slow-onset disasters from extreme weather.

In ADAM one focus of the research on extremes is concerned with providing digital maps of risks form natural extremes for Europe and identifying the associated monetary losses. The innovation with respect to available maps is that they are consistent, probability based and spatially explicit[16]. For instance, we find that almost all of the newest EU Member States have a potential flood damage risk higher than 1% of GDP. As hazards and risks are

[15] Contributed by Reinhard Mechler, Carlo Lavalle & Zbigniew Kundzewicz

[16] The maps are on a 50 × 50 km^2 grid level for Europe and currently project monetary losses for 20, 50, and 100 year riverine flood events and drought risks. Other extreme event hazards, e.g. forest fires will follow.

projected into the future, we find a considerable increase in extremes (such as intense precipitation) in comparison to the control period (1961-1990). While for the 2020s differences to the control are small, there is a considerable increase in extremes for the 2090s, in particular for a high temperature increase trajectory (SRES A2 scenario). For example, drought extremes in the Guadiana river basin and wet extremes in the Tisza river basin (two ADAM regional foci) will be significantly enhanced. Such risk analysis is hence important for local stakeholders and national/European authorities alike to raise awareness to exposures to current and future risks as well as to adapt more effective and adaptation measures. For instance, the information may inform a more equitable and risk-based allocation of the EU solidarity fund, which was set up in 2002 to provide financial aid to member states for post-disaster emergency measures.

5.2 Assessing fiscal and economic disaster risks

Building on the above task of mapping monetary risks to public and private assets for selected natural hazards over Europe, the 2nd research focus presented here estimates economic vulnerability of European households, businesses and governments to probabilistic disaster losses. The key question addressed is how those economic agents can absorb (or not) the monetary disaster losses and risks, which involves assessing their capacity to reduce risks before, provide relief and rebuild assets after an event.

A stream of activity focuses on the fiscal consequences and the modelling undertaken involves incorporating financial disaster risk and potential financing gaps for funding these losses into macroeconomic projections in order to determine fiscal and economic consequences. Economic vulnerability can have serious repercussions on the national or regional economy and the population. If a government cannot replace or repair damaged infrastructure, for example, roads and hospitals, and fails to provide assistance to those in need after a disaster, there may be long-term consequences. As one test case, flooding in the Upper Danube basin and the fiscal repercussions for Austria have been assessed. Based on 10,000 disaster scenarios simulated, the analysis shows that the government may face serious fiscal problems to finance large loss events or recurring events affecting a large portion of infrastructure and requiring massive relief support to the affected population. The analysis demonstrates that disasters may have important fiscal consequences today and in a future climate with increasing flood losses, and that those effects can be accounted for in budget and other planning procedures. Other research in this line of work focuses on important economic sectors and their vulnerability and associated risks now and in the future. The final aim of this part of the ADAM project is to identify a set of extreme events and associated return periods that may be beyond the adaptive capacity of identified regions and sectors in Europe by placing unacceptable stress on the economic system. Importantly, all results derived in this thematic area of ADAM will be compiled in a digital compendium, which will be made available to the public via the internet and thus will provide a transparent, open-domain resource for informing interested and affected stakeholders on local, national and EU levels.

6. Uncertainties surrounding adaptation[17]

This section explores different concepts of uncertainties surrounding climate change and variability in the context of adaptation. It is argued that responses will depend on the range of uncertainty. More importantly, adaptive measures are best suited if they enable structural change while being sufficiently flexible to allow recalibration when uncertainties are reduced. Yet, the devil is in the detail.

The issue of uncertainty pervades the scientific and policy literature on climate change. The Intergovernmental Panel on Climate Change (IPCC), for example, has worked hard to develop guidelines for modelling, interpreting, and communicating uncertainty, in preparation for writing their Fourth Assessment Report, seeing these elements as a key cross-cutting element. There has been a great deal of literature examining how this uncertainty ought to influence decisions made with respect to climate change mitigation. Although the implications of uncertainty are at least as great, there has been much less examination of the effects of uncertainty for climate change to adaptation, probably because the issue of adaptation has surfaced more recently.

