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Adaptation and Mitigation Strategies

Supporting European Climate Policy

Final Report

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Sixth Framework Programme

Project and Contact Information

Coordinated by the UK's Tyndall Centre for Climate Change Research, ADAM is an integrated research project running from 2006 to 2009 that will lead to a better understanding of the conflicts and opportunities of climate change adaptation and mitigation policies. ADAM is supporting EU policy development in the next stage of an international climate regime and will inform the emergence of new adaptation and mitigation strategies for Europe.

ADAM is funded by the European Commission under the 6th Framework Programme Priority: Global Change and Ecosystems

This is the final report summarising the ADAM project. For more information please visit us at www.adamproject.eu or contact us at the address below.

ADAM project office

Tyndall Centre for Climate Change Research, University of East Anglia, Norwich, NR4 7TJ, UK

Prof. Mike Hulme
ADAM Coordinator
+441603593162
m.hulme@uea.ac.uk

Dr. Henry Neufeldt
ADAM Project Manager
+441603591120
h.neufeldt@uea.ac.uk

Ms. Angela Ritchie
ADAM Administrator
+44 1603 59 1227
a.ritchie@uea.ac.uk

European Commission

Climate Change and Environmental Risks Unit, General Directorate for Research, European Commission, CDMA 3/006, B-1049 Brussels, Belgium

Dr.-Ing. Wolfram Schrimpf
Responsible Scientific Officer
wolfram.schrimpf@ec.europa.eu

Editors

Mike Hulme, Henry Neufeldt and Helen Colyer all of the School of Environmental Sciences, University of East Anglia, Norwich, UK.

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Full list of organisations and researchers involved on page 43.

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Executive Summary

The ADAM Project

The ADAM project was funded by the European Commission to research strategies for mitigating and adapting to climate change from a European perspective but in a global context. The research was conducted between March 2006 and July 2009 by a Consortium of 24 European research institutes, together with one partner from each of China and India. The Consortium was led by the Tyndall Centre for Climate Change Research at the University of East Anglia, UK.

ADAM research identified, analysed and appraised existing and new policy options that contributed to different combinations of adaptation and mitigation strategies. These options addressed the demands a changing climate will place on protecting citizens and valued ecosystems – i.e., adaptation – as well as addressing the necessity to minimise humankind's perturbation to global climate to a desirable level – i.e., mitigation. The appraisal of these options recognised the existence of multiple criteria: costs and benefits, cost effectiveness, equity, legitimacy, public support and environmental integrity. Such an appraisal identified where policy options can contribute to both objectives – i.e., adaptation and mitigation – and where policy trade-offs or conflicts may emerge.

The ADAM work programme was structured around four overarching domains: Scenarios, Adaptation, Mitigation and Policy Appraisal. In addition, four Case Studies were completed in which synergies and trade-offs between climate change mitigation and adaptation strategies were analysed at different scales, both within and outside Europe. Key findings from the research conducted within these domains are highlighted below.

Integrated Scenarios

Adaptation and mitigation are sometimes regarded as alternative strategies, but they are certainly not mutually exclusive. Effective climate policy involves a portfolio of both adaptation and mitigation activities. **Even with high levels of mitigation – limiting global-mean temperature increase to no more than 2°C above pre-industrial levels – climate change impacts will require considerable adaptation efforts.** Moreover, given the uncertainties involved, a strategy that aims for 2°C could also lead to a 3°C temperature rise. In contrast, scenarios without any mitigation may lead to a temperature increase of 4°C or more and could make effective adaptation very costly or else impossible. Integrated assessment of the costs and benefits of different strategies show that these strongly depend on key uncertainties – such as the climate sensitivity and climate damages – but even more so on normative judgements such as the discount rate.

European Climate Policy

Existing European climate policies and measures are not sufficient to meet stated climate goals such as the 2°C target. The contribution of EU climate policy to historical emissions reductions cannot easily be assessed, with other market and technological factors playing an important role. Such effects and uncertainties will continue to be important in the future. **To meet its own targets, climate policy in the EU beyond 2012 will need to become increasingly 'Europeanised', including key competences related to energy and fiscal policy. In this way, climate policy poses a challenge to European governance more broadly.** Future effectiveness of EU climate policy also depends on greater attention being paid to implementation, monitoring and policy appraisal.

Achieving the EU's Two-Degree Target

Reaching the 2° target with a high likelihood will require a broad portfolio of mitigation options. **The ADAM analysis shows that a set of different models finds low greenhouse gas concentration targets to be technically feasible at maximum cost of a few percent of global GDP.** If the whole portfolio of mitigation technologies is not available, either the cost will increase or else low concentrations will not be possible. Depending on the stringency of the target, there are multiple possible technological mitigation pathways; different models suggest different combination of technologies that could lead to low concentration targets. However, the models seem to agree on the ranking of importance of either including or excluding individual energy technologies: the lower the target greenhouse gas concentration, the more important becomes the use of bio-energy and carbon capture and storage.

Securing European Emissions Reductions

Assuming a framework of an effective global climate policy and with strong energy efficiency gains and increasing use of renewables stimulated by sector-specific policies, **Europe can make its proportionate contribution to achieving the 'two-degree target' by reducing greenhouse gas emissions by between 60 and 80 per cent by 2050.** Sector-specific policies for industry, services, energy conversion, transport and households have to be implemented to overcome market barriers for new technologies and organisational improvements that will increase energy efficiency, reduce energy demand and foster the strong market penetration of renewable energy technologies in the different sectors.

The European Electricity Sector

Europe can meet 2020 – and longer-term – mitigation goals at modest cost, with energy efficiency and the electricity sector playing major roles. An early emphasis on technological change, rather than a narrow focus on cost effectiveness, would best serve the long-term goals of global participation, and of energy security. Mitigation strategies will need to focus on more efficient electricity use, but also on improved conversion rates and new technologies such as renewables and carbon capture and storage. The sector will also have to adapt because climate change will have significant impacts on the ability to generate electricity and to deliver it without interruption. **These impacts will be felt differently between northern and southern Europe.**

Information for Adaptation Decision-Making

Using different methods of information structuring, storage and retrieval, **ADAM has produced an open-access web-based digital compendium that combines the heterogeneous knowledge of European impacts, vulnerability and adaptation**. All content is hyperlinked, free-text-searchable and consistently labelled by sector, region and climate-related hazard. It allows a decision-maker to explore for a specific sector or region what is known in the literature, what the future risks and economic consequences could be, what adaptation options are available and which practical experiences already exists.

Adaptive Risk Management

Adaptation is not just attaining a physical outcome, but is a dynamic process that relies on institutional mechanisms to enable implementation of selected measures and to build local capacity. **Involving stakeholders in adaptation and risk management processes is a key component of building adaptive capacity.** For example, in relation to flood risk, stakeholder interactions showed a need for adaptive flood risk management that would continually update data and build flexibility into policy decisions. Higher capitalisation of the EU Solidarity Fund or, alternatively, a reconsideration of its purpose may be needed. One novel idea is to use the Solidarity Fund instead to reinsure or capitalise national disaster insurance systems.

Climate Adaptation and Regional Planning

Based on our research in the Guadiana and Tisza River Basins, and in Inner Mongolia, we find that adaptation is enhanced by pilot projects that test and debate diverse sets of new ideas through collaboration between recognised actors from civil society, policy and science. **Integrating (traditional) agro-environmental land use systems with new technologies, organisational responsibilities and financial instruments provides opportunities for adaptation.** Informal networks are crucial for social learning and adaptive capacity and may be particularly useful in times of crisis. At the same time, formal rules are required to include adaptation in longer term planning, investment and financial support of experimentation and adaptation. A key challenge is to create flexible financial instruments that facilitate benefit- and burden-sharing and social learning, and that support a diverse set of potentially better-adapted new activities rather than compensate for climate impacts on existing activities.

Mainstreaming Climate Change in Development Policy

The process of mainstreaming climate change concerns into development assistance needs to be designed carefully in order to avoid unintended consequences. It is necessary to make sure that climate concerns do not overwhelm existing development programs. Beneficiaries of mainstreaming policies, which are often not those sought to be helped in the more general context of development assistance, need to be identified. It is important to identify how mainstreaming augments or interferes with existing norms of political accountability, and the diversity of perspectives and voices that exist within recipient countries. It is also important to design aid that does not crowd out local efforts, such as those by the private sector.

Global Climate Governance Beyond 2012

Global climate policy that is aimed at large emissions reductions beyond 2012 requires a strong, integrated governance architecture that involves both public and private actors and that provides a regulatory framework on both mitigation and adaptation. **Highly fragmented global climate governance is likely to be more costly, less effective in terms of environmental goals, and less equitable regarding smaller countries, particularly in the global South.** Strengthening dialogues between climate change and development and trade concerns appears crucial. Further international institutionalisation of adaptation is also needed; options could include a climate refugee protection and resettlement fund and an agreement on adaptation and food security. Integrated analysis shows that current programmes to finance adaptation in developing countries are insufficient.

Climate Policy Appraisal

Climate policy goals need to be regularly re-assessed in the light of shifting social, economic, political and scientific contexts and this is best achieved through a reflexive policy appraisal process. At present, there is a lack of such reflexivity in climate policy appraisal processes in Europe. To enhance reflexivity in the appraisal process we suggest the following: boundary organisations be created to conduct reflexive appraisals; new platforms be secured to enable inclusive and deliberative stakeholder processes; and ‘windows of opportunity for learning’ caused by shocks or changes to wider society systems be recognised and grasped.

Learning within the ADAM Project

A final section of this brochure summarises the findings of two evaluations of the ADAM project commissioned by the co-ordinators. One evaluation used a questionnaire to survey ADAM researchers about their learning experiences within the project. The other evaluation interviewed a number of ADAM modellers and of policy-stakeholders in the European Commission to examine the relationship between ADAM’s modelling strategies and the policy needs of the Commission.

Section 1: Introduction to the ADAM Project

Background and Outline

At the time the final draft of the ADAM[1] project proposal was being prepared early in 2005, the Kyoto Protocol had just been ratified. This was a milestone in international environmental policy and marked the beginning of the *political implementation phase* of the world's relationship with anthropogenic global climate change. We are now nearly halfway through the reporting period of the Kyoto Protocol and although the Protocol is a pioneering international agreement, its climate benefits are likely to be somewhat disappointing.

The international *political negotiation phase* of anthropogenic climate change had started 17 years earlier, in June 1988. The Toronto Conference on the Changing Atmosphere marked the beginning of the recognition by political leaders that climate change would lead to unprecedented impacts on ecosystems and societies to which a global and coordinated political response would be required. This phase continues today with annual meetings of the Conference of the Parties (COP) to the United Nations Framework Convention on Climate Change (UNFCCC). During COP-15 in Copenhagen in December 2009 this process will reach a new stage through the likely agreement of a transformed global climate policy regime. This agreement is one in which both mitigation of climate change and adaptation to its effects will be attended to.

The *scientific phase* of anthropogenic global climate change commenced well over a hundred years earlier. The science of climate change began with the theories and discoveries of, *inter alia*, Jean-Baptiste Joseph Fourier, John Tyndall and Svante Arrhenius and culminated in the establishment of the UN Intergovernmental Panel on Climate Change (IPCC) in November 1988. In February 2007, Working Group I of the Fourth Assessment Report (AR4) of the IPCC concluded that 'warming of the climate system is unequivocal' and that most of this recent warming is 'very likely' due to human emissions of greenhouse gases into the atmosphere. This scientific phase continues into the future now with the preparation of the IPCC Fifth Assessment Report due in 2013 or 2014.

It is against this background of research, negotiation and implementation that the ADAM project commenced its three year work programme in March 2006. Several events had recently placed, or were shortly to place, global climate change further into the centre of public awareness and political debates. The 2002 and 2007 floods in central Europe, the 2003 western European heatwave, hurricane Katrina in 2005, and the Australian wildfires of 2009 have offered dramatic and very visible evidence of human and ecological susceptibility to extremes of weather. By September 2007, Arctic summer sea ice had shrunk to its smallest extent since it has been regularly monitored.

During the period of ADAM's work both the Stern Review – in October 2006 – and the IPCC Fourth Assessment Report – at various dates during 2007 – were published. Both these reports have had significant repercussions for political debates about climate change, have influenced public attitudes to climate change and have shaped academic research practice.

The EU-funded ADAM project (Adaptation and Mitigation Strategies: Supporting European Climate Policy) is DG Research's flagship project on climate change adaptation and mitigation with a funding of almost 13 million Euro over three and a half years. Coordinated by the Tyndall Centre for Climate Change Research in the UK and including 26 research institutions from Europe and overseas, ADAM research is contributing to a better understanding of the conflicts and opportunities of climate policies. It is supporting EU policy development in the next stage of an international climate regime and is informing the emergence of new adaptation and mitigation strategies for Europe.

Now, just over three years later, in May 2009, this brochure offers a summary of the research that the ADAM project has completed during this period of global change, public anxiety and political uncertainty with respect to climate change. We capture the findings of this major EU-funded project through a series of headline statements and then elaborate each of these findings through short research narratives drawn from each of the main areas of work in the ADAM project.

[1] *ADAM stands for: Adaptation and Mitigation Strategies: Supporting European Climate Policy*

We also offer, in a second part of this report, some reflections on what has been learned by the participants in the project: about how multi-site, multi-disciplinary research within Europe is conducted; about the learning that takes place within projects such as this; and about how the project relates to outside stakeholder interests. We report on the challenges for project funders and managers to consider these well-documented difficulties in future projects and to take into account the possible solutions suggested in this and previous research.

At the end of this report we list further sources of information about this research. The primary synthesis of the ADAM project will be published in December 2009 in a book called *'Making Climate Change Work For Us: European perspectives on Adaptation and Mitigation Strategies'* (Hulme, M. and Neufeldt, H., eds., Cambridge University Press). Three other books based on ADAM research will appear in this mini-book series, and two special journal issues – in *The Energy Journal* and *Mitigation and Adaptation Strategies for Global Change* – will also be dedicated to reporting ADAM research. The ADAM website – www.adamproject.eu – provides all of the detailed technical reports and tools developed upon which the results summarised in this report are based.

What is ADAM About?

The economic and scientific challenges of changing our current climate trajectory towards one that will lead to a world no more than 2°C warmer than pre-industrial times are formidable. They have been addressed recently by, respectively, the Stern Review and the IPCC AR4. But the challenges at the international political level to develop a global climate regime that will guide the implementation of the necessary policy measures will be greater still. This is because of the multi-dimensionality of the climate problem, because of the many uncertainties in knowledge and understanding that prevail at all levels of scale, and because of the conflicts of beliefs, values and interests that climate change reveals. Negotiators will have to balance opposing opinions between and within groups of countries, just as policymakers will have to provide the necessary mechanisms to develop, implement and enforce national mitigation and adaptation policies against the organised will of certain business sectors which will fight against the possibility of losing assets and against parts of the civil society which demand either greater or slower rates of policy development.

These challenges are important for all nations. Yet they are particularly demanding for the European Union, which has consciously assumed a leading role in the design of international climate policies and has recently reaffirmed its will to achieve the 'two-degree target'. Appropriate European climate change policies therefore need simultaneously to secure long-term climate protection goals, to be integrated across multiple sectors, to secure economic benefits, and to be designed to resonate with emerging international agreements and geo-political developments. They must also be acceptable to Europe's citizens and stakeholders, a specific challenge in democratic societies when costs may be incurred now, yet when many benefits are realised only in future decades. ADAM research has provided important policy support which has contributed to the European Union's White Paper on Adaptation and examined the feasibilities of securing the EU's 'two-degree target'.

The ADAM project was funded by the European Commission to address these challenges by identifying, illuminating and appraising existing and new policy options. These options address the demands a de-stabilised climate will place on protecting citizens and valued ecosystems – i.e., adaptation – as well as addressing the necessity to minimise humankind's perturbation to global climate to a desirable level whilst simultaneously safeguarding and transforming economic activities – i.e., mitigation. The appraisal of these options must recognise the existence of multiple criteria, such as costs and benefits, cost effectiveness, equity, legitimacy, societal support and environmental integrity. Such an appraisal must also identify where policy options can contribute to both objectives – i.e., adaptation and mitigation – and where policy trade-offs or conflicts may emerge. It is in this territory – the interface between research, negotiation and implementation, in particular providing new insights, tools and process in support of policy appraisal – that the ADAM project has operated over these last three years.

The Organisation of ADAM Research

The core objectives of the ADAM project have been:

- To assess the extent to which existing climate policies can achieve a socially and economically tolerable transition to a world with a global climate no warmer than 2°C above pre-industrial levels
- To develop a portfolio of longer-term policy options that could contribute to the EU's 2°C mitigation target and to emerging targets for adaptation

- To develop the requirements for climate change appraisal in different contexts to enhance the emergence of innovative mitigation and adaptation strategies

The ADAM work programme was structured around four overarching domains: Scenarios, Adaptation, Mitigation and Policy Appraisal. In addition, four Case Studies were completed in which synergies and trade-offs between climate change mitigation and adaptation strategies were analysed at different scales, both within and outside Europe.

The **Scenarios Domain** developed framing scenarios for the ADAM project that spanned a range of climate futures from a 2°C stabilisation scenario, in which the primary challenge is mitigation, to a 4°C warming scenario, for which impact and adaptation costs may be substantial.

The **Mitigation Domain** evaluated the costs and effectiveness of different mitigation options at the EU and global levels, including issues of international trade, technology transfer, competitiveness and investments.

The **Adaptation Domain** developed a quantitative knowledge base on Europe's vulnerability to climate change. The social, technical and environmental factors that influence adaptive capacity to climate change were analysed, with a particular focus on extreme weather events.

The **Policy Domain** mapped and appraised the effectiveness of existing climate policies in the EU and developed portfolios of novel policy scenarios to address current insufficiencies. Requirements for enhancing climate change policy appraisal processes were developed, in which particular attention was paid to enhancing social learning and allowing for the emergence of innovative solutions.

