The Centre for Climate Change Economics and Policy (CCCEP): Summary of Phase One Projects

CCCEP Phase One consisted of four core-funded research programmes, together comprising, in total, fifteen research projects. Figure 1 indicates the projects undertaken in each programme and their duration and timing. The project personnel, foci and key results are summarised below.

Figure 1. Schedule of core-funded programmes and projects in Phase One.

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<tr><td>Research programme</td><td colspan="5">Year</td></tr>
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1a. Improving the use of evidence from climate models

Lenny Smith, Piers Forster and collaborators

This project has brought together climate scientists, economists, philosophers of science and statisticians around the key question: what might we learn from climate models?

At a fundamental level, it has sought clarity on, and a shared understanding of, what uncertainty about climate change means (e.g. Smith and Stern 2011). Different disciplines have brought different understandings, presenting an opportunity for interdisciplinary work. But its core focus has been on improving our understanding of two sources of uncertainty in climate modelling, (i) parametric uncertainty and (ii) so-called ‘model inadequacy’, i.e. known structural flaws in climate models. Work on (i) has shown, among other things, that uncertainties about anthropogenic soot emissions play a very significant role in climate projections, at least twice previous estimates. We have also shown how recent modelling techniques fail to reduce parametric uncertainty (e.g. Crook and Forster 2011). Work on (ii) has strongly cast into doubt whether the results of climate-model experiments can be interpreted as probabilistic, with fundamental implications for the economics of climate change. It has further shown how standard modelling practices are limiting our understanding of model inadequacy and has suggested new approaches (e.g. Lopez, Smith et al. 2011). Based on these insights, we have sought to correct the naïve interpretation of climate-model output that prevails in policy-focused research and in practice (e.g. Oreskes, Stainforth et al. 2010); this work has had a wider impact on policy-making in the UK, US and Netherlands, for example.

Applications of Project 1a have built on these theoretical insights, as well as those from 1b (described below). One set has conducted innovative coupled climate-catastrophe modelling,

including of hurricanes in Florida (Ranger and Niehörster In press), inland flood risk in Mumbai and storm-surge risk in Copenhagen. Another set has explored the range of feasible global carbon-emissions paths consistent with a long-term temperature target of 2°C or even 1.5°C. This work was a key input to the UK's negotiating position in the run up to the UN Climate Conference in Copenhagen in December 2009.

Key project outputs

- High-level briefings before the Copenhagen UN Climate Conference in 2009, supported by: Bowen, A. and N. Ranger, 2009. "Mitigating climate change through reductions in greenhouse gas emissions: the science and economics of future paths for global annual emissions", *CCCEP Policy Brief*.
- Expert advisory inputs to the *UK Climate Impacts Programme 2009* and the UK's first national *Climate Change Risk Assessment*;
- Crook, J.A. and P.M. Forster, 2011. "A balance between radiative forcing and climate feedback in the modeled 20th century temperature response". *Journal of Geophysical Research*, **116**, D17108.
- Lopez, A., L.A. Smith and E. Suckling, 2011. "Pattern scaled climate change scenarios: are these useful for adaptation?" *CCCEP Working Paper 80*.
- Oreskes, N., D.A. Stainforth, and L.A. Smith, 2011. "Adaptation to global warming: do climate models tell us what we need to know? *Philosophy of Science*, **77(5)**, 1012-1028.
- Ranger, N. and F. Niehoerster, forthcoming. "Uncertainty in long-term hurricane risk: scenario generation and implications for future climate experiments." *Global Environmental Change*.
- Smith, L.A. and N. Stern, 2011. "Uncertainty in science and its role in climate policy". *Philosophical Transactions of the Royal Society A*, **13**, 4818-4841.

1b. Risk, uncertainty and the economic evaluation of climate-change policies

Simon Dietz and collaborators

This project started with the view that economic analysis has tended to treat climate-policy uncertainties poorly, if at all. Most studies had ignored uncertainty, while those that did not had remained within a 'risk' framework, basing their conclusions on probabilities as if they were robust (like tossing a fair coin). By contrast, Millner, Dietz and Heal (2010) dropped the assumption that climate-policy impacts have known probabilities (considering the probabilities 'ambiguous'), while at the same time allowing the decision-maker to be ambiguity-averse. They showed that the value of emissions abatement is likely to increase as ambiguity aversion increases, and that this ambiguity 'premium' can in some plausible cases be very large. However, the framework they used, while at the cutting edge of applied economic research, is arguably still too restrictive. In particular, it assumes complete knowledge of the future, in the sense that all possible scenarios are accounted for in the set of models we have. Further work has therefore considered how to make decisions, when the decision-maker is worried that her knowledge about future scenarios is incomplete. This work is not just of interest to climate economics and policy: it is a general contribution to decision theory.