There are four main sources of uncertainty that are relevant for adaptation planning, and distinguishing these is relevant to understanding the pace at which uncertainty will be resolved.

- First, the level of uncertainty concerning the basic science of the climate system, and the responses of biological and social systems to changes in climate, is high. Continued scientific research may help to resolve some of this uncertainty, although it may also uncover

[17] Contributed by Anthony Patt.

additional uncertainty, such as particular feedbacks. Over the last two decades, the second of these two forces has dominated, such that the estimated range of uncertainty has grown larger, although hopefully more accurate.

- Second, predictions of the future state of the climate system are sensitive to uncertainties concerning the current state of the climate system. More complete measurement of current climate variables, as well as the use of more proxy records for the past climate state, may help to resolve some of this uncertainty. Cox and Stephenson (2007) suggest that uncertainty over initial conditions is most important for trying to make predictions about the state of the climate system over the next 20 years. In this case, inter-annual and multi-decadal variability dominates the climate signal, and it is current data limitations that give rise to uncertainty about these factors (Smith et al., 2007).

- Third, the climate system will respond over time to future emissions, which in turn are influenced by long-term economic and technological development trends, and by policies that are specific responses to climate change. The former are captured to some extent by the range in the SRES emissions scenarios (although it is worth noting that the world is currently above the high end of the SRES range). Climate-specific policies are not captured by any standard scenarios, although the range has some likely boundaries: from no significant mitigation policy at all, to policies that completely eliminate greenhouse gas emissions in the next few decades. This range of uncertainty, especially due to climate-specific actions, narrows only in response to actual events playing out, such as the signing of an international treaty, or the invention of a new technology. Together, these three factors account for a great deal of uncertainty about what climate impacts will occur, at what level, and in what place.

- Fourth, there is a great deal of uncertainty about how adaptation policies will work, and indeed what policy measures can contribute to increasing adaptive capacity. Greater case study research may provide guidance on this, although such case studies would analyse the effectiveness attempts at actual adaptation planning, and these are only starting now. Hence, it will be some years before uncertainty concerning the effectiveness of adaptation policies becomes less.

For adaptation, it is especially the timescales that are important, since some adaptations are to infrastructure with discrete lifetimes, such as 30 or 40 years, while others will affect human settlement and activity patterns into the distant future. The spatial aspect is also important, because with few exceptions, adaptation will made at the local to national level. In comparison, for mitigation, it is the total range of uncertainty, rather than its temporal or spatial aspects, which is most important. This is because the effects of today's mitigation decision will be felt for centuries, and globally.

Irrespective, some adaptations can be made in response to observed changes, however others, especially those with longer time horizons, need to be anticipatory. Given the analytic difficulties associated with estimating the range of uncertainty, one response could be to adapt to the mean expected change. Another possibility could be to adopt a risk management framework, and to adapt to changes expected at a particular confidence level, such as 99%. If, for example, the median warming estimate for the next 100 years is 4°C, and at the 99% confidence level it will be less than 7°C, then the risk management approach may be to adapt to the set of conditions that would occur given that 7°C future. This would minimize risk, but might also be quite wasteful, since it is unlikely that the full 7°C of warming will happen. The third – and most complicated – approach is to take a real options approach, which takes into account the irreversibility of action, and the rate at which uncertainty will be resolved over time. If uncertainty is expected to be resolved quickly, then it makes sense to postpone irreversible decisions until the uncertainty is resolved. While it is possible that some event could resolve a large piece of uncertainty – a breakthrough in solar technology that makes a zero emissions future suddenly certain – this is unlikely to be the case; more likely is that the uncertainty over events occurring more than about 40 years into the future will decrease somewhat over time, that there will be very little further decrease in uncertainty for events within that 40 year window, and that the remaining uncertainty will be resolved at the last minute.