These requirements built upon, and contributed to, the lessons learned in the following four ADAM case studies:

- **Climate governance beyond 2012:** How can different international climate governance regimes in the period beyond 2012 be appraised?
- **Mainstreaming climate change into EU development policy:** How can EU's international development assistance simultaneously meet the objectives of the Millennium Development Goals and of the UNFCCC?
- **Transforming the European electricity sector:** How can the European electricity sector contribute to the reduction of carbon dioxide emissions? How is this sector affected by the impacts of climate change?
- **Mainstreaming adaptation into regional land use planning:** How can regional land use planning policies and management incorporate climate change adaptation and mitigation? Three regional studies were conducted for the Tisza River in Hungary (where flooding is a key concern), the Guadiana Basin in Spain/Portugal (drought), and the Alxa region of Inner Mongolia (desertification).

This section has been written by Mike Hulme and Henry Neufeldt. Further information is available from the ADAM website: www.adamproject.eu

Part 1 Research in ADAM

Section 2: Scenarios in the ADAM Project

Adaptation and mitigation are sometimes regarded as alternative strategies, but they are certainly not mutually exclusive. Effective climate policy involves a portfolio of both adaptation and mitigation activities. Even with high levels of mitigation – limiting global-mean temperature increase to no more than 2°C above pre-industrial levels – climate change impacts will require considerable adaptation efforts.

Aims and Scope

Both within the ADAM project and elsewhere in the scientific community, there is interest in exploring the relationships between adaptation and mitigation based on consistent sets of assumptions. The ADAM project developed scenarios to quantitatively assess possible future world developments, but also to provide a common basis of analysis for different Work Packages in the ADAM project. These scenarios were based on different combinations of assumed adaptation and mitigation strategies.
One core scenario assumed no pro-active mitigation, but assumed an efficient *adaptation* strategy thereby reducing climate change impacts. This led on average to a 4°C temperature increase by 2100. A second core scenario incorporated stringent *mitigation* action and hence an implied need for less adaptation[2]. This led on average to a 2°C temperature increase by 2100. Some variants were made to these scenarios. The scenarios were described in terms of consequences for energy systems and land use, but also in terms of some climate impacts and adaptation actions. This work was led by the Netherlands Environmental Assessment Agency and the scenarios were mostly developed using integrated assessment modelling tools, notably the IMAGE and FAIR models.

Key Methods and Findings

The core ADAM scenarios

For the *adaptation* scenario, a continuation of current trends was assumed. As energy use in this scenario continues to be mostly based on fossil fuels, this scenario leads to considerable climate change; a temperature increase relative to pre-industrial levels in the order 3 to 5°C by 2100. This scenario indicates that the EU 'two-degree target' is not going to be achieved without additional explicit policies to constrain emissions.

The *mitigation* scenario focused on the 2°C target. The greenhouse gas concentration target required to meet this target depends critically on uncertainty in the climate sensitivity and carbon cycle. In order to raise the likelihood of achieving the 2°C target above 50 per cent, the greenhouse gas (GHG) stabilisation concentration should remain below 450 ppm CO_2e (carbon dioxide equivalent) in the long run. To increase the likelihood of achieving the EU policy goal to over 70 per cent a long-run concentration below 400 ppm CO_2e would be required.

Both of these two stabilisation scenarios allow for a temporary overshoot of the long-term concentration. Even with stabilisation at 450 ppm CO_2e, the global temperature increase could be in the order of 3.5°C if climate sensitivity is high. Consequently, in addition to efforts to reduce anthropogenic greenhouse gas emissions, societies should also consider strategies for adapting to higher global temperatures. This also suggests that adaptation and mitigation are not necessarily trade-offs, but two connected sides of an effective climate policy.

> *Even with high levels of mitigation considerable adaptation efforts will be needed.*

The emissions reductions required for staying within 2°C (see Figure 2.1) are challenging, amounting to more than 70 per cent, by 2050 and about 80 to 90 per cent by 2100. Excluding different world regions from mitigation actions will either raise the costs or render the target unachievable. The 400 and 450 ppm CO_2e ADAM *mitigation* scenarios show that in both cases the energy system will be very different from that of the *adaptation* scenario. Important emissions reduction measures include enhanced material and energy efficiencies, use of renewable energies and of

[2] *In fact, a third scenario was developed – a baseline scenario – in which we assumed no mitigation and also no explicit adaptation. This scenario was useful as an analytical point of reference, but it is rather implausible.*

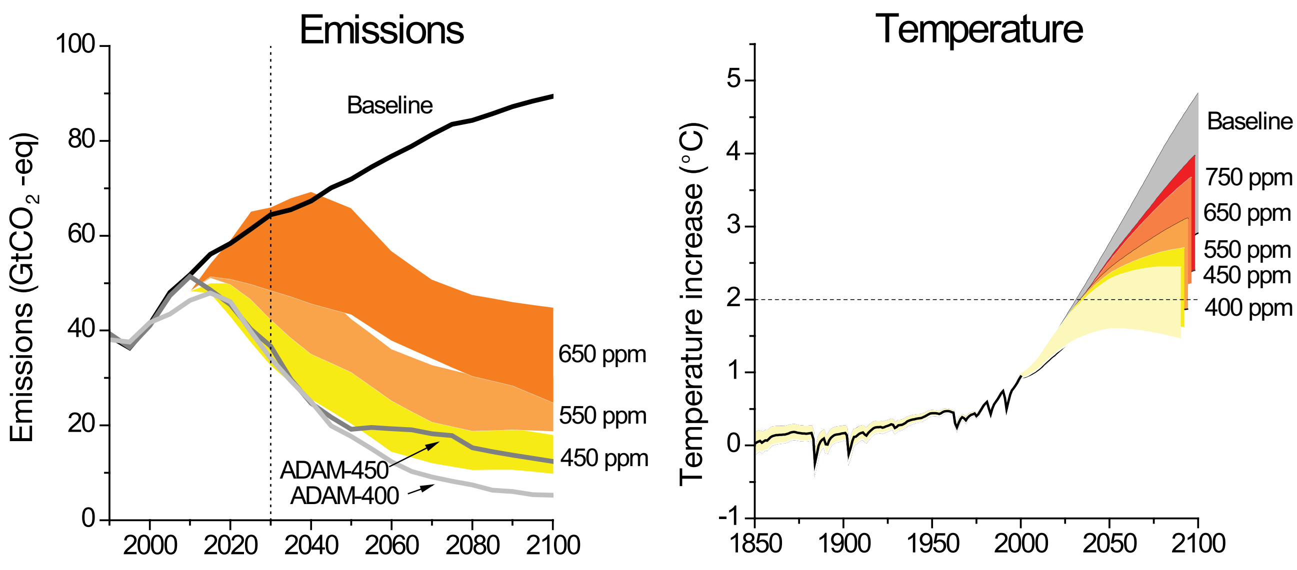


Figure 2.1: Indications of emissions profiles and global-mean temperature outcomes of different stabilisation targets.

carbon capture and storage, reducing non-carbon dioxide gases and an increased use of bio-energy. For the 400 ppm CO_2e scenario, it is most probable that 'negative emissions' from the energy system by the end of the century would be required – this can be achieved by utilising bio-energy and carbon capture and storage. It is also likely that climate policy will have major consequences for land use, given the role of bio-energy and carbon sequestration.

The 400 and 450 ppm CO_2e mitigation emissions profiles both show a peak in global emissions around 2020. The most important policy challenge for achieving low stabilisation targets is participation in an international mitigation regime. This will require a clearer understanding of the required emissions reductions over time for different countries and sectors. Political strategies need to constitute an acceptable combination of long-term mitigation targets and the appropriate investment in R&D to reduce costs through more advanced technologies in the future.

Costs and benefits

This work explored the possible implications of the two core ADAM scenarios for malaria risks, water scarcity, heating and cooling energy demand, coastal flooding and agriculture. A typical pattern seen for several impacts is that only an effective mix of mitigation and adaptation policies is able to significantly reduce climate risks substantially. Two important examples are sea level rise and impacts on food production.

For sea level rise, our analysis showed that, as a single strategy, adaptation can be more effective than mitigation. However, mitigation still has a role to play in reducing damages and thus the costs of adaptation. Risks are minimised in the scenario that combines both adaptation and stringent mitigation.

Agriculture presents an example where adaptation and mitigation are both clearly necessary. Global crop yields in agriculture are projected to be adversely impacted by climate change in the absence of both adaptation and mitigation action. Without stringent mitigation, adaptation could contain the negative impacts, but not remove them.

The same pattern is also observed for a tentative analysis of costs and benefits of both strategies. For optimal implementation of 450 ppm CO_2e stabilisation scenarios at a global scale, models typically assess the costs of mitigation to be between zero and three per cent of global GDP. Regional costs can be considerably higher; for example, greater than 10 per cent for oil-exporting countries. A few models report net economic gains even for very stringent stabilisation targets (see Section 4). At the same time, estimates of the costs of impacts of climate change vary over a very wide range.

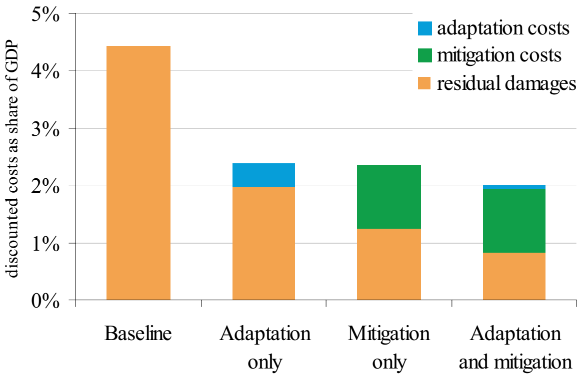


Figure 2.2: Mitigation costs, adaptation costs, and residual damages due to climate change as share of GDP to 2200. (FAIR model)

While the damage curves for a baseline scenario included in most models typically lead to costs in the order of a few per cent of global GDP, under extreme assumptions these costs may be up to 25 per cent or higher. Finally, adaptation investments are mostly assessed to be smaller than mitigation investments and residual damages. However, such investments are very important in limiting residual damages.

While uncertainties mean that cost-benefit analysis is not very useful to determine optimal mitigation and adaptation levels, it can give some indication of impacts of different assumptions. Under default settings of the FAIR model, the discounted costs of climate change impacts for the period 2005-2200 at 2.5 per cent discount rate amount to nearly 4.5 per cent of global GDP in the baseline case (see Figure 2.2). These costs rise sharply after 2100. Adaptation reduces these costs substantially to around 2.5 percent by 2100 – but they rise rapidly afterwards. By comparison, the mitigation-only case leads to a discounted cost of just over 2 per cent of GDP by 2200, but follows a completely different time profile with mitigation costs incurred early in the twenty-first century. The combination of mitigation and adaptation leads to the lowest discounted costs, namely 2 per cent of global GDP.

Significance of this Work

This analysis shows that while adaptation and mitigation are sometimes regarded as alternative strategies, they are certainly not mutually exclusive. Effective climate policy involves a portfolio of both adaptation and mitigation activities. For example, even with high levels of mitigation, some climate change impacts will require considerable adaptation efforts. In contrast, a large magnitude of climate change could make effective adaptation impossible, which means that there is a need for some minimum level of mitigation.

The ADAM scenarios show that, in principle, a 2°C target can still be achieved. This requires stringent emissions reduction – and participation of all major emitting countries in emissions reduction over the next one to two decades. However, even the mitigation scenarios could still lead to much higher temperature increase than 2°C because of uncertainty in the climate system.

Integrated adaptation and mitigation scenarios are useful for assessing some potential synergies and trade-offs in more detail (e.g. climate impacts on bio-energy; integrated urban planning; hydropower). While scenarios have now started to explore the consequences of baseline emissions and ambitious targets in a more integrated way, the analysis also shows that there are huge uncertainties and that normative assumptions are always involved in qualifying the different strategies. Moreover, there are large differences in the consequences of climate impacts and of mitigation strategies for different regions and actors. Further integrated research in this area is useful. The goal would not be to determine an optimal mix of mitigation and adaption, but rather to explore the impacts of various assumptions and uncertainties.

This section has been written by Detlef van Vuuren detlef.vanvuuren@pbl.nl and Andries Hof. Further information is available from: Van Vuuren,D. et al. (2008) Temperature increase of 21st century mitigation scenarios **Proceedings of the National Academy of Sciences** 105(40), 15,258-15,262

Section 3: Risk, Vulnerability and Adaptation in Europe

Adaptation is not just attaining a physical outcome, but a dynamic process relying on institutional mechanisms to enable the implementation of selected measures and the building of local capacity. Involving stakeholders in adaptation and risk management processes is a key component of building adaptive capacity.

ADAM has produced an open-access web-based digital compendium that combines the heterogeneous knowledge of European impacts, vulnerability and adaptation.

Overview

The world has warmed by almost 1°C since industrialisation began in the mid-nineteenth century. A further warming of about 0.6°C is inevitable during this century as a result of greenhouse gases already emitted. Regardless of any global climate agreement reached in Copenhagen at the end of 2009, the warming that is already unavoidable will affect millions of people in Europe and the rest of the world. Yet if greenhouse gas emissions are not substantially reduced within the next few decades, the world may well see a level of climate change that is unmanageable for the next generations (see Section 2). Cutting greenhouse gas emissions is therefore a priority. However, taking action to adapt to unavoidable impacts is equally important.

Involving stakeholders in adaptation and risk management processes is key.

In Europe, adapting to changes in the risk of extreme weather is high on the agenda. Losses from extremes, such as floods, droughts and other climate-related events, have risen sharply in recent decades, a rise that cannot be attributed solely to increased exposure of economic wealth. The IPCC Fourth Assessment Report concluded that anthropogenic climate change is 'likely' to 'very likely' to lead to increases in intensity and frequency of weather extremes. This is of concern to European policymakers. The recent EU White Paper 'Adapting to Climate Change: Towards a European Framework for Action' has set out an adaptation strategy that, among other things, emphasises the role of disaster risk management. ADAM research has contributed significantly to improving the knowledge base, and identifying knowledge gaps, for managing the changing risks of climate change in Europe.

Context and Aims

'Adaptation' is the term used to describe all activities aimed at preparing for or dealing with the impacts of climate change, be it at the level of individual households, communities and firms, or of entire economic sectors, watersheds and countries. Adaptation thus serves to reduce the damage resulting from the unavoidable impacts of climate change, as well as to protect people's lives and livelihoods.

Although humans have some capacity for self-adjustment, the pace and intensity of climate change are likely to be such that plans for adaptation will need to be developed in advance to address the impacts effectively. However, practical evidence of what makes adaptation work is scarce. Matters are made worse because the studies that do exist are inconsistent in how knowledge on climate change impacts, vulnerability and adaptation is represented. Relevant concepts, such as vulnerability, adaptive capacity, sensitivity and risk, overlap in their meanings and are often defined ambiguously.

Much adaptation will have to take place on a local scale, yet decision-making at national and regional levels will play a role as well. How local stakeholders adapt is subject to, for example, economic incentives provided by national authorities. In addition, adaptation may lead to structural change that is of concern to national-level policymakers. Finally, national government infrastructure is exposed to climate variability and extremes.

Research in ADAM has sought to make a contribution to the embryonic, but evolving, knowledge base by considering the theoretical underpinnings of adaptation, and ultimately how the theory translates into practice in different settings. Specifically, ADAM research on adaptation has pursued the following aims:

- To develop a formal conceptual framework for climate change impacts, vulnerability and adaptation, and to use this framework to take stock of the relevant knowledge available in Europe, and synthesise and present it in a consistent manner;

- To identify macro-economic barriers to market-driven adaptation between geographical regions, and identify implications for policymaking at the national level;
- To analyse institutional adaptive management and issues of adaptive capacity, in particular the role of institutions in supporting the actual implementation of measures;
- To generate probabilistic estimates and maps of drought and flood risk across European Union member states and, focusing on European 'hot spots', to project these risks into a future with climate change;
- To examine the economic vulnerability of selected countries on the basis of the government's ability to cope with extreme weather events, and to assess the viability of risk pooling arrangements.

Methods and Findings

Meta-analysis of vulnerability

In order to shed light on the conceptual ambiguity associated with adaptation to climate change, we applied methods of linguistic analysis and formalisation to a large body of literature on climate change impacts, vulnerability and adaptation. By abstracting and formally representing common elements, it was found that vulnerability assessment methodologies are often only loosely connected to the theoretical definitions that should inform them. It was also found that many methodologies are not unique to climate change, but in fact are similar to those applied in other fields, such as disaster risk and poverty.

The qualitative meta-analysis of vulnerability conducted by the ADAM project was based on all journal articles cited in the Europe chapter of Working Group 2 of the IPCC Fourth Assessment Report. The sectors considered were agriculture and fisheries, human health, tourism, energy and transport, water resources and insurance. The meta-analysis found that there are significant gaps in knowledge. Only a few studies consider adaptation, there is little cross-sectoral analysis, and most research focuses on Western Europe (especially the UK). Knowledge on how climate change translates into impacts is only readily available for the agricultural and water sectors. Vulnerability and adaptive capacity, even if mentioned in the articles, do not seem to play an important role in the actual research.