The treatment of uncertainty in economic analysis of climate policy interacts with the treatment of time, i.e. the practice of 'discounting'. A second strand of Project 1b looks at this interface. We conducted the first empirical investigation of Martin Weitzman's now famous 'Dismal Theorem' about the results of cost-benefit analysis of highly uncertain climate policies, finding that welfare estimates strongly depend on 'fat tails', but that discounting still matters (Dietz 2011). Elsewhere we showed uncertainty can result in large errors in standard cost-benefit analysis, while we applied to climate change one of the latest theories from the literature on axiomatic social choice (Dietz and Asheim 2012).

Another strand of Project 1b has considered the more immediately practical question of how decisions should be made today in the absence of fully convincing empirical and theoretical models, either in science or in economics. This work has addressed carbon pricing, adaptation planning and strategic appraisal. Work on carbon pricing has been influential in the UK and US, where a social cost of carbon has been introduced for regulatory impact assessment, while work on strategic appraisal won "Best Paper of 2011" in the journal Risk Analysis (Dietz and Morton 2011).

Key project outputs

- Input into the social cost of carbon for regulatory impact assessment in the US and UK, supported by: Dietz, S. and S. Fankhauser, 2010. "Environmental prices, uncertainty and learning", *Oxford Review of Economic Policy*, **26(2)**, 270-284; Dietz, S., 2012. "The treatment of risk and uncertainty in the US social cost of carbon for regulatory impact analysis", *Economics*, **6**, paper no. 2012-18.
- Barrieu, P. and B. Sinclair-Desgagné, 2010. "Economic policy when models disagree". *CCCEP Working Paper 5*.
- Dietz, S. 2011. "High impact, low probability? An empirical analysis of risk in the economics of climate change", *Climatic Change*, **103(3)**, 519-541.
- Dietz, S. and G.B. Asheim, 2012. "Climate policy under sustainable discounted utilitarianism", *Journal of Environmental Economics and Management*, **63(3)**, 321-335.
- Dietz, S. and A. Morton, 2011. "Strategic appraisal of environmental risks: a contrast between the UK's Stern Review on the Economics of Climate Change and its Committee on Radioactive Waste Management", *Risk Analysis*, **31(1)**, 129-142. Recipient of a "Best Paper of 2011" award from the journal.
- Millner, A., S. Dietz and G. Heal, 2010. "Ambiguity and climate policy". *National Bureau for Economic Research (NBER) Working Paper 16050, CCCEP Working Paper 28*.
- Expert advice to the UK Committee on Climate Change on adaptation, supported by: Ranger, N., A. Millner, et al., 2010. "Adaptation in the UK: a decision-making process", *CCCEP Policy Brief*.

1c. Closing the loop: Interpreting user needs and facilitating co-evolution through participatory appraisal

Andrew Dougill and collaborators

This project has examined the extent to which climate models and their outputs can be strengthened through participatory appraisal and the integration of local knowledge, thus forging an important connection between macro-scale models and actors at the micro level. It has important implications for the ways in which climate information should be communicated and presented to vulnerable groups, and in turn for the ways in which their needs are (or are not) articulated to and assimilated by the producers of climate information. We have developed novel methods combining science and local knowledge to assess vulnerability to climate change, how different actors (in our case farmers, development practitioners and policy-makers in sub-Saharan African) use climate information, and how integrated assessments of vulnerability and adaptation strategies can be used to develop scenarios that reflect climatic, socio-economic and political factors across multiple scales. The research was reported in a special issue of the high-impact journal Ecology and Society in 2011, which was edited by CCCEP researchers and their collaborators (e.g. Quinn, Ziervogel et al. 2011; Twyman, Fraser et al. 2011).

Key project outputs

- Dougill, A., E. Fraser et al., 2010. "Anticipating vulnerability to climate change in dryland pastoral systems: using dynamic systems models for the Kalahari", *Ecology and Society*, **15**(2), 17.

- Quinn, C.H., G. Ziervogel, A. Taylor, T. Takama, and F. Thomalla, 2011. "Coping with multiple stresses in rural South Africa", *Ecology and Society*, **16(3)**, 2.
- Sallu, S.M., C. Twyman, and L.C. Stringer, 2010. "Resilient or vulnerable livelihoods? Assessing livelihood dynamics