In conclusion, uncertainty is thus not a good justification for postponing action (i.e. anticipatory adaptations with payoffs within that 40 year window) since the uncertainty will probably only be resolved too late to still engage in anticipation. However, uncertainty means making adaptations flexible, rather than irreversible, so that at the last minute they can easily be scaled up, or scaled back, as conditions dictate. How much flexibility to invest in needs to be resolved on a case-by-case basis, since depending on technological and social constraints it will come at very different costs.

References

Aaheim, H.A., N. Rive and K.E. Hauge (forthcoming), *Adaptation and world market effects of climate change on forestry*, CICERO, Oslo.

Adger, W.N. (2006), *Vulnerability Global Environmental Change*, Vol. 16, pp. 268-281.

Berkhout, F. (2005), "Rationales for adaptation in EU Climate Policy", *Climate Policy*, 5(3), pp. 377-391.

Bosello, F., R. Roson and R. Tol (2006), "Economy-wide estimates of the implications of climate change: Human health", *Ecological Economics*, 58, pp. 579-591.

Boyd, R. and A. Hunt (2006), *Costing the local and regional impacts of climate change using UKCIP costing methodology*, Metroeconomica Limited.

Brooks, N. (2003), *Vulnerability, risk and adaptation: A conceptual framework*, Tyndall Centre for Climate Change Research, Working Paper 38.

Cox, P. and D. Stephenson (2007), "A changing climate for prediction", *Science*, 317: 207-208.

European Commission (2007a), *Adapting to Climate Change in Europe – Options for EU Action*, Green Paper, COM(2007) 354, Commission of the European Communities, Brussels.

European Commission (2007b), *Limiting Climate Change to 2 degrees Celsius: The way ahead for 2020 and beyond*, Communication, COM(2007) 2, Commission of the European Communities, Brussels.

European Commission (2007c), "Climate change: Europe must take adaptation measures to lessen impacts of current and future warming", DG ENV Press release IP/07/979, Brussels, 29 June.

EEA (2004), *Impacts of Europe's changing climate: an indicator-based assessment*, European Environment Agency, Report 2/2004, Office for Official Publications of the European Communities, Luxembourg.

EEA (2006), *Vulnerability and adaptation to climate change in Europe*, EEA Technical Report, No. 7/2005, European Environment Agency, Copenhagen.

EEA (2007), *Climate Change: The Cost of Inaction and the Cost of Adaptation*, EEA Technical Report No 13/2007, European Environment Agency, Copenhagen.

Emanuel, K. (2005), "Increasing destructiveness of tropical cyclones over the past 30 years", *Nature* 436, pp. 686-688.

Environment Canada (1997), *The Canada country study: climate impacts and adaptation*, National summary for policy-makers, Environment Canada, Ottawa.

EWA (2007), Edison Wetlands Association (www.edisonwetlands.org/resources/glossary.html).

Falconer, K. (2000), "Farm-level constraints on agri-environmental scheme participation: A transactional perspective", *Journal of Rural Studies*, 16, pp. 379-294.

Genovese, E., N. Lugeri, C. Lavalle, J. Barredo, M. Bindi and M. Moriondo (2007), "An assessment of weather-related risks in Europe DA2.1. Preliminary month 18 report on maps of flood and drought risks", ADAM 18-months deliverable D-A.2.1a.

Hochrainer, S. and R. Mechler (2007), "Preliminary report on Europe's financial and economic vulnerability to meteorological extremes", ADAM 18-months deliverable D-A.2.3a.

IPCC (2001), *Climate Change 2001: Impacts, Adaptation and Vulnerability*, Working Group II contribution to the Intergovernmental Panel on Climate Change Third Assessment Report, Cambridge: Cambridge University Press.