Market mechanisms in adaptation

Market mechanisms are potentially important drivers for adaptation to climate change. General equilibrium models could therefore be useful tools to study adaptation, but they typically assume full flexibility of natural resources, labour and capital. As a result, they find that market-driven adaptation takes place automatically and without transaction costs. Reality, however, is different. For example, if climate change were to affect the natural resources in a community to such an extent that people had to move and work in

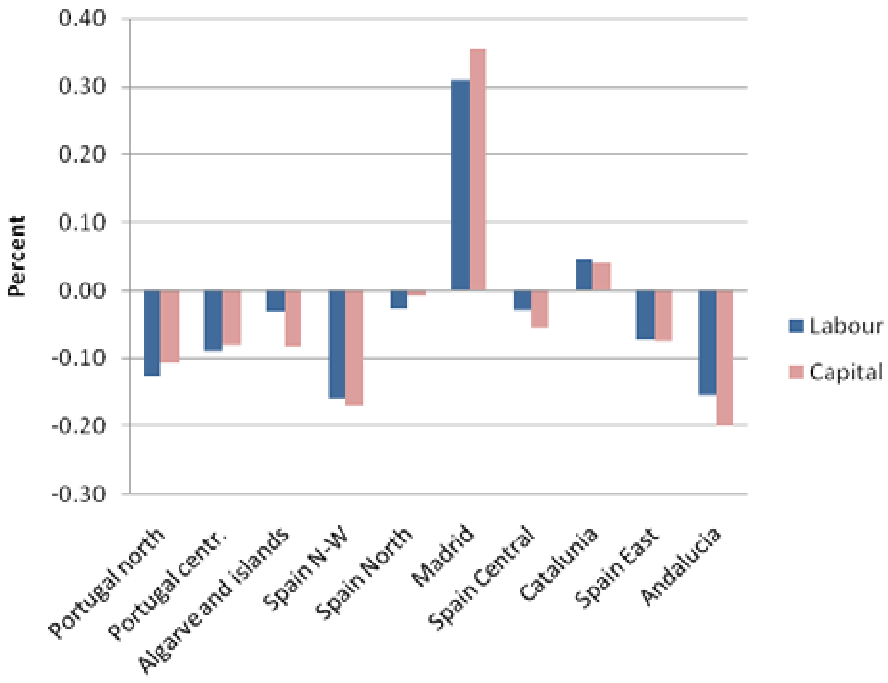


Figure 3.1: Per cent change in price of real capital and labour by province in the Iberian Peninsula resulting from climate change.

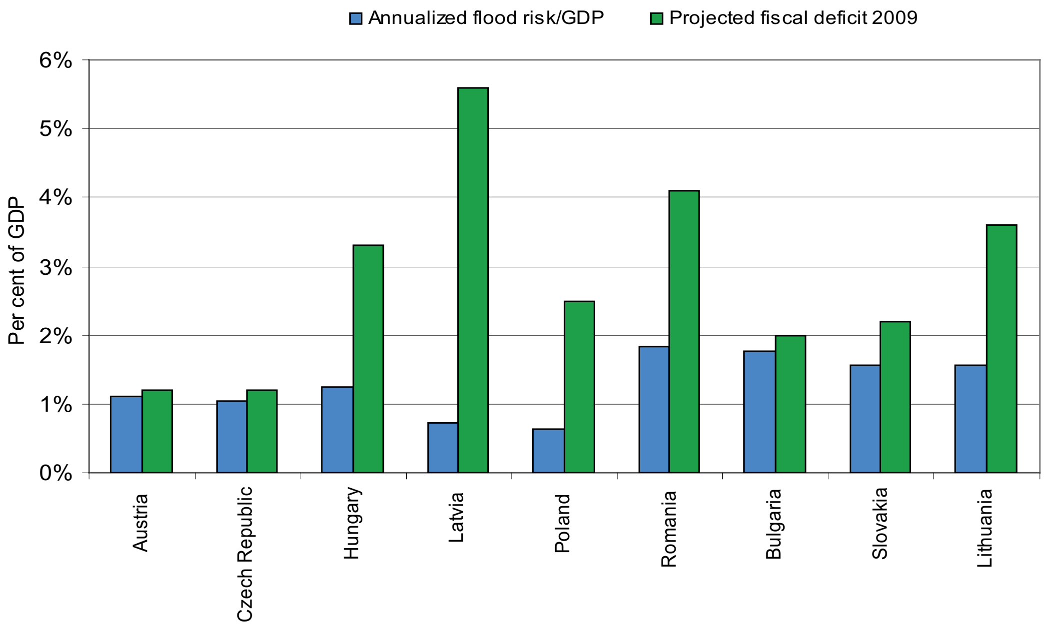


Figure 3.2: Annualised disaster risk and fiscal deficits in selected flood-prone European countries (today's conditions)

another sector of the economy, then such adaptation will face barriers and costs. People depend on family and other social relations and real estate cannot be moved, but its value could go down. In addition, capital cannot easily be transformed into something useful in a different sector.

An illustrative finding of a model – developed in the ADAM project – that accounts for such barriers and costs is shown in Figure 3.1. It shows how much the change of factor prices deviate from the average change across provinces on the Iberian Peninsula. Higher wages and higher return on capital occur in the Madrid province and Catalunia, which includes Barcelona. The other provinces are more negatively affected by climate change, and the factor prices therefore decrease relative to the average. This indicates that climate change increases pressures on already densely populated areas.

Adaptation as process

Different methods were used to analyse the role of institutions in supporting adaptation, including reviews of academic and grey literature for different hazards, sectors and themes; policy analysis; actor mapping; and the use of participatory approaches. The analysis was predominantly place-based, reflecting an understanding that the risks associated with climate change are context-specific. Learning examples were chosen to ensure representation of a range of different characteristics and circumstances. Synthesising the evidence from across the learning examples, five important steps of an adaptation 'ladder' could be distinguished (which resonates with the notion of adaptation as an ongoing socio-political process):

- recognising and understanding climate-related risk;
- individual and organisational willingness to respond;
- adequate capacity to take action;
- learning to adapt;
- sustaining adaptation activity in the longer term.

The analysis also resulted in an adaptation 'catalogue': an inventory of practical adaptation options and associated enabling institutional frameworks. The catalogue differentiates between options according to the form of adaptation: technological, management, best practice, planning and design, legal and regulatory, insurance and financial, or institutional. Supporting analysis includes an assessment of the potential feasibility and application of measures in different contexts, their associated costs and benefits (where such quantitative data are available), and the wider implications for sustainable development.

Risk-based management

ADAM research focused particularly on adaptation options in the context of catastrophic impacts, which can be very large, uncertain and unevenly distributed (so-called fat tails of a non-normal distribution). These are characteristics of flood and drought risks in Europe. While flood and drought maps exist in some EU member states, ADAM has provided the first comprehensive probabilistic maps of these hazards across the EU, combining estimates of hazard, vulnerability and exposure to generate estimates of probabilistic monetary loss. These calculations remain uncertain, but they mark the beginning of applying risk-based approaches to managing these hazards, an approach that is expected to have great influence on national and local policymakers as they prepare for climate change.

The analyses remain exploratory, but they lead to a number of relevant findings:

- Europe is already vulnerable to floods and droughts. This means that there is a non-negligible probability of disasters with consequences of a magnitude with which national authorities could not easily cope.
- As shown in Figure 3.2, Eastern Europe is highly vulnerable to flood risks. In many of the newer EU member states, annualised flood risk has exceeded one per cent of GDP. In some events, national authorities have had severe fiscal problems in financing the recovery process.
- Southern Europe, and especially its agricultural sector, is at significant risk to drought and heat stress, and ADAM findings shows how these hazards and risks will be affected by climate change. At the same time, many agricultural regions in Northern Europe are expected to benefit from climate change.
- Even Europe's wealthier countries can have difficulties coping economically and politically with risks of extreme weather. For example, after large scale flooding in 2002, Austria faced a political and fiscal crisis that triggered new elections and a change in government. By modelling Austria's flood risks, ADAM research has demonstrated the economic benefits of risk transfer instruments for the government.

ADAM has produced an open-access web-based digital compendium of impacts, vulnerability and adaptation.

Significance of this Work

The ADAM findings on adaptation will contribute not only to changing the way European policymakers manage climate-related risk; they also prove the importance of involving stakeholders in the adaptation and risk management process. Adaptation is not just attaining a physical outcome, but is also a dynamic process that relies on institutional mechanisms to enable implementation of selected measures and to build local capacity. Access to scientific data in formats suitable for end-users, knowledge transfer and 'spaces' for learning were three factors identified as particularly important to enhance local capacity.

The 'standard' ways of communicating scientific results (e.g. reports) need to be complemented by approaches

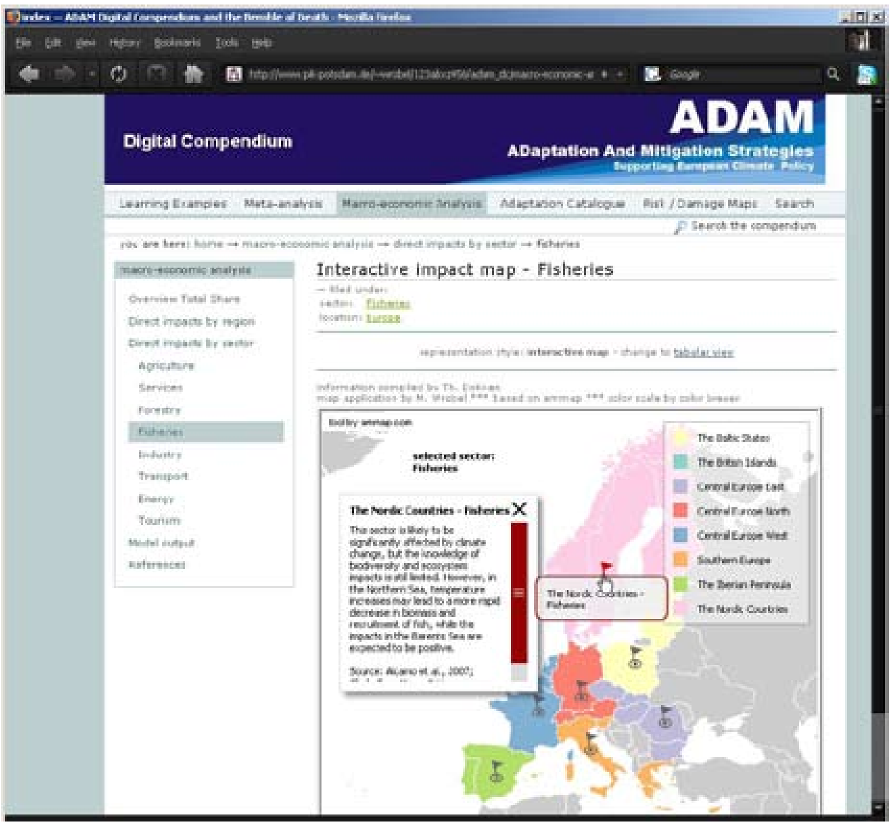


Figure 3.3: Screenshot of the digital compendium.

that support a higher degree of integration, interaction and requirement-driven filtering of information. ADAM has produced an open-access web-based digital compendium that combines the heterogeneous knowledge of European impacts, vulnerability and adaptation. It uses different methods of information structuring, storage and retrieval to present the following knowledge to users:

- current knowledge on impacts, vulnerability and adaptation in the literature;
- current and future risks of climate extremes (e.g. floods and droughts);
- macro-economic consequences of climate change and extremes;
- available adaptation options;
- experiences gained in adaptation practice.

Despite its heterogeneity all content is hyperlinked, free-text-searchable and consistently labelled by sector, region and climate-related hazard. It thus allows a decision-maker to explore for a specific sector or region what is known in the literature, what the future risks and economic consequences could be, what adaptation options are available and which practical experience already exists. Figure 3.3 shows a screenshot of the digital compendium.

Three other ADAM results with high policy relevance are summarised here.

- Flood defence design throughout Europe has been based on the 'stationarity' assumption (the past is the key to the future), but climate and land-use changes present challenges to this approach. At the same time, projections of future flood risks in view of climate change are highly uncertain. In light of this uncertainty, stakeholder interactions showed a need for adaptive flood risk management that would continually update data and build flexibility into policy decisions.
- According to ADAM estimates, the EU Solidarity Fund, which compensates member states for losses from extreme events above a specified trigger, has a risk (estimates show about 15 per cent) of being called upon to provide compensation above its annual allocation of €1 billion. This risk is even higher if the Solidarity Fund covers drought losses, which it has not covered in the past. ADAM research in the Guadiana Basin and elsewhere (see Section 9) shows that future droughts may be so economically damaging as to trigger payment from the fund. This suggests higher capitalisation of the fund or, alternatively, a reconsideration of its purpose. One novel idea is to use the Solidarity Fund instead to reinsure or capitalise national disaster insurance systems.
- Finally, the ADAM risk management approach will advance integrated modelling of climate mitigation and adaptation. A huge challenge is incorporating adaptation in integrated assessment models, which in the past has been overly simplified, for example, using add-on damage functions that are based on averages of past impacts and contingent on gradual temperature increase. Probabilistic loss damage estimates combined with the costs of adaptation measures can greatly improve these modelling practices. Identifying the knowledge gaps and providing a basis for further research to fill these gaps is an important contribution for long-term adaptation policy in the EU.

This section has been written by Richard J.T. Klein richard.klein@sei.se, Joanne Linnerooth-Bayer, Asbjørn Aaheim, Jochen Hinkel, Darryn McEvoy and Reinhard Mechler. Further information is available in the journal **Mitigation and Adaptation Strategies for Global Change** 2009 Special Issue on *'Assessing adaptation to extreme weather events in Europe'* edited by Reinhard Mechler and colleagues.

Section 4: Mitigation at European and Global Scales

Assuming a framework of an effective global climate policy and with strong energy efficiency gains and increasing use of renewables stimulated by sector-specific policies, Europe can make its proportionate contribution to achieving the 'two-degree target' by reducing greenhouse gas emissions by between 60 and 80 per cent by 2050.

The ADAM analysis shows that a set of different models finds low greenhouse gas concentration targets to be technically feasible at maximum cost of a few percent of global GDP.

Context and Aims

The Mitigation Domain within ADAM had two foci: mitigation in Europe and mitigation at the global level. The European perspective focused on an integrated assessment of a holistic European climate policy programme covering the sectors industry, services, energy conversion, transport and households. This integrated assessment considered market introduction of new technologies and polices to foster such technologies and climate friendly behaviour from a bottom-up perspective. Macro-level policies feeding into a macro-economic assessment were integrated with this bottom-up analysis. On the global level, the work explored possible mitigation strategies that lead to ambitious stabilisation of greenhouse gases on the basis of mitigation potentials and costs. With increasing awareness of possible impacts of inexorable temperature and sea-level rise, the need for ambitious climate protection targets in line with the EU€s 2°C policy goal has grown in recent years.

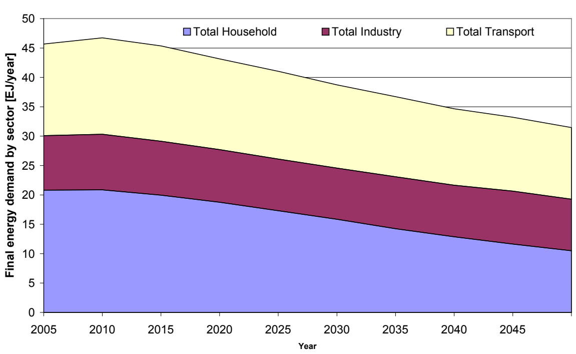
> *Europe can reduce greenhouse gas emissions by up to 80 per cent by 2050.*

Specifically, the work summarised here answers two key questions:

- What are the technical and economic consequences of different stabilisation targets that could lead to compliance with the 2°C target?
- What are some of the technological barriers and economic and political factors that are crucial for obtaining the intended emissions stabilisation outcome?

Methods and Results – European level

The core element of the European-scale analysis in ADAM was an integrated modelling system. The individual models of the system were connected via their inputs and outputs, following common assumptions to develop a consistent hybrid model of Europe. The model system covered the industry sector, the services sector, the household sector, the transport sector, renewable energy technologies and conventional energy technologies. The models in each of these sectors adopted a technology-based bottom-up approach. The macro-economic framework and analysis was provided by the economic modules of the ASTRA model and the global greenhouse gas emissions constraints were estimated by the POLES world energy model.



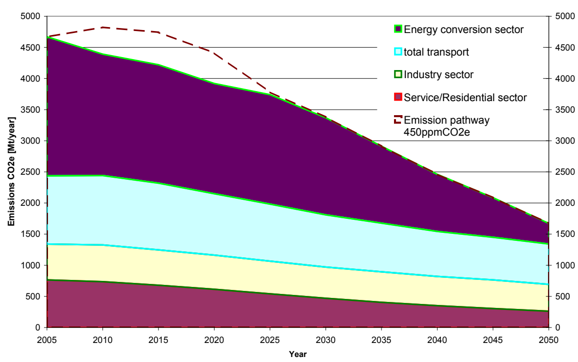


Figure 4.1: European energy demand (left) and greenhouse gas emissions by sector (right) to achieve a 450 ppm CO_2-equivalent scenario.

In addition to assuming that the EU Emissions Trading Scheme (ETS) will be integrated into a World-ETS in the next decade for each sector, specific policies were defined and implemented in the models that together formed a holistic European climate policy programme. The ETS alone is not expected to be sufficient to overcome the inherent barriers and market imperfections to achieve the required 60 to 80 per cent reductions in greenhouse gas emissions in Europe by 2050.

Two main elements constitute the European strategy to achieve a low carbon society: improved energy efficiency and increased use of renewables. Improved energy efficiency enables a reduction in final energy demand of 50 per cent in households, 5 per cent in industry and 20 per cent in transport for the period 2005 to 2050 (See Figure 4.1, left). On top of these energy efficiency gains, fuel switching to zero- or low-carbon fuels will reduce carbon dioxide emissions from 4.6 to about 1.6 GtC in Europe. The energy conversion sector share reduces its emissions by more than 80 per cent, households by more than 60 per cent, transport by 40 per cent and industry by 25 per cent (see Figure 4.1, right). The shift towards renewable energies will be particularly significant for electricity generation: more than 65 per cent will come from renewables by 2050.

The required investments to accomplish the transition towards a low-carbon economy in Europe over the period 2005 to 2050 is estimated at more than €7trillion. As buildings constitute the largest share of the total capital stock, about 70 per cent of these investments would be directed towards improving energy efficiency in buildings. About 17 per cent would be needed for the transition of the energy system into a largely renewables based system.

The disadvantage of making these investments would be higher production costs. Temporarily higher energy costs are compensated for by reduced energy demand due to the efficiency gains. In total, the balance between the investment push and the cost increase is close to neutral for economic development. Moderate employment shifts from service sectors to investment goods producing sectors are expected due to the large climate policy induced investments.

Methods and Results – Global level

Globally, the EU's 2°C policy goal can be achieved with different emission pathways at different probabilities. Feasibility in terms of technologies and economic viability is explored for three different carbon dioxide concentration pathways: a 550ppm, 450ppm, and a 400ppm CO_2e target. To get a robust picture of mitigation costs and technological options a model inter-comparison exercise using five state-of-the-art energy-environment-economy models was completed. Global mitigation costs, expressed as aggregated GDP losses until 2100, were reported to be below 0.8 per cent for the 550ppm scenario and below 2.5 per cent for the 400ppm scenario (see Figure 4.2). The annual losses are moderate until 2040, but increase in four of the five models during the transition phase of the energy system. Costs stabilise, or even decline, thereafter. One model – E3MG – reports overall economic gains for all stabilisation pathways.