IPCC (2007), *Climate Change 2007: Climate Change Impacts, Adaptation and Vulnerability*, Working Group II Contribution to the Intergovernmental Panel on Climate Change Fourth Assessment Report, Cambridge: Cambridge University Press.

Klein, R.J.T. and R.S.J Tol (1997), *Adaptation to Climate Change: Options and Technologies*, Vrije Universiteit Amsterdam.

Klein, R.J.T., E.L. Schipper and S. Dessai (2005), "Integrating mitigation and adaptation into climate and development policy: three research questions", *Environmental Science and Policy*, 8, pp. 579-588.

Levina, E. and D. Tirpak (2006), *Adaptation to Climate Change*, Key Terms OECD/IEA unclassified publication COM/ENV/EPOC/IEA/SLT(2006)1.

McEvoy, D., S. Lindley and J. Handley (2006), *Adaptation and mitigation in urban areas: Synergies and conflicts Proceedings of the Institution of Civil Engineers*, Municipal Engineer, 159, No. 4, pp. 185-191.

McEvoy, D. et al. (2007), "A draft synthesis report of the actor-based analysis of adaptation to climate change", ADAM 18-months deliverable D-A1.4a.

McEvoy, D., K. Lonsdale and P. Matczak (2008), *Adaptation and Mainstreaming of EU Climate Change Policy: An Actor-Based Perspective*, CEPS Policy Brief, Centre for European Policy Studies, Brussels.

Mendelsohn, R. (2006), "The role of markets and governments in helping society adapt to a changing climate", *Climatic Change*, 78, pp. 203-215.

Metroeconomica (2004), *Costing the impacts of climate change in the UK: Overview of guidelines UKCIP technical report*, UKCIP, Oxford.

PESETA (2007), Projection of Economic impacts of Climate Change in Sectors of the European Union based on bottom-up Analysis (from http://peseta.jrc.es/index.htm).

Schönwiese, C.D., J. Greaser and S. Trowel (2003), "Secular change of extreme monthly precipitation in Europe", *Theoretical and Applied Climatology*, 75, pp. 245-250.

Smith, D. et al. (2007), "Improved temperature prediction for the coming decade from a global climate model", *Science*, 317, pp. 796-799.

Stern, N. (2006), *The Economics of Climate Change* (The Stern Review), Report for the Cabinet Office – HM Treasury, Cambridge: Cambridge University Press.

Tompkins, E., E. Boyd, S.A. Nicholson-Cole, K. Weatherhead, N.W. Arnell and W.N. Adger (2005), *Linking Adaptation Research and Practice*, report submitted to Defra as part of the Climate Change Impacts and Adaptation Cross-Regional Research Programme, Defra, London.

Appendix 1.
Illustrative matrix of EU policy area and the interaction with adaptation and mainstreaming

	Sectoral area									
EU policy Area	**Impacts on water cycle and water resources management**	**Marine resources and coastal zones and tourism**	**Human health**	**Agriculture and forestry**	**Biodiversity**	**Regional planning, built environment, public and energy infrastructure, Structural funds**	**Urban planning and construction**	**Development cooperation**	**Role of insurance industry**	**Building national strategies for adaptation (country reports)**
Employment and social rights	**	*	*	*		**	**	*		
Justice and citizens' rights	*	*	*			**	**	***		
Environment, consumers and health	***	***	***	***	***	***	***	***		
Agriculture, fisheries and food	***	*	***		***					
Culture, education and youth										
Regions and local development						***				
Transport and travel		***				***				
Economy, finance and tax		***				***				
Business										
Cross-cutting policies										
External relations and foreign affairs	***		***					***		
Science and technology			*							
Energy and natural resources	*			***	**	*				
OVERALL IMPORTANCE OF MAINSTREAMING										
Major role	***			***		***		***		
Some Role in influencing MS		**/*	**		**/*		**/*			**
Little role									*	

*Key: * Some potential effect. ** Likely influence. *** Very important influence.*

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European Network of Economic Policy Research Institutes (ENEPRI)
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