The regional distribution of the mitigation costs differ greatly among the models. Costs for the three developed country categories – EU27, USA, and Japan – cluster closely together and are lower than for the world as a whole. The United States consistently has the highest costs of the three regions. By contrast, differences between the developing country groups or countries tend to show much larger variations between models and depend substantially on the target. China reports much higher costs than the world average in most of the models. This could be an important factor in international negotiations, since China may demand compensation before consenting to incur high mitigation costs. India faces the highest mitigation costs in the MERGE and POLES models for 400ppm, and costs for India are higher than the World-average in the REMIND model. In MERGE, Russia benefits substantially from its large biomass potential and can therefore sell emission permits, especially in the low stabilisation case. Results are difficult to generalise for other developing countries.

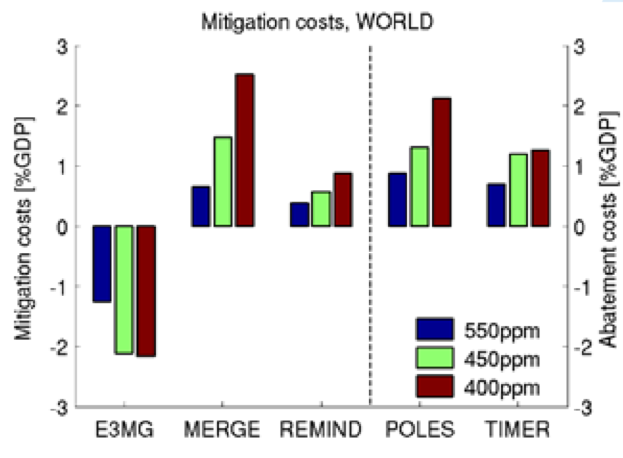


Figure 4.2: Global costs of implementing the three carbon dioxide concentration pathways using the five ADAM models.

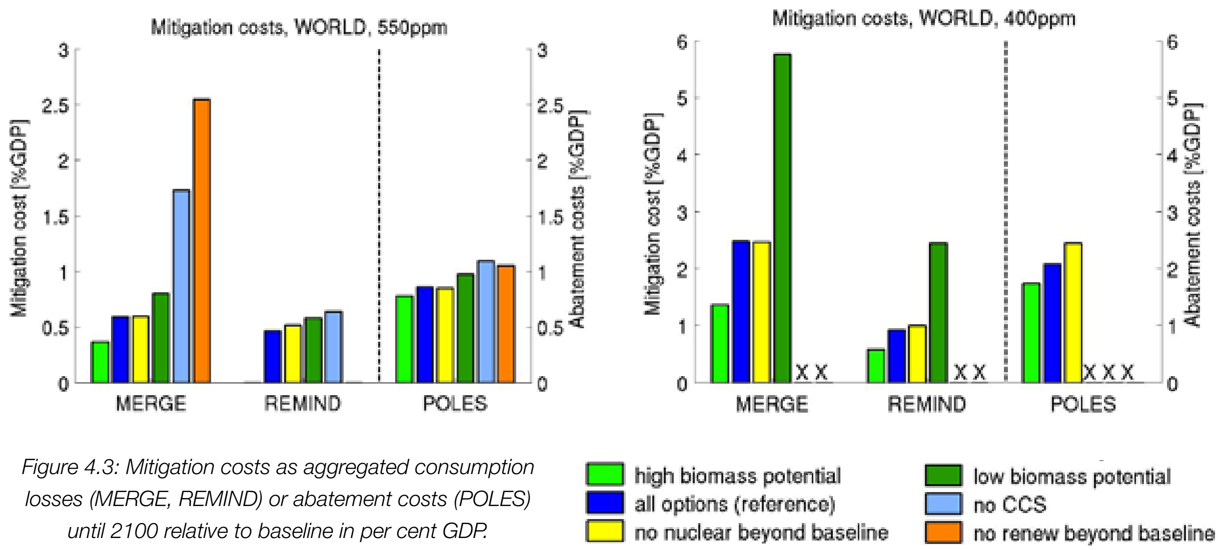


Figure 4.3: Mitigation costs as aggregated consumption losses (MERGE, REMIND) or abatement costs (POLES) until 2100 relative to baseline in per cent GDP.

In all mitigation scenarios the energy mix is very different for the various models. Several alternative ways exist to achieve emission reductions: extension of renewables, use of carbon capture and storage, increase of nuclear power, increase in biomass use and energy efficiency improvements. This conclusion is reinforced by a sensitivity analysis for the 550ppm scenario for individual models. It shows that there is flexibility in the deployment of the different technologies (see Figure 4.3, left): one technology can replace another without increasing the costs dramatically.

However, for more ambitious targets, this flexibility is lost (see Figure 4.3, right): model analysis shows that without carbon capture and storage technology or without the induced extension of renewables, the required emissions reductions for the 400ppm target cannot be achieved. When analysing the importance of individual technologies for the two stabilisation targets of 400ppm and 550ppm, the key findings are:

Low greenhouse gas concentration targets are technically feasible at a few percent of global GDP.

- The models provide a robust answer – across the models and across the two mitigation scenarios – as to which are the most important technologies for mitigation in terms of costs.
- The flexibility of substituting one technology with another (in case one technology fails or is not available) is lost in the case of low stabilisation.
- Renewables and carbon capture and storage are the most important technologies for mitigation because without them, the 400ppm target is not feasible and the 550ppm target becomes very expensive. Nuclear power is dispensable as a mitigation option because 400ppm remains technically feasible without this option and in both mitigation scenarios the cost increases only marginally if nuclear is not available.
- The biomass potential dominates the costs in case of low stabilisation.

The biomass potential also has an important influence on the energy mix. In some cases, a high amount of biomass limits other renewables – such as wind, solar, and hydro – from entering the market. It is important to note that in this ADAM work we did not investigate conflicts with other types of land use, in particular food production and biodiversity protection. Nor do we investigate whether this biomass potential can be sustainably harvested. , There can also be greenhouse gas emissions associated with bio-energy use. These emissions can be large for food crops, but are relatively small for most second-generation bio-energy technologies.

The availability of carbon capture and storage is crucially important for achieving low stabilisation levels: without it, the 400ppm CO_2e target is not achievable. However, depending on the model even a low carbon capture and storage potential of only about 120 GtC could be enough for reaching ambitious targets, but with the disadvantage of increasing costs. The large-scale use of this technology still has to be proven.

For some models, the use of nuclear power is an important technology in the business-as-usual case. Yet in other models, nuclear does not seem to play an important additional role in mitigation scenarios: abstaining from using nuclear power has minimal effect on overall costs. An important factor is that nuclear power and carbon capture and storage power plants could constitute substitutes. Nuclear power could also become a more important option when Fast Breeder technology is considered.

Significance of this Work

The energy-economic modelling work in ADAM summarised here illustrates ways in which a low stabilisation target of 400ppm CO_2e can be achieved at moderate cost. The models provide a number of different technology pathways that are consistent with the EU 2°C policy goal and have a high likelihood of achieving this goal (see Section 2). The less ambitious target of 550ppm is more robust against the failure of deployment of certain technologies. All models here assume global participation in climate policy in the near-term and shift technology transfer across regions. However, this remains an enormous challenge for international climate policy to achieve.

On the European level the analysis revealed that the Emissions Trading Scheme has to be supported by sectoral policies that foster the introduction of new technologies into the market and that eliminate barriers for the success of carbon-lean technologies or behaviours. Such policies would consist of standards (e.g. greenhouse gas emissions limits for cars), information campaigns (e.g. labeling of efficient electric appliances) and financial incentives (e.g. loans to fund insulation of buildings, feed-in tariffs for renewables).

Although model results show the technical and economic feasibility of low stabilisation, political and institutional prerequisites especially in the context of low stabilisation are also needed and cannot be fully addressed by the models used here. The possibility of removing carbon dioxide from the atmosphere relies on the availability of carbon capture and storage technology and a sufficient biomass potential. Institutional settings have to be designed so that biomass production will not conflict with food production or with conservation of biodiversity. It is a future research task to design instruments to incorporate emission certificates from the generation of biomass with carbon capture and storage into an international emission trading scheme.

Moreover, massive R&D investments are needed to stimulate the development of low carbon technologies so that through learning effects and economies of scale these innovative technologies become competitive. These policy mechanisms are crucial for achieving low-stabilisation targets.

This section has been written by Brigitte Knopf knopf@pik-potsdam.de and Wolfgang Schade. Further information is available in **The Energy Journal** 2009 Special Issue on ‘The economics of low stabilisation’ edited by Ottmar Edenhofer and colleagues.

Section 5: Appraising European Climate Policies

Existing European climate policies and measures are not sufficient to meet existing climate goals such as the 2°C target. To meet its own targets, climate policy in the EU beyond 2012 will need to become increasingly 'Europeanised', including key competences related to energy and fiscal policy. Future effectiveness of EU climate policy also depends on greater attention being paid to implementation, monitoring and policy appraisal.

Climate policy goals need to be regularly re-assessed in the light of shifting social, economic, political and scientific contexts and this is best achieved through a reflexive policy appraisal process.

Context and Aims

Policy appraisal has been practised in the United States for decades and it has become an increasingly popular tool in the domain of environmental policy in many EU states since the publication of the Brundtland report on sustainable development. Studies of such appraisal systems suggest however, that their impact on policy has been relatively minimal, with their focus primarily on the instruments for delivery and implementation, not on the fundamental goals of policy and other related initiatives (for example better regulation). Used in this way, the capacity to re-assess policy goals for complex domains such as climate policy is limited.

By contrast, the shifting targets surrounding climate change require that policy is regularly re-appraised. Given the right conditions and design, policy appraisal can act as a catalyst for more reflexive policy-making to respond to the changing demands of climate change. We call such an approach 'reflexive appraisal' because it focuses on whether current policy goals and overriding policy frameworks are appropriate in the current scientific, social, economic and political context. Reflexive appraisal can allow for the reframing of climate change goals and policy where necessary.

The aims of the Policy Domain in ADAM were therefore twofold: first, to develop a framework for analysing climate change appraisals with regard to different criteria and then apply it to recent climate policy appraisal exercises in Europe; and, second, to analyse the emergence and effectiveness of EU climate policies and to offer insights about how climate policies may develop in the future. This latter aim was secured through a three-stage process: a meta-analysis of climate policy evaluations; the investigation of governance dilemmas; and the development and evaluation of four future EU climate policy scenarios.

Methods and Key Findings

Reflexive policy appraisals

We developed an analytical framework for evaluating the degree of reflexivity present in appraisals of climate change policies. This framework made use of the literature on social learning to outline five (interacting) elements of a reflexive appraisal process:

- The inclusion of a wide variety of stakeholders, including those who have traditionally not been part of the policy community, at the earliest stages of policy development. Interaction with stakeholders should be more than simple consultation.
- The learning processes occurring amongst stakeholders and policy-makers should be able to challenge existing policy goals and allow for the consideration of alternatives; so-called 'double-loop learning'.
- Consideration of tradeoffs and synergies should be framed in terms of wider sustainable development goals.
- It should draw on a diverse range of knowledge types including modelling, analysis, scientific data, social science, and stakeholder and lay perspectives. In a reflexive appraisal, one specific type of knowledge should not simply be given preference over the others.
- A reflexive appraisal process should tackle the cross-sectoral nature of climate change and its interactions with other sustainable development issues.

Climate policy goals need to be regularly re-assessed through a reflexive policy appraisal process.

This analytical framework was applied to a sample of ten empirical case studies of the appraisal of climate-related policy at different European governance levels (for example the Commission, member states and regions). There was little evidence of widespread reflexivity in the ten appraisal processes examined. Indeed, apart from an appraisal conducted by the UK Sustainable Development Commission, and to a lesser extent appraisals conducted for the regional management of the Tisza basin in Hungary and the Norfolk Broads in the UK, none of the appraisal processes analysed were strongly reflexive. Crucially, despite the need to constantly reassess climate policy goals in the light of changing social, economic, political and scientific contexts, the more strategic-level European and Member State policy appraisals were shown to be far from reflexive.

A meta-analysis of climate policy evaluations

EU climate policy was analyzed through a review of existing climate policy evaluations. The evaluations were collected through journal database searches, the Internet and contacts with policy makers and others in the policy community. This search resulted in an extensive list of evaluations conducted since 1998 in six EU Member States – Germany, UK, Italy, Finland, Portugal and Poland – and at the EU-level. From this list, we identified studies that offered a systematic assessment of policies already in place (*ex post* evaluations) and excluded those that were either not sufficiently systematic (such as position papers by lobby groups) or that were wholly *ex ante*. This selection process resulted in a dataset of 262 evaluations.

From an analysis of these evaluations (see Figure 5.1) – and using a novel 'governance dilemmas framework' (see further information, below) – we draw some conclusions about the nature and impact of these policies:

- Co-benefits are a proven way to make strong arguments for emissions reductions policies, but do not necessarily add to the climate-effectiveness of these policies.
- Emissions reductions goals of climate policies are often compromised by provisions to deal with distributional issues (whether socially or in industrial sectors).
- EU-level policies support national policy efforts amongst laggard countries and do not compromise policy efforts by leading countries (like Germany and the UK).
- Voluntary action generally tends to be ineffective in climate policy.
- Policy offering a long-term perspective to energy producers and users is more effective than policy that retains a large-measure of short-term flexibility.
- Successful implementation of climate policy instruments largely depends on sound monitoring, but the provisions made for this are generally poor.

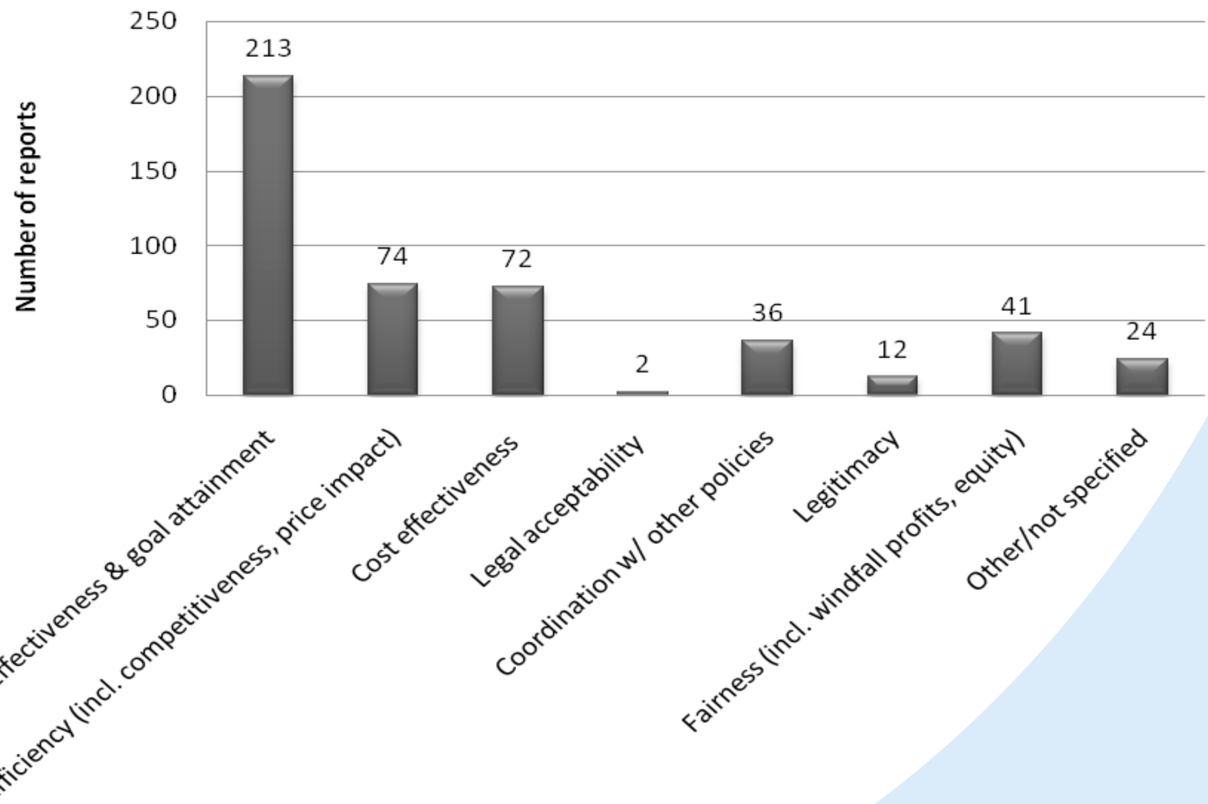


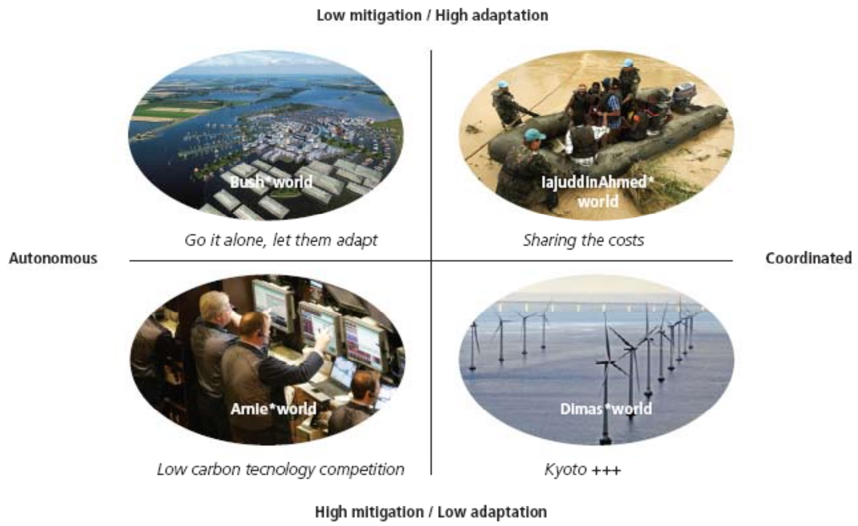
Figure 5.1: Criteria used in the evaluations (EU and six member states).

We still know surprisingly little about the effectiveness of EU climate policies. Although goal attainment has been an important criterion for many policy evaluations, very few evaluation studies make quantitative estimates of the emissions reductions impacts of particular policies, or of portfolios of policies. The value of EU climate policies in terms of their primary goal – emissions reductions – is therefore still an open question. One of the greatest failings is the lack of adequate *ex ante* baselines from which it would be possible to estimate the impacts of policies, against those of other contingent factors, or of counterfactuals (i.e., what would have happened without the EU?).

Analysis of the development of EU climate policy over the past 20 years found that a complex multi-level texture of climate policies has emerged. Much of this policy is made and implemented by the EU Member States, but common and coordinated policies and measures have become more important in the EU, especially with the advent of the Emissions Trading Scheme in 2005. An initial period of high policy experimentation may be coming to an end, and there appears now to be a trend towards greater harmonisation at the EU level. The 'Europeanisation' of climate policy is explained by the widely-recognised need to coordinate emissions reduction at the European level, both to allocate effort within the EU and to present a more powerful European voice in international negotiations. Climate change has also gradually become an important *raison d'etre* for the European project, at a time when European citizens and their governments are becoming more sceptical about deeper and faster European integration. The EU continues to play a leading role in international climate politics and political leaders have found this an important vehicle for projecting the EU's 'soft' power globally.

Future EU Climate Policy Scenarios

- To explore how European climate policies might evolve over the longer term, we constructed a scenario framework that set out a range of background conditions for European climate governance in the coming decades (to 2040).
- Two principal dimensions were defined as shaping EU climate policy: the climate policy objective; and, the degree of international coordination of climate policy. The primary policy goal of the first dimension is whether to mitigate climate change through emissions reductions or to adapt to the impacts. We defined two alternatives in terms of global-mean temperature increases by 2100, consistent with climate scenarios used elsewhere in the ADAM project (see Section 2). Specifically, we assumed either a 2°C 'world' in which mitigation is the key objective, or a 4°C 'world' in which mitigation is not the primary goal of climate policy, but adaptation has become more significant.
- The second dimension relates to the nature of international climate governance regime over the coming 30 years (see Section 6). At one end of the scale we imagine a truly international architecture of agreements and commitments that enables climate governance to be fully coordinated (whether mitigation or adaptation). At the other we assume



*George W. Bush is President of the USA, IajuddinAhmed is President of Bangladesh, Stavros Dimas is European Commisioner for the Environment, Arnold Schwarzenegger is Governor of California

The framework of scenarios WP2 assumes four futures defined by global mean temperature increases by 2100 (2degC or 4degC) and by the nature of global climate institutional regimes (over the course of the 21st Century). We have interpolated these conditions as representing on the one hand, either a low mitigation/high adaptation world (4degC mean temperature increase) or a high mitigation/low adaptation world (2degC increase); and on the other hand, a global climate regime composed of autonomous state actors, or a climate regime in which there is high coordination between states. These axes define four 'worlds' in which we would expect EU climate policies to have specific features.

Figure 5.2: The four ADAM climate policy scenarios

international climate action dominated by choices made by autonomous state and private sector actors, with little emphasis on political coordination.

- Drawing these two dimensions together creates a 'possibility space' with four quadrants (see Figure 5.2), each defining a specific set of basic conditions under which EU climate policy might develop. Taking these as starting points, the challenge of the first stage of the analysis is to make a sketch of EU climate policy for each of the scenarios. This is primarily a process of deduction, although one that may draw on political or economic theory and on historical precedents.

EU climate policy currently inhabits one of the four scenarios: coordinated mitigation (Dimasworld, Kyoto+++). There are good reasons for this. Climate change is a problem of a global collective good for which coordinated global action is necessary and by far the most economically-efficient way of avoiding dangerous climate change by stabilising atmospheric concentrations of greenhouse gases. As the emitter of about 10 per cent of the world's greenhouse gas, the EU acting alone would achieve little. Moreover, the EU has played a leading role in the construction of the international climate treaty regime (UNFCCC and Kyoto), and now sees this system and its leadership role in it as fundamental to its political strategy and identity. Given its political commitment to greater international political coordination on climate change, it is unsurprising that this particular model should also underpin its assumptions about the future of EU policy.

But our scenario analysis makes plain that other futures are also imaginable. These alternative policy futures should be accounted for in broader policy strategy, as well as in the specific design of policy instruments. A degree of flexibility needs to be maintained, giving policies the room to evolve in response to changing politico-institutional conditions (what we have called above 'reflexive policy appraisal'). We see this idea most clearly in the examples from the EU-Emissions Trading Scheme (EU-ETS) and burden-sharing studies.

The EU-ETS has a place in each of the four scenarios, but clearly a more prominent one in mitigation-oriented scenarios, with a variety of configurations possible along the range from less to more coordinated international climate policy. At one end, the system remains as an EU system, possibly with border tax adjustments, but it could become linked to other trading systems, or could evolve into a globally-integrated system – a prospect that many analysts in the EU believe is the natural objective of the scheme. We can see similar contrasts in the burden-sharing case. The overall lesson appears to be that the future evolution of policy may not accord with the assumptions of policy-makers and it is good policy-making to consider alternative outcomes. This is common practice in business strategy and could become more common in policy strategy as well.

We also conducted a detailed analysis of the possible development of EU climate policies under each of four ADAM climate policy scenarios. Specifically, we looked at several key elements of policy including the EU-ETS, support schemes for renewable energy sources, effort/burden sharing in EU climate policy, and adaptation policies. This analysis found that key elements of policy are appropriate to quite different future policy settings, and that they play different roles under different conditions. While the elements themselves appear to be flexible enough to be adapted to variable conditions, whether this flexibility is employed will depend on the configuration of political forces that hold at critical decision points, with the European Commission playing an important role. In this sense, in broad terms, this scenarios study shows that EU climate policy appears quite robust, so long as policy-makers remain sensitive to the need to be adaptive.

Climate policy in the EU beyond 2012 will need to become increasingly 'Europeanised'.

Significance of this Work

One general conclusion from this work stands out – the importance of EU integration as a background condition for EU climate policy under almost all circumstances. Greater EU integration generally removes barriers to climate policy implementation and creates more effective outcomes. Institutional development of the EU therefore lies behind the capacity of the Union to respond in a timely and effective way to the challenges of both climate mitigation and adaptation. For mitigation, this means that markets for low-carbon energy become harmonised and liberalised across the EU eventually removing the need for national targets and burden-sharing altogether. For adaptation, much of the policy discourse concerns the 'localness' of vulnerability and adaptation (see Section 3). But it is likely that as climate change impacts become more marked and with it the unequal distribution of vulnerability and damages, there will be an increasing move towards action at the European level, a process that may already be underway in the 'climate mainstreaming' process (see Section 9).

The EU's 2008 climate and energy policy package can be interpreted as a sign of greater Europeanisation of climate policy in the EU. But on the basis of our scenario analysis this is only a partial integration and does not yet contribute in a fundamental way to making climate policy more robust. For this to happen some of the challenges of EU integration need to be addressed. The deep-seated integration which may be vital for robust EU climate governance will not be easy. The risk is that EU climate governance may be handicapped without further moves towards broader EU integration. And in this sense, climate governance poses a serious challenge to EU governance more generally.

Future EU policy needs to confront a range of possible international 'climate outcomes' both in political and in physical-economic terms. The current EU strategy on emissions reductions is to offer a tougher EU target if other countries work towards binding targets. Beyond this, there has been no significant consideration given to the possibility of a failure of EU climate policy to achieve its own targets, which is a distinct possibility given the uncertainty surrounding the effectiveness of policies. Failure to achieve the hoped-for breakthrough in international negotiations, a possibility predicted by many international relations and economics scholars, will require adjustment of European policy strategy. There is also a need to be able to quickly respond to more rapid and dangerous climate change in Europe and globally.

We therefore argue that climate policy and goals need to be regularly re-assessed in the light of shifting (social, economic, political and scientific) contexts through a reflexive policy appraisal process. The finding of the empirical work pointed to an overall lack of reflexivity in current climate policy appraisal processes in Europe. We highlight four key implications:

Enhancing reflexivity in the appraisal process. There is a strong need to enhance reflexivity in the process of appraising climate-related policy. Reflexive appraisals should: involve a wide variety of stakeholders; challenge existing policy goals through fundamental learning processes; explicitly consider the trade-offs and synergies that mitigating and adapting to climate change might generate; integrate a wide variety of knowledge types (e.g. lay and expert); and, incorporate an understanding of wider policy integration issues (relating to the cross-sectoral nature of climate change and its interactions with other sustainable development issues).

Creating boundary organisations to conduct reflexive appraisals. There is strong case for reflexive policy appraisals to be conducted by well-resourced organisations that sit on the boundary of science and policy (cf. the UK Sustainable Development Commission case). Such an organisation needs to be distant enough from the policy-making process to avoid being bound by previous policy and institutional outlooks, while at the same time being a powerful enough political actor to influence EU policy.

Ensuring a platform for an inclusive and deliberative stakeholder process. Where stakeholder input is employed in appraisals, it needs to go far beyond simple consultation if it is to enhance opportunities for reflexivity. Stakeholder processes need to allow for multi-way dialogue. To enhance participation, stakeholders need to know that the appraisal will be fully integrated into the decision-making process.

Recognising windows of opportunity. In order to maximise opportunities for more reflexive appraisals of climate policy it will sometimes be necessary to connect appraisals to 'windows of opportunity for learning' caused by shocks or changes to wider society systems (e.g. economic downturn, extreme weather events). In such situations, appraisals might be used at the right time to speak to several policy agendas and provide an opportunity for more profound learning to occur.

This section has been written by Alex Haxeltine Alex.Haxeltine@uea.ac.uk and Frans Berkhout. Further information is available in: **Climate Change Policy in the European Union: Confronting the Dilemmas of Mitigation and Adaptation** (edited by Jordan,A.J., Huitema,D., van Asselt,H., Rayner,T. and Berkhout,F., Cambridge University Press, 2010)

Section 6: Case Study A – Climate Governance Beyond 2012

Global climate policy beyond 2012 requires a strong, integrated governance architecture that involves both public and private actors and that provides a regulatory framework on both mitigation and adaptation. Highly fragmented global climate governance is likely to be more costly, less effective in terms of environmental goals, and less equitable regarding smaller countries, particularly in the global South.

Context

Many observers have hailed the entry into force in 2005 of the Kyoto Protocol to the United Nations Framework Convention on Climate Change as a landmark achievement in combating global climate change. However, this treaty is but a first step, and its core commitments will expire in 2012. Even full compliance with the Kyoto agreement will not prevent 'dangerous anthropogenic interference with the climate system' – the overall objective of the climate convention. This situation has led to wide-ranging debates among policy-makers, academics and environmentalists on the future of climate governance after 2012. This quest of finding stable, effective and equitable solutions for long-term climate governance has been the focus of the 'Climate Governance Beyond 2012' case study of the ADAM Project.

> *Fragmented global climate governance is likely to be more costly, less effective, and less equitable in smaller countries.*

Aims and Methods

The ADAM research team focused on three research domains that are crucial for future climate governance:

- the relative performance of different *architectures* of global climate governance;
- the relative performance of new forms of *agency* (in particular beyond the state), including the role of business and environmentalist organisations in governance arrangements and the role of market-based solutions;
- policy options for the *adaptation* of regions, countries and international institutions to the consequences of climate change.

Each research domain was assessed by three sets of methodologies:

- *qualitative policy analysis* mainly from the perspective of international relations, and legal analysis;
- *formal modelling*, drawing on the FAIR meta-model and the REMIND energy-economics model;
- *participatory forms of assessment*, including a series of workshops in Europe and India with representatives from governments, non-governmental organisations, policy advisors, and business representatives from both North and South.

The core research was carried out by 30 researchers drawn from institutions in Bangladesh, Germany, India, Indonesia, the Netherlands, Norway, South Africa, Sweden and the United Kingdom.

The research was academic in nature yet policy-relevant in orientation. Most efforts were directed at scoping or developing policy options that could provide a basis for future climate governance, and at appraising these options through multi-disciplinary assessment methodologies. While many of these policy options were derived from current debates, their appraisal took a much broader, long-term perspective, in a search for solutions that may be relevant and viable long after the current negotiations have been brought to an end.

Results

The architecture of climate governance

For the problem of architecture, ADAM research concluded that higher degrees of fragmentation in global governance architectures tend to reduce their overall performance. Fragmented global climate governance is likely to be more costly, less effective in terms of environmental goals, and less fair regarding smaller countries, particularly in developing countries. This calls for policies that reduce fragmentation and seek to integrate, or at least link, diverse governance approaches. Policy recommendations include the following:

- to strengthen dialogues between environment, trade and development ministries;
- to open the EU emissions trading scheme and to link it with other schemes;
- to initiate formal co-operation between the UN climate regime, the Asia-Pacific Partnership and other multilateral partnerships;
- to agree on science-based sustainability criteria for removing trade barriers for climate-friendly goods and services;
- to consider climate-related issue links and package deals in the World Trade Organization Doha Round.

Forms of agency beyond the state

Entirely private governance mechanisms in the role of agency beyond the state are probably less effective than often believed. In particular, public-private partnerships can be only marginally effective, since several obstacles prevent the realisation of their full potential. There is a geographical bias towards global partnerships – instead of local or regional ones – which reflect pre-existing interest-structures. These seldom deliver benefits additional to more traditional multilateral or bilateral implementation arrangements. It also appeared that a stronger link with the UN climate regime may benefit both the partnerships, by giving them guidance and a clear goal, and the climate regime, by assisting its implementation. Likewise, some private market-based solutions, for example in the field of carbon-offsetting, appear to offer little promise, at least at present.

At a more detailed level, the research indicates a number of policy recommendations to strengthen private involvement in climate governance, for example through creating or strengthening public funds to stimulate private research and development. It appears important to differentiate among Clean Development Mechanism (CDM) target countries, project types and technologies and to agree on science-based sustain-ability standards for CDM projects.

Governing adaptation

The ADAM research team used integrated assessment models to examine different combinations of adaptation and mitigation. Whilst adaptation can effectively reduce climate change damages in the short-term, it is less effective in the long-term, whilst mitigation is potentially effective in reducing climate change damages in the longer-term. Implementing both adaptation and mitigation policies gives the best results (see Section 2).

In terms of global governance mechanisms for adaptation, the project analysed three challenges: climate change-induced migration; climate-change induced food insecurity; and the need for coordinated adaptation funding. Two specific geographical analyses were also conducted: one from the perspective of developing countries as a group of nations and one from the perspective of the poorest of the poor. Overall, further international institutionalisation of adaptation appears crucial. This could include a legally binding agreement on the recognition, protection and resettlement of climate refugees under the climate convention; a climate refugee protection and resettlement fund; or a legally binding agreement on adaptation and food security.

This section has been written by Frank Biermann frank.biermann@ivm.vu.nl, Philipp Pattberg and Fariborz Zelli.
The complete findings of this study programme are published in a comprehensive book volume: **Global Climate Governance Beyond 2012: Architecture, Agency and Adaptation** (edited by Biermann,F., Pattberg,P. and Zelli,F., Cambridge University Press, 2010).

Section 7: Case Study B – Mainstreaming Climate Change into EU Development Policy

The process of mainstreaming climate change concerns into development assistance needs to be designed carefully in order to avoid unintended consequences. Climate concerns must not overwhelm existing development programs; the beneficiaries of mainstreaming policies must be clearly identified; how mainstreaming augments or interferes with existing norms of political accountability must be determined; and aid must be designed so that it does not crowd out local efforts.

Overview

The goal of this ADAM case study was to examine how European policy-makers are mainstreaming climate concerns into development assistance policies and consider how mainstreaming should in the future. The five partners to this study each investigated different aspects of mainstreaming, as follows:

> *Mainstreaming climate change needs to be designed carefully in order to avoid unintended consequences.*

- whether mainstreaming is appropriate, basing analysis on the historical goals and objectives of both climate and development policy makers.
- how European governments and international agencies and organizations are currently mainstreaming, identifying some of the difficulties at policy integration.
- the successes and failures of mainstreaming efforts in the Lake Victoria region of East Africa,
- the successes and failures of mainstreaming efforts in Nepal.
- the role that insurance and finance-related risk management options could play in an international climate and development assistance framework.

Each of these research groups undertook largely independent work, and yet their results display substantial synergies.

Methods and Results

Patterns, objectives, and criteria for mainstreaming

Research studying the links between climate change and sustainable development, took into account past literature, global policy processes on development cooperation and climate change, the need for climate change assistance and the supply of assistance. The research reached the important conclusion that mainstreaming of climate change should not be a primary goal of development cooperation. This is for three reasons:

- the target group for development cooperation is quite different from the target group of climate change assistance;
- the assistance needed for climate change dwarfs that needed for other development goals;
- there is a lack of clarity concerning the determination of goals of climate adaptation compared to other development goals.

Rather than make mainstreaming climate change a primary goal of development, it is important instead to have a number of guiding principles for climate related development assistance. These can ensure that mainstreaming does not interfere with other development objectives. They include making sure that climate related assistance is additional to pre-existing aid, making sure that the control of resources is split fairly and clearly between donor and recipient countries, ensuring that assistance reaches the poor, and avoiding market distortions and conditions of aid dependency.

Current European mainstreaming practices

The empirical review of mainstreaming practices among donors showed that there has been a rapid development over the last decade from adaptation being a non-issue to increasing awareness and development of analytical and procedural tools for meso- and micro-level mainstreaming. A recent survey of awareness-raising activities, Overseas Development Assistance (ODA) policies and mainstreaming tools and guidelines suggests that there is now intense activity, especially among the five to ten most proactive donor agencies.

In the translation of mainstreaming procedures into substance, two critical issues deserve further attention. First, the 2005 Paris Declaration on Aid Effectiveness is changing the modes of governance used in ODA, with greater emphasis on, inter alia, partner country ownership, alignment with national development priorities and programmatic approaches. Second, research has shown that while progress on 'greening' aid has been substantial,

this progress has been overridden by continued investment of ODA resources into environmentally harmful activities.

Mainstreaming effects on the poor in East Africa

Research in East Africa examined mainstreaming efforts in this region and sought to develop theoretical insights of general application. Lessons from the development field show that policies intended for poverty eradication, such as micro-finance schemes, may have an unintended consequence of marginalising certain groups. This strengthens the social stratification of the poor and contributes to the reproduction of 'the poorest of the poor'. Policy making for adaptation must seek to avoid such marginalisation.

Neither the Clean Development Mechanism nor the Reduced Emissions from Deforestation and Degradation mechanism actually provide benefits for the poorest of the poor. This is due both to the nature of the problem of reaching this target group, and the political construction of the policies.

There is a need to rethink development from a sustainability perspective rather than mainstreaming climate change and adaptation into the narrower paradigm of development. Yet mainstreaming may be the only option for the short term, provided that long-term problems are not created through path dependence or lock-in situations. At the national and local level, there is a need to specifically target policies so that the poorest of the poor are able to reap the benefits in spite of their marginalisation. At the global level, there is an urgent need to assess climate change policies from the perspective of the poorest people in order to avoid damaging policies, such as the current policies on bio-fuels.

Mainstreaming effects of political cultures and discourses: case study from Nepal

The case study from Nepal similarly investigated the effects of development assistance on climate adaptation and mitigation. Following the overthrow of the Rana regime (in the 1950s) Nepal's forests were nationalized and placed under the control of the Forestry Service. This intervention destroyed village level institutions, precipitating a rapid deterioration of the country's forests. This deterioration was then wrongly ascribed by all the international aid donors, and their scientific advisors, to population growth: the Theory of Himalayan Environmental Degradation as it is now called. Since then, careful research has demolished this theory and enabled other actors to gain a toehold in the policy process. The result, 20 years later, is that Nepal's forests have undergone a massive transformation and are now carbon-sequestering

Interestingly, climate change was not a concern when these changes began to take place, and is still not according to most Nepalese. Yet such a huge nationwide increase in both mitigation and adaptation is precisely what is now being called for in EU development policy. Policy design needs to be sensitive to both social scale (what is the appropriate level?) and cultural style (which voices are being excluded or not responded to?).

Merging climate change and risk management in development assistance

The Bali Action Plan specifically calls for 'consideration of risk sharing and transfer mechanisms, such as insurance' as a means to address loss and damage in developing countries that are particularly vulnerable to climate change. Numerous proposals mentioning insurance have been tabled in the negotiation process. Yet the precise role of insurance mechanisms in an adaptation strategy was, until recently, largely undetermined.

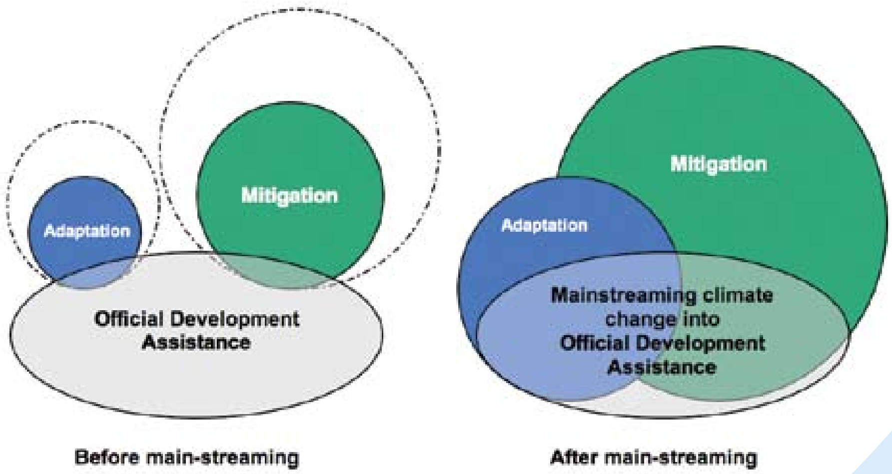
Based on ADAM research, a Munich Climate Insurance Initiative (MCII) proposal, with two distinct pillars, was developed and submitted to the climate negotiations, addressing high- and medium-layers of risk. The first tier takes the form of a Climate Insurance Pool that indemnifies victims of extreme catastrophes in non-Annex 1 countries by a percentage of their losses. A second tier provides support to facilitate micro- and national insurance systems in vulnerable developing countries by providing technical assistance, capacity building and possibly absorbing a portion of the insurance costs. The MCII proposal meets the challenge of providing support to promote sustainable, affordable and incentive-compatible insurance programs for vulnerable households and governments in the developing world. It simultaneously facilitates private sector involvement.

Significance of this Work

Mainstreaming is often seen as both inevitable and common sense – why would one not want to include climate related concerns into existing development assistance?

It is for this reason that a number of bilateral and multi-lateral donors are taking actions geared towards mainstreaming. The research in ADAM has shown, however, that the process needs to be designed carefully in order to avoid unintended consequences. First, it is necessary to make sure that climate concerns do not overwhelm existing development programs. This is especially risky because the goals of mainstreaming, being relatively new, are often less clear than those of established programs. Second, it is important to identify the beneficiaries of mainstreaming policies, which are often not those sought to be helped in the more general context of development assistance. Third, it is important to identify how mainstreaming, and indeed development aid in general, augments or interferes with existing norms of political accountability, and the diversity of perspectives and voices that exist within recipient countries. There is a long history of aid making matters worse not better. Finally, it is important to design aid that does not crowd out local efforts, such as those by the private sector. This was a primary goal of the ADAM work on insurance and the results show how difficult this can be.

More research is clearly needed, if only because mainstreaming is a practice that is evolving so rapidly. There will be a tremendous need to monitor the success and failure of mainstreaming efforts, using some of the criteria that have been developed in this project.



This section has been written by Anthony Patt, Joanne Linnerooth-Bayer, Mike Thompson, Åsa Persson, Joyeeta Gupta, and Lennart Olsson. Further information is available in the book: **Mainstreaming Climate Change in Development Cooperation: Theory, Practice and Implications for the European Union** (edited by Gupta,J. and van der Grijp,N., Cambridge University Press, 2010).

Section 8: Case Study C – Transforming the European Electricity Sector

Europe can meet its mitigation goals for 2020 and the longer term at modest cost, with energy efficiency and the electricity sector playing major roles. Early emphasis on technological change, research and development, rather than narrowly focusing on cost effectiveness, would better serve the long-term goals of global emission reductions and of energy security. Adaptation to climate change, differing geographically, will address changes in heating and cooling, as well as uninterrupted supply.

Aims and Scope

Electricity use and generation play a central role in the European Union's efforts to achieve greenhouse gas (GHG) reductions of at least 20 per cent by 2020 compared to 1990 levels. The electricity sector is currently responsible for about one-third of Europe's total energy-related GHG emissions, with a large potential for reducing emissions. This case study focuses on four issues relevant to the nexus between climate change and the electricity sector: the impacts of climate change on electricity demand and supply; policy instruments for enabling the transition; new technologies; and the global consequences of European actions.

Methods and Findings

To answer these questions, the ADAM project developed and employed detailed bottom-up technology models to estimate direct impacts and changes to the European electricity demand and supply, and top-down economy-wide equilibrium models which allow the analysis of the interaction between various sectors of the economy.

Impacts of climate change on the European electricity system

Southern European countries will most likely be faced with less energy demand for heating but substantially increased electricity demand for air conditioning. They will experience losses in hydropower and problems with cooling of thermal power plants. Northern European countries will also experience less demand for heating and may gain potential for additional electricity production from hydropower and biomass. At the same time, they may have to adapt to more storms and heavy precipitation. In both regions, electricity supply disruptions due to storms, floods and heat waves require adaptation measures, such as decentralised generation.

Europe can meet mitigation goals at modest cost, with a significant contribution from the energy sector.

These impacts may lead to increasing regional inequalities. The benefits of climate change – greater electricity supply and lower heating demand – will mainly be experienced in northern Europe while the costs of adaptation – reduced generation capacity and higher cooling demand – will be felt predominantly in southern Europe. These regional inequalities will need to be addressed through political solutions and investments (e.g. transmission lines) at the European level. Moreover, without public policy driven incentives to develop

Case Study of Switzerland

One case study of this research estimated Swiss electricity demand for cooling and air-conditioning to more than double by 2035 under the ADAM adaption scenario. Sixty per cent of the projected increase can be attributed to an expansion of partially or fully air conditioned spaces in buildings. The remaining 40 per cent of the increase resulted from higher specific requirements of the space that is already air-conditioned. Climate change is estimated to raise total electricity demand of buildings in Switzerland on average by between 5 and10 per cent by 2035 (up to 15 per cent in specific cases). The study of changes in electricity demand as adaptation to changes in temperature estimated that reduced heating dominates in northern Europe in the winter, increased cooling in the south in the summer.

innovative solutions (e.g. passive ventilation, integrated spatial planning) autonomous responses to climate impacts, such as air conditioning, could lead to 'lock-in' situations. This would have long-term consequences for energy demand and mitigation needs.

Policy instruments: Enabling and shaping the transition

This section focuses on policy options to facilitate the transition of the electricity sector towards a well-adapted, carbon-lean system. A stable and predictable policy framework is a necessary precondition for investment decisions by the private sector. However, policy instruments need to be assessed according to their effects on wealth distribution, choice of technology and time horizon. Similarly, affected groups (e.g. producers, investors, industries, households) need to be considered when enhancing the political feasibility of policy interventions. Many EU member states are likely to opt for combinations of policy instruments. This will overcome various sectoral or technology-specific barriers and promote non-fossil options with substantial innovative and cost-reduction potentials.

It is likely that the EU Emissions Trading Scheme, together with renewables support schemes (e.g. quotas, feed-in tariffs), will succeed both in creating pressures for emissions reductions from existing polluters and in assisting the introduction of currently known low-carbon technologies in electricity use and supply. These support mechanisms allow for more efficient electricity generation and for low-emitting technologies to be introduced without higher prices for emissions and electricity. The stimulation of long-term R&D, however, is dependent on new ideas for basic technical innovations (e.g. electricity production in North Africa and transmission to Europe, thermo-electrical solutions). If prices for electricity and emissions are too low, private funding of R&D will be too risky and insufficiently profitable, requiring other means of support for energy technology R&D (e.g. long term targets, publicly funded R&D support).

Impacts will be felt differently between northern and southern Europe.

Technologies and technological change

An assessment of technologies and technological change shows that the electricity sector could contribute more than its proportional share to the EU GHG reduction target if the most cost-effective options are pursued. In a 20 per cent emissions reduction scenario for 2020, electricity use and generation provide two thirds of Europe's total emission reductions, much more than its share of emissions of approximately 40 per cent (see Figure 8.1). These emission reduction options include greater efficiency in electricity use and generation, more co-generation, substitution towards natural gas, more nuclear energy and renewables, as well as realising the potential of carbon capture and storage after 2020.

Technological change through innovation, induced by high prices for emissions, electricity and fossil fuels has the potential to give Europe – and the world – entirely different energy and electricity systems. Uncertainty about future electricity demand and climate variability may also induce new generating capacities with shorter life times.

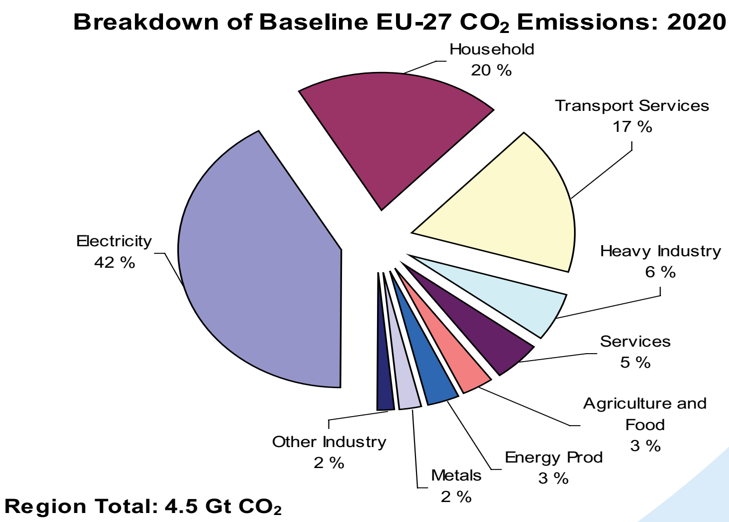


Figure 8.1: Breakdown of carbon dioxide emissions by sector in 2020 in the ADAM adaptation scenario

Retrofitting of existing thermal power plants at their present sites could become less standard than in the past.

European choices in a global context

Stringent mitigation targets in Europe have the potential to bring about new efficient solutions in electricity use and generation in all sectors of the economy. These solutions include co- and tri-generation, highly efficient thermal power plants, renewable energies, and reduced costs of those new technologies through learning and scale effects. This effect of targets in guiding the technological pathways may be exemplified by the cases summarised below. These not only reflect manufacturing and global networking of companies, but also transfer of knowledge and skills.

- Large power plants are constructed only by a few global companies. Strict European carbon dioxide targets will stimulate research in Europe and thus also the products of these global players. As these companies compete worldwide, they can resort to the most up-to-date technologies, including, for example, carbon capture and storage if the European Commission made this technology obligatory by 2020.

- Similar processes of technology advancement and transfer can be observed in smaller companies in the areas of energy efficiency and renewable energies. Many European wind technology manufacturers, for example, have founded joint ventures in Asian countries, as have manufacturers of control techniques, power electronics or efficient motor systems.

- There are many (and an increasing number of) large industrial companies worldwide that have introduced company-wide technological standards in order to reduce transaction costs. Where European production sites are in the lead regarding energy efficiency and low carbon emissions, they will influence all sites of a company worldwide and thus the performance of the competing companies as well.
- Many talented students from emerging countries obtain degrees and experience in engineering, natural sciences and business economics in Europe. They advance quickly in their home countries to influence standards and business practices, extending the potential reach of ambitious European policies.

Significance of this work

In summary, the medium- to long-term impact of a stringent climate change policy in Europe may have the potential to guide and accelerate the world's technological path in a sustainable direction. This places additional value on R&D and far-reaching technological change, with potential to be realized through global companies, human capacity-building in Europe and by international cooperation through technology treaties, tradable quotas, the Clean Development Mechanism and Joint implementation.

This section has been written by Gunnar Eskeland gunnar.eskeland@cicero.uio.no Eberhard Jochem and Henry Neufeldt. Further information is available in: The future of European electricity: choices before 2020. CEPS Policy Brief No 164, 2008, by Eskeland et al.

Section 9: Case Study D – Mainstreaming Adaptation into Regional Land Use Planning

We find that adaptation is enhanced by pilot projects that test and debate diverse sets of new ideas through collaboration between recognised actors from civil society, policy and science. Integrating (traditional) agro-environmental land use systems and new technologies, organisational responsibilities and financial instruments provides opportunities for adaptation. A key challenge is to create flexible financial instruments that facilitate benefit- and burden-sharing, social learning and that support a diverse set of potentially better-adapted new activities rather than compensate for climate impacts on existing activities.

Scope and Aim

Whereas the literature on adaptation is rich in detail on impacts, vulnerability and limits to adaptation, less is known on the conditions that facilitate adaptation in practice. Step-wise advances in action, coordination and engagement of actors at the local and regional level will be needed to handle the projected incremental changes in climate, and to address the increased possibility of extreme weather events. We use the term mainstreaming for this step-wise integration of adaptation actions into ongoing sectoral planning to reduce climate vulnerability. Land and water resources are directly impacted by climate change, and decisions regarding these resources affect ecosystems and human vulnerability. Although changing land use planning is a promising adaptation strategy to cope with climate change impacts, it is not yet extensively practised.

In this study we examined the constraints and opportunities for mainstreaming adaptation to climate change in land use and water management in three study regions: the Guadiana River Basin in Spain and Portugal, the Tisza River Basin in Hungary and the Alxa region in western Inner Mongolia, China (see Table 9.1). The three regions have in common that they increasingly struggle with climate impacts on land use and water resources, including desertification and the occurrence of extreme events such as floods and droughts. However, the institutional contexts and governance traditions upon which adaptation practices have developed differ greatly. We analysed the conditions that either facilitate or limit adaptation according to six analytical dimensions: biophysical, technical, financial, institutional, social, and cognitive (the latter including informational aspects).

Key Findings

Opportunities for using land use and water management planning to support adaptation and climate-proof regional development have started to emerge. These have been analysed within the following aspects:

Biophysical aspects: In all three regions, ecosystems have degraded and water resources are heavily exploited. Traditional landscape and resource use practices, such as the traditional floodplain production systems in the Tisza, had an active role in regulating climate extremes. This regulating service has motivated local populations, scientists and policy makers to explore the traditional agro-ecological production systems. Our research in the Tisza and Guadiana river basins show that preserving and managing diversification of land use has a great potential for reducing climate related risks.

> *Integrating land use systems with new technologies, organisations and financial instruments provides opportunities for adaptation.*

Technical aspects: Existing technical solutions, like building dikes, run into limits or add to undesirable and/or longer-term effects. Pilot projects and demonstration activities have started to test the feasibility of new technologies. There is scope for the development and exchange of more sustainable technologies and information systems, including early warning systems (e.g. the cell phone based warning service in Inner Mongolia). Currently available integrated assessment models are not parameterised for assessing new technologies and more complex and innovative adaptation strategies, creating a barrier for the appraisal of mainstreaming.

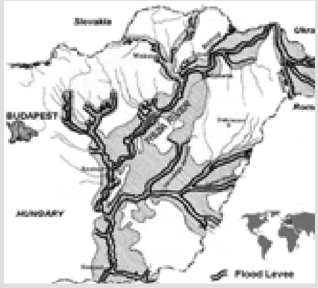
	Guadiana Basin **Spain & Portugal**	Inner Mongolia **Alxa Region, China**	Tisza River Basin **Hungary**
			
			
Biophysical, land-use	Semi-arid climate, forest, agriculture, tourism	Arid climate, desert, livestock, agriculture	Continental climate, grassland, agriculture
Climate projection	Significant temperature increase,rainfall decrease	Temperature increase, rainfall trend uncertain	Temperature increase, rainfall more irregular
Area / Arable land	66,800 km2 / 20 million ha	270,000 km2 (main study area 72,000 km²) / 30,000 ha + 9 million ha steppe	46,000 km² (Hungarian part basin) / 2.6 million ha
Technical	2000 dams. Reservoir and irrigation system	Irrigation, groundwater and water transfers	2800 km river dikes, drainage system
Economic	Participation in EU and global market. Tourism. GDP 20,000 per capita Below EU average	Increasing market forces and industrialisation. GDP 2,000 euro per capita	Transition economy. GDP: 4,500 euro per capita. Below country average
Institutional	EU member in 1986. EU regulation. Regional competences defined in Spain and Portugal	Communist party-led state; well defined limited regional autonomy	EU member in 2004. Implementation national and EU regulations
Social	4 million people. Aging	200,000 people. Mongol minority	4.1 million people. Roma minority

Table 9.1: Characteristics of the three study regions

Financial aspects: Financial resources are limited in each of the study regions and adaptation is often considered too costly and uncertain compared to expected benefits. Whereas there is a pressure on existing financial services (like insurance) to become more expensive, new financial instruments are also emerging (e.g. micro-grants). The implementation of adaptation strategies is constrained by unequal distribution of costs and benefits. For instance, measures taken to reduce land degradation and sand storms may be financially unsustainable, and water retention increases risks for those who store the water for the benefits of others. Mainstreaming adaptation complicates existing relations with donors or financial instruments. The European agro-environmental schemes for example, are not designed for inter-annual land use changes, driven by water availability. Creating markets for adaptation is a key challenge. All three regions identified opportunities for public-private partnerships in which marketable products obtain additional support in exchange for providing social and environmental services that support adaptation.

Institutional aspects: Divided, changing or unclear responsibilities are key constraints for adaptation actions in the Guadiana and the Tisza river basins. By contrast, in Inner Mongolia, the rigidity of the strictly defined roles of different organisations is considered a constraint, as is the limited communication of intended policy goals to beneficiaries. Stable adaptive governance is a complicated paradox. Adaptive governance is a relatively new concept that needs to be demonstrated to gain acceptance. Inspiring examples are the emerging coalitions of government and non-government actors that are helping to put the adaptation agenda in a regional context and encouraging action in this area. Successful coalitions often have close connections to academics who act as brokers in the communication of climate risk and adaptation information.

Our analysis in the Tisza region shows the importance of recognition of adaptation at an abstract level by responsible civil servants and advocating an adaptation strategy by a credible regional coalition. The recognition of adaptation and political attention following a number of major (near) floods, provided a window of opportunity for changing land use and water management. Opposition is inherent to implementing more fundamental policy change and engaging with (potential) opponents is an important activity in adaptation planning.

Social aspects: Adaptation can fail or be counterproductive because social processes and structures are imperfectly understood. In the Tisza basin, for example, sites for water retention were rejected. In the Alxa region, the enclosure of livestock conflicts with traditional lifestyles. The Tisza study region shows that informal social networks around local production systems have degraded, but are remediable. Local populations hold a wealth of knowledge on how to cope with climate variability, which deserves to be taken into account while developing new policies and measures.

Cognitive and informational aspects: In the Alxa and Guadiana regions in particular, people struggle to connect regional trends to global climate change. The causes of trends in desertification and reduced water availability are heavily contested. Adaptation policy so far does not address the diverse perceptions of risks and their causes. The Tisza region shows benefits of debating climate related risks and how best to respond; after various discussions on adaptation options, actors were quick to take advantage of a micro-grant scheme for implementing local solutions. This supports the notion of adaptation as a social learning process. All three regions suffer from a lack of (access to) information about climate impacts and adaptation options and policies. Newly emerging forums for debating adaptation strategies may prove to be valuable in this regard. At the regional level these are often associated with internationally funded projects. Yet, a gap remains between scientific adaptation theory and adaptation practice on the ground. There is a mismatch between model assessments of impacts and adaptation on one hand and 'real' adaptation options as discussed by people in the region or in the policy plans on the other.

Significance of this Work

Our research suggests that all six aspects of adaptation discussed above are relevant in capitalising on opportunities for successful planning and implementation of adaptation measures. Institutional and cognitive aspects have been identified as particularly important, but the relative weight of each aspect depends on location and will vary over time. In all three regions, lessons can be learned from integrating traditional agro-environmental land use systems with new technologies and institutional designs, for example to preserve diversity in landscape and the regulation of climate impacts as ecosystem services. The study regions suggest that it is important to balance formal regulatory rules and informal social factors in planning and implementation. Informal networks are crucial for social learning and adaptive capacity and may be particularly useful in times of crisis. At the same time, formal rules are required to include adaptation in longer-term planning, investment and financial support of experimentation and adaptation.

We thank all interviewees, research partners and participants of the regional workshops for sharing their experience on adaptation practice.

This section has been written by Saskia E. Werners Saskia.Werners@wur.nl, J. David Tàbara, Xingang Dai, Zsuzsanna Flachner and Gert-Jan Nabuurs. Further information is available from **Mainstreaming Adaptation in Regional Land Use and Water Management** (In Adaptation and Mitigation Opportunities in European Climate Policy (edited by Hulme, M. and H. Neufeldt. Cambridge University Press, 2009)

Part 2 Self-Evaluation

Learning within the ADAM Project

Self-evaluations of the ADAM project with regard to social learning, modelling strategies and policy interactions reveal two key findings: lack of integration was a problem for large, interdisciplinary, multi-institution EU projects, and strategies for interaction between researchers and policy-makers vary according to the position of the issue (i.e. mitigation, adaptaion) in the policy cycle and the maturity of the available analytical research capacity.

Two Self-Evaluation Studies

In addition to the formal deliverables produced by the ADAM project, for the end of the project the coordinators commissioned two semi-independent studies to evaluate what had been achieved and learned within the three-year project period. These studies were prompted, in part, by comments from the two independent reviewers of the ADAM project's Year 1 report and, in part, by our awareness of the importance to reflect on research practice, especially in large, inter-disciplinary projects. These studies were designed to provide insights into how project staff, and the wider research and policy community, have been impacted by, and benefited from, the project; how modelling strategies were developed within ADAM to contribute to policy questions; and how future integrated climate change research projects might learn from the experiences of ADAM.

The first study used an internal questionnaire to evaluate the technical and social learning amongst the European researchers involved with ADAM. The questions were designed to investigate successes and weaknesses of the ADAM project, and learning (technical and social) amongst project staff. An internet survey of ADAM staff (both current and past) was conducted in February 2009. In total, 59 researchers responded to the survey, of which 46 were still working on ADAM. The second study was targeted at the relationship between modelling and policy and examined the modelling strategies that ADAM researchers had employed to produce research results that would be relevant to the policy process. Of particular interest were the decisions made regarding model development, the choice of model experiments, and interactions with policy makers (as potential users of the research).

The results were based on interviews with a purposive selection of 20 ADAM researchers and five officers at the European Commission (EC). The EC was considered the main client of the ADAM project, although ADAM results will be used by many stakeholders. EC officers were asked for their personal views and their responses should not be interpreted as the viewpoints of the EC. These two studies were conducted by two researchers external to the ADAM project – respectively, Lorraine Whitmarsh, an experienced social science researcher at the University of East Anglia, and Serge Stalpers, a PhD student from the University of Wageningen. The full reports from these two studies are available from the ADAM website. Only a few salient conclusions are summarised here.

Context

Recent academic research has highlighted the evolving, porous and contested nature of the science-policy boundary. This interest in the science-policy boundary stems, at the most profound level, from post-modern epistemological challenges to scientific hegemony and a realisation that legitimate and effective policy-making demands a more participatory approach. Scientific controversies, technological risks and environmental problems highlight the need to reconsider the science-policy relationship. For example, due to the 'pervasive uncertainties and unacknowledged assumptions' exposed in risk assessments, the distance between 'experts' and 'citizens' has been reduced. New categories of 'lay experts' and 'citizen scientists' have been defined. There have been calls to move towards 'co-producing' knowledge and 'upstreaming' stakeholder engagement in the policy-making process. This focus on participation is consistent with the notion of post-normal science or 'Mode 2' science, which is more interdisciplinary, socially-accountable and applied than traditional scientific models of knowledge production.

There is much literature which has examined the types of 'learning' which may be pursued and achieved through stakeholder participation in sustainability science. This research suggests there are different levels at which learning can occur – ranging from technical, through conceptual, to paradigmatic. In particular, an important distinction is made between 'single-loop' (or technical) learning and 'double-loop' (or social) learning. While single-loop learning involves adaptation and error correction in respect of a fixed goal, double-loop is more fundamental and connects error correction to adjustment of underlying objectives, values, norms and beliefs (see Section 5). Double-loop learning is needed for re-conceptualisation and re-framing within issue domains. Social interaction appears to be particularly appropriate to foster double-loop learning since it involves an encounter with other stakeholders' beliefs and values. Learning on multiple levels can be enhanced through evaluation, particularly within interdisciplinary projects.

Funding for EU Framework Programme collaborations has increased in each consecutive programme, with such collaborations distinguished by their wide geographic dispersion and different institutional and disciplinary backgrounds of partners. These collaborations are recognised as being important for training and mobility of researchers, as well as for advancing and coordinating research and contributing to the development of a European Research Area. Evaluations of other European Integrated Projects have highlighted the challenges of interdisciplinary research, whereby learning to work with other disciplines involves getting to know their language, concepts and assumptions and acknowledging differences. Yet, interdisciplinary research is also shown to be particularly appropriate for social learning and for reframing issues.

Other learning from these projects relates to experiences with stakeholder engagement. Stakeholder engagement is seen as particularly relevant to sustainability research and decision-making given the complexity, ambiguity and subjectivity that surround persistent problems of unsustainability and climate change, and is thus advocated for substantive, normative and instrumental reasons. Previous integrated projects have exposed both the benefits of stakeholder engagement (e.g., to broaden the scope of analysis by involving diverse perspectives) and the significant challenges and constraints (e.g., time, resources, facilitation skills, stakeholder buy-in) involved.

It is these themes of 'collaboration, communication, interdisciplinarity, stakeholder engagement, research process and outcomes, and social learning' which emerge from previous studies of the EU Framework Programmes and sustainability projects that were the focus of the two studies summarised in this section.

Internal Survey Results

The internal survey results show that ADAM project staff held largely positive opinions about the project. The most commonly mentioned achievements of the ADAM project, derived from this self-evaluation survey, were:

- identification of climate policy options;
- conducting multi-faceted research on climate change;
- advancing research on adaptation and mitigation;
- building research networks;
- acting as a focal point for climate change research and publishing;
- highlighting the challenges of integration (across disciplines, scales, WPs).

Most staff also identify difficulties, commonly in respect of limited integration within the project. Consistent with this, suggested improvements mostly relate to integration and cooperation. These included reducing the project size or ambition for integration, or finding ways of promoting integrating across Work Packages (WPs) through project design or management techniques. To a much smaller extent there was concern about some external aspects of the project: a few participants suggested a need for greater policy relevance or stakeholder contact.

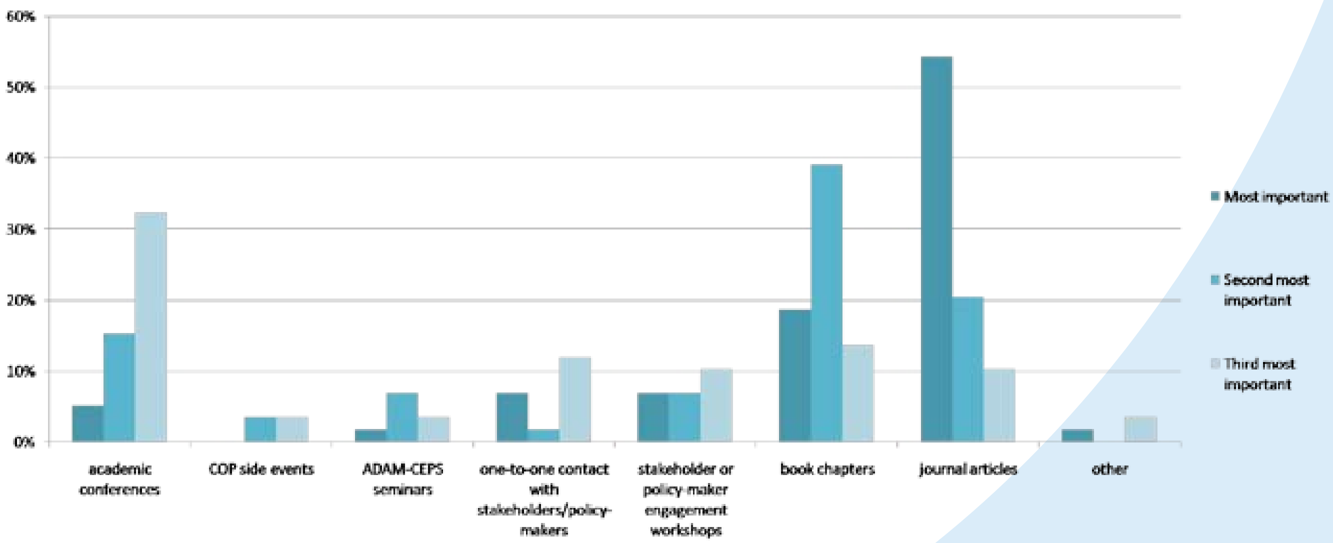


Figure 10.1: Most important research dissemination methods as reported by survey of ADAM researchers

Methods

The research methods used in ADAM included documentary analysis (66% of respondents), workshops (58%), interviews (53%), computer models (47%), and surveys (39%). In almost all cases, these had been used by researchers prior to their involvement with ADAM. Most respondents felt the mix of methods used in the project was 'quite appropriate' to achieve the project aims. While researchers tended not to have used unfamiliar methods during the course of the project, they did appear to have been more innovative in respect of theory. Over two-thirds indicated they had modified the theories or conceptual models they had used during the course of the project; and the same proportion say they had developed new theories or models.

Dissemination

Research dissemination within ADAM largely focussed on academic audiences rather than via policy-makers or other stakeholder groups (see Figure 10.1). This is broadly consistent with traditional models of scientific knowledge production and suggests there may be barriers to a closer relationship between science and policy. Nevertheless, researchers' awareness of policy developments led most of them to change their research questions or activities to at least some extent during the course of the project; around half believed the ADAM project will achieve a high level of policy impact.

Management

Attitudes to ADAM's project management were generally positive, most agreeing that the project had been well-managed. Attitudes were particularly positive about the composition of the project in terms of researcher skills and disciplines represented, although one-fifth disagreed that ADAM has been a 'truly interdisciplinary' project. Indeed, most felt that ADAM should have developed a stronger overarching conceptual basis on which to help integrate results. Nevertheless, most researchers felt their own research has been interdisciplinary and that they had interacted with people from many disciplines while working on ADAM.

Learning Outcomes (see Figure 10.2)

Overall, most researchers were satisfied with the work they had done (but would have liked to have achieved more) and felt working on ADAM had been a positive experience, benefiting their career development. Perhaps unsurprisingly, around half said they had encountered problems in conducting their research. Learning outcomes included technical, and to a lesser extent, social learning. Two-thirds felt they had learnt a great deal about climate change by working on the ADAM project, while less than half that proportion (27 per cent) agreed that the work they had done in ADAM had challenged their views about climate change. Nevertheless, most considered the ADAM project to have changed their perceptions of the interlinkages between mitigation and adaptation (see Figure 10.3).

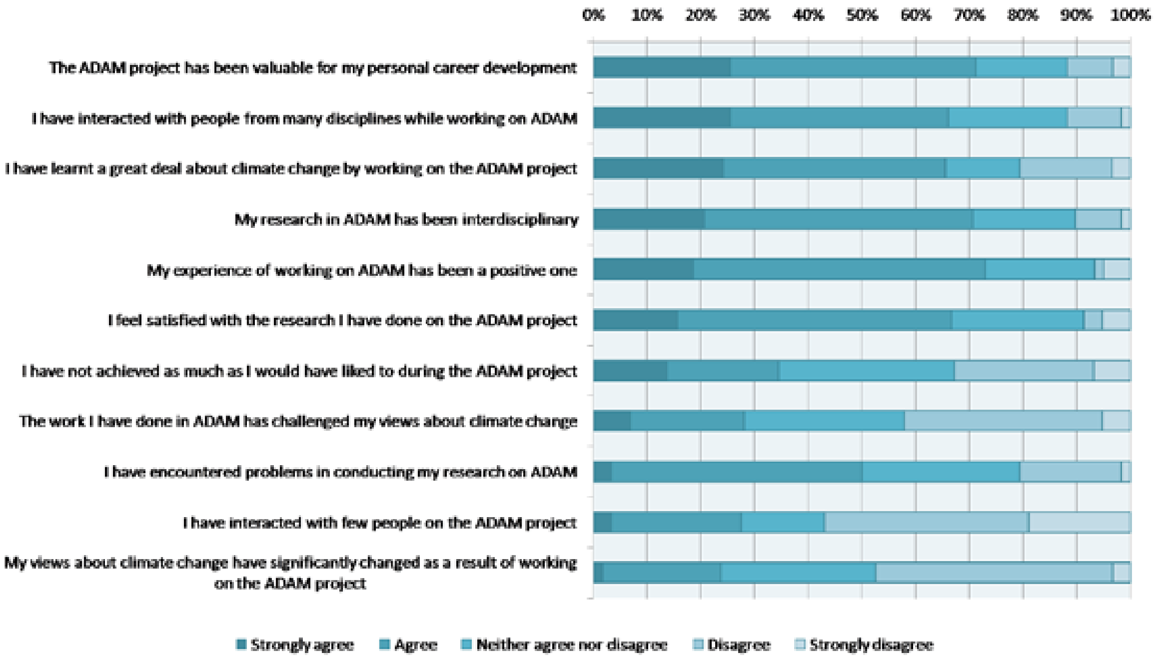


Figure 10.2: Attitudes relating to personal and social learning

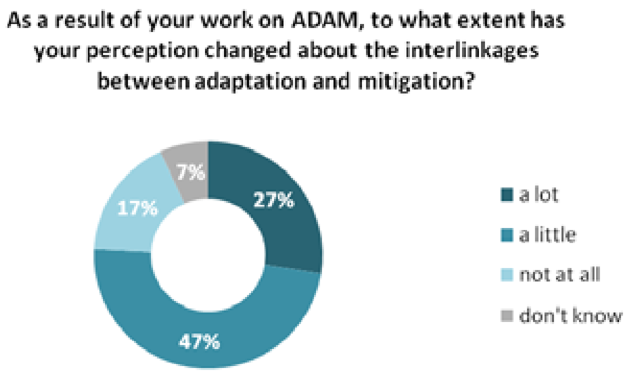


Figure 10.3: Change in perceived interlinkages between mitigation and adaptation

Yet, when asked for the most important things that they had personally learnt as a result of being involved in ADAM, researchers tended to highlight more instrumental than technical lessons. Interactions with others in the project, and to a lesser extent with policy-makers, form crucial learning outcomes for ADAM researchers. Technical (i.e., scientific or research-focussed) lessons, while important, were secondary to these 'softer' instrumental outcomes. This was consistent with participants' responses relating to achievements from ADAM as a whole.

Adaptation and Mitigation

To some extent, adaptation still appears to be the poor relation of mitigation in the field of climate change. First, in relation to the main achievements of ADAM, adaptation research was mentioned by fewer respondents than was mitigation. Second, when asked about which aspect should be given more attention in research and policy, more respondents felt mitigation should be given greater attention in both (though there was more support for adaptation in research than in policy). In general, though, respondents' perceptions of the relationship between adaptation and mitigation generally reflected a perception that they should be given equal attention in policy and research, although not all agreed that they can or should be integrated.

Modelling Strategies and Stakeholder Interactions

One of the important rationales of the ADAM project was to 'support EU policy development [in] negotiations around a post-2012 global climate policy regime, and inform the emergence of new adaptation strategies for Europe.' Reviews of previous research projects on the sciences of climate change have demonstrated the difficulty of providing policy relevant and policy usable information. Developing and using analytical models that are policy relevant can be particularly challenging. Models must necessarily simplify reality while decision-makers need to take into account many complexities; difficulties also usually arise in communicating model uncertainties.

What information did the EC need?

There were two over-arching climate policy concerns within the EU that provided the back-drop against which ADAM research was conducted during the period 2006 to 2009: the EU's 'two-degree target' and the emergence of a European adaptation policy initiative. The EU policy goal of limiting global-mean temperature rise to no more than 2ºC above the pre-industrial level is the starting position of the EU in international climate negotiations. The EC wants to underpin the two-degree target by demonstrating its technical feasibility and economic affordability, in particular before the 15th United Nations Framework Convention on Climate Change (UNFCCC) Conference of the Parties (COP-15) in December 2009. With regard to adaptation, the EU published an adaptation Green Paper in 2007 and a White Paper in April 2009. According to some researchers and EC officers interviewed, there was a lack of adaptation studies at the European level and existing studies were using different definitions and incomparable baseline scenarios. Also, few studies had explored the interlinkages between European adaptation and mitigation. As one EC officer stated: 'Any scientific information on adaptation is useful'.

What were the strategies for modelling?

The ADAM project undertook a major energy-economic modelling comparison exercise (see Section 4 in this brochure). Baseline scenarios were explored in five integrated assessment models in order to find robust technology options, and their associated costs, for achieving various mitigation targets, including the EU two-degree target. A second modelling strategy in ADAM was to model adaptation using a top-down macro-economic modelling framework, rather than from bottom-up using existing local studies. This approach matched a European scale of analysis and allowed the investigation of the autonomous adaptation of markets (see Section 3). A third modelling approach used the AD-FAIR model which integrates adaptation and mitigation in one model, allowing investigation of costs of global adaptation and trade-offs with mitigation and residual damage costs (see Section 2).

What were the strategies for interacting with EU policy-makers?

There was much positive evidence of interactions between ADAM researchers and EU policy-makers. This occurred through a series of policy workshops held in Brussels with senior EU policy makers (and hosted by the Centre for European Policy Studies), through interactions with DG-Environment (both by individual researchers and coordinated by the project as a whole), and through research presentations at major conferences (such as COP-13 in Bali and COP-14 in Poznan). Many of the senior researchers in the ADAM project also had strong links to their national negotiating teams.

There was less evidence, however, of two-way interactions aimed at explicitly identifying the modelling needs of users. The general strategy was to perform ADAM's modelling work on research questions that were derived from a continuation of an ongoing research agenda. They were also based on a perception of policy needs that was derived from the literature and scientific assessments (such as the IPCC), and/or on interactions with policy-makers occurring outside of the context of the ADAM project

At the start of ADAM, the lowest emission scenario considered by the project corresponding to the EU two-degree target was stabilisation down to a concentration of 450ppm CO_2-equivalent. Towards the end of 2007, however, EC DG-Environment officers approached the researchers with the request to work on a 400ppm CO_2-equivalent scenario. In response to this request, some of the modelling tasks were re-focused. Most models used in ADAM did not include appropriate technology options for such a low stabilisation scenario, in particular bio-energy carbon capture and storage, and so resources were reallocated to incorporating these technologies into the models. The results of this exercise were presented at a CEPS science-policy seminar in February 2009.

ADAM researchers working on adaptation modelling had early contact with EC officers at a kick-off meeting and at a science-policy seminar, both held in October 2007. According to researchers when they asked policy-makers what adaptation options would be relevant to investigate, they got no clear response. Some researchers, attributed this to the unstructured nature of the European adaptation problem. In response, the researchers oriented their investigation to questions they thought policy-makers should be asking, including the macro-economic implications of adaptation.

The AD-FAIR modelling team did not feel the need to have much interaction with policy makers during the ADAM project because the researchers were experienced in working for policy-makers and had often used the parent model, FAIR, in science-policy workshops. The macro-economic adaptation and AD-FAIR modellers did not present their results to policy-makers until the end of the project. They said they preferred to wait until they had time to improve the models.

Strategies of researchers for interacting with policy-makers varied according to the position of the issue in the policy cycle and the maturity of the research capacity (e.g., the modelling approach(s) used). Researchers working on mitigation responded to clear requests from policy-makers and kept them informed of interim results. In contrast, researchers working on adaptation, lacking such clear requests, did not have as many interactions, preferring to develop new modelling approaches based on anticipated policy needs and wait for these results to mature.

Policy Relevance

The study revealed considerable evidence that the ADAM project produced policy relevant results and enhanced the knowledge base being used by climate negotiators from both the EC and other countries. Yet researchers and users both found room for improvement. They identified various factors that affected the policy relevance of model results which are summarised below:

Timing

Both researchers and users interviewed for this study said that ADAM was timely in many respects. COP-15 will occur just a few months after the project ends, so that the mitigation modelling results can contribute to discussions leading up to the conference. On the other hand, results from the modelling efforts investigated in this study came too late to contribute to an important EC Green Paper on adaptation and an impact assessment preceding the White Paper on adaptation. Despite this, the project has produced important insights that will help structure the problem of European adaptation to climate change.

Project resources

The resources allocated to the project allowed for large modelling efforts such as the model inter-comparison and for developing novel model approaches such as the macro-economic modelling of adaptation. At the same time, a large majority of researchers would prefer working in smaller research projects to allow better integration across Work Packages, in particular on tradeoffs between adaptation and mitigation.

Modelling strategies deployed

ADAM modelling strategies were designed to be policy relevant in scale, robustness of results, and level of integration. The Mitigation Domain aimed to produce findings that were robust under different economic assumptions, whilst the macro-economic modelling of adaptation matched the scales at which European policy is made. Integrating adaptation and residual damages in the AD-FAIR model produced insights in the interlinkages between adaptation and mitigation.

Project mandate

The mandate of the ADAM project to work 'in support of' European climate policy raised the interest of EC officers to follow the project and led most researchers to make an effort to produce results relevant to the EC. Yet there were differences in interpretation of the implications of the mandate. Some researchers argued that their research objectives should be aligned with policy-maker needs in a research consultancy mode, a position agreed by most policy-makers. Other researchers expressed concerns about being caught in 'policy fashions' of the day and, in the extreme case, expose themselves too much to interference from policy-makers. They argued that, to be policy relevant, scientists should develop their research objectives and in this way influence policy thinking in the longer term. In their view this requires working in a more fundamental research mode in some isolation from policy and politics to leave room for novel approaches to emerge. For example, some researchers working on new approaches for modelling adaptation would not want to have more interactions with policy-makers, preferring to wait until model results were solidified.

In contrast, EC officers suggested that ADAM results could perhaps have fed into the adaptation White Paper process if they had been informed earlier of these results, even if uncertainties remained large. This illustrates some of the tensions involved in getting the balance right between the independence, practices (e.g. publishing) and timescales of the scientific research process and the needs, practices and timescales of the policy process.

Interaction with policy-makers

In many cases, direct interactions between researchers and policy makers in ADAM were limited. The majority of researchers and users interviewed for this study recommended more interactions in future projects in the form of yearly or half-yearly workshops to improve policy relevance. Almost all researchers and EC users suggested having a workshop early in the project to understand policy needs and align objectives. If adopted in future projects, such an approach could facilitate mutual learning where researchers learn about policy-makers' needs and policy-makers learn about the possibilities and limitations of modelling. If continuous negotiation takes place between modellers and users, it must maintain space for researchers to pursue questions they believe need to be asked, whilst allowing effort to be put into synthesising and tailoring modelling results to more immediate policy needs.

Significance of this Work

In many respects, the findings of these two studies reflect those of previous evaluations of large EU Integrated Projects and (more broadly) of sustainability research and assessment projects. Indeed, many respondents in the internal survey acknowledged that lack of integration was a common problem for large, interdisciplinary, multi-institution projects, and that ADAM was not unique in this respect. The challenges and value of stakeholder engagement were also raised in this evaluation research, as in previous projects. An important lesson for future projects concerned getting the balance right between the independence, practices (e.g., publishing) and timescales of the scientific research process and the needs, practices and timescales of the policy process. Strategies for science-policy interactions within the ADAM project suggests the degree of interaction between researchers and policy-makers varied according to the position of the issue (mitigation versus adaptation) in the policy cycle and the maturity of the research capacity (e.g., the modelling approach(s) used). The challenge remains for project funders and managers to consider these well-documented difficulties in future projects and to take into account the possible solutions suggested in this and previous research.

This section has been written by Mike Hulme and Henry Neufeldt drawing upon reports written by Lorraine Whitmarsh, Serge Stalpers and Alex Haxeltine. Further information is available from: Whitmarsh,L. (2009) **The ADAM learning report** ADAM Internal Report, March 2009,; and Stalpers, S. and Haxeltine, A. (2009). **Addressing user needs in climate modelling**. ADAM Internal Report. Both reports available at: www.adamproject.eu

Further Sources of Information

ADAM book series

Hulme,M. and Neufeldt,H. (eds.) (2010) **Making climate change work for us: European perspectives on adaptation and mitigation strategies** Cambridge University Press, Cambridge, UK

Biermann,F., Pattberg,P. and Zelli,F. (eds.) (2010) **Global climate governance beyond 2012: architecture, agency and adaptation** Cambridge University Press, Cambridge, UK

Gupta,J. and van der Grijp,N. (eds.) (2010) **Mainstreaming climate change in development cooperation: theory, practice and implications for the European Union** Cambridge University Press, Cambridge, UK

Jordan,A.J., Huitema,D., van Asselt,H., Rayner,T. and Berkhout,F. (eds.) (2010) **Climate change policy in the European Union: confronting the dilemmas of mitigation and adaptation** Cambridge University Press, Cambridge, UK

Special journal issues

Edenhofer,O. (ed.) (2009) The economics of low stabilisation **The Energy Journal**

Mechler,R. (ed.) (2010) Assessing adaptation to extreme weather events in Europe **Mitigation and Adaptation Strategies for Global Change**

Web site www.adamproject.eu

The website lists reports of milestone achievements, policy briefs and past newsletter publications, tools developed during the project, pod-casts of previous COP meetings and conference presentations. Varied knowledge dissemination activities can be viewed on the website, including the learning reports used as a basis for the final section of this publication.

List of ADAM Partners and Researchers

- **Tyndall Centre for Climate Change Research**, University of East Anglia, UK. Neil Adger; Helen Colyer; Emanuela Elia; Javier Delgado-Esteban; Alex Haxeltine; Mike Hulme; Andrew Jordan; Henry Neufeldt; Tim Rayner; Angela Ritchie; Duncan Russel; Adrian Southern; Paul Weaver; Anita Wreford; Fari Zelli
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- **ALTERRA Research Centre**, Wageningen University, The Netherlands. Koen Kramer; Gert-Jan Nabuurs; Mart-Jan Schelhaas; Herbert ter Maat; Saskia E. Werners
- **International Institute for Applied Systems Analysis**, Austria. Stefan Hochrainer; Joanne Linneroth-Bayer; Reinhard Mechler; Patrick Nussbaumer; Anthony Patt; Michael Thompson
- **Paul Scherrer Institute**, Switzerland. Leonardo Barreto; Socrates Kypreos; Bertrand Magné; Ulrich Reiter; Hal Turton
- **Centre for Sustainability Studies**, Lund University, Sweden. Karin Bäckstrand; Sara Gabrielsson; Roger Hildingson; Anne Jerneck; Lennart Olsson; Johannes Stripple
- **International Centre for Integrated Assessment and Sustainable Development**, University of Maastricht, The Netherlands. Pim Martens; Darryn McEvoy; Lorena Santamarta
- **Institute for Environmental Science and Technology**, Autonomous University of Barcelona, Spain. Francesc Cots; Elisabet Roca; Anna Serra; Joan David Tàbara
- **Institute of Agricultural and Forest Environment**, Polish Academy of Science, Poland. Ilona Banaszak; Adam Chorynski; Agnieszka Heller; Andrzej Kędziora; Zbigniew Kundzewicz; Piotr Matczak; Maciej Radziejewski; Malgorzata Szwed
- **Environmental Assessment Agency**, The Netherlands. Johannes Bollen; Michel den Elzen; Andries Hof; Morna Isaac; Paul Lucas; Elke Stehfest; Willemijn Tuinstra; Jasper van Vilet, Detlef van Vuuren
- **Fraunhofer Institute for Systems and Innovation Research**, Germany. Wolfgang Eichhammer; Anne Held; Nicki Helfrich; Eberhard Jochem; Wilhelm Mannsbart; Mario Ragwitz; Laura Quandt; Wolfgang Schade; Joachim Schleich; Rainer Walz; Martin Wietschel
- **Centre for Climate Change Mitigation Research**, University of Cambridge, UK. Terry Barker; Mairead Curran; Katie Jenkins; Serban Scrieciu; Stephen Stretton; Svetlana Tashchilova
- **Institute for Environment and Sustainability**, Joint Research Centre, European Commission. José Barredo; Elisabetta Genovese; Sandro Federici; Carlo Lavalle; Nicola Lugeri; Suvi Monni; Frank Raes
- **Department of Agronomy and Land Management**, University of Florence, Italy. Marco Bindi; Francesca Incerti; Marco Moriondo; Lorenzo Orioli; Giacomo Trombi
- **Stockholm Environment Institute**, Sweden and UK. Sukaina Bharwani; Ruth Butterfield; Tom Downing; Minlei Du; Bo Kjellén; Richard Klein; Kate Lonsdale; Vikrom Mathur; Åsa Persson; Julia Rawlins; Takeshi Takama; Richard Taylor; Gareth Walker; Paul Watkiss

continued overleaf

- **Energy and Environmental Policy Department**, National Centre for Scientific Research, France. Elie Bellevrat; Patrick Criqui; Silvana Mima; Julien Morel
- **Corvinus University Budapest**, Hungary. Éva Szabóné Erdélyi; Csilla Farkas; Zsuzsanna Flachner; Márta Gaál; Zsolt Harnos (now deceased); Levente Horvath; Márton Jolánkai; Márta Ladányi; István Lang
- **EnerData**, France. Bertrand Chateau; Alban Kitous
- **German Institute for Economic Research**, Germany. Thure Traber
- **Centre for Energy Policy and Economics**, Swiss. Federal Institute of Technology Zurich, Switzerland Bernhard Aebischer; Giacomo Catenazzi; Andrea Honnegar; Martin Jakob; Uta Thun; Reinhard Madlener
- **Environmental Systems Analysis Group**, Wageningen University, The Netherlands. Rik Leemans; Serge Stalpers
- **Centre for European Policy Studies**, Belgium. Monica Alessi; Arno Behrens; Christian Egenhofer
- **The Energy and Resources Institute**, India. Nitu Goel; Manish Kumar Shrivastava
- **Institute of Atmospheric Physics**, Chinese Academy of Sciences, China. Jieming Chou; Xingang Dai; Congbin Fu; Weidong Guo; Gensuo Jia; Hongtao Liu; Yanling Sun; Yinlong Xu; Yong Zhang

The ADAM Project

The ADAM project was funded by the European Commission to research strategies for mitigating and adapting to climate change from a European perspective but in a global context. The research was conducted between March 2006 and July 2009 by a Consortium of 24 European research institutes, together with one partner from each of China and India. The Consortium was led by the Tyndall Centre for Climate Change Research at the University of East Anglia, UK.

ADAM research identified, analysed and appraised existing and new policy options that contributed to different combinations of adaptation and mitigation strategies. These options addressed the demands a changing climate will place on protecting citizens and valued ecosystems – i.e., adaptation – as well as addressing the necessity to minimise humankind's perturbation to global climate to a desirable level – i.e., mitigation.

The ADAM work programme was structured around four overarching domains: Scenarios, Adaptation, Mitigation and Policy Appraisal. In addition, four Case Studies were completed in which synergies and trade-offs between climate change mitigation and adaptation strategies were analysed at different scales, both within and outside Europe. The results of the project are summarised in this report.

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Tyndall Centre for Climate Change Research
University of East Anglia, Norwich, NR4 7TJ, UK
www.adamproject.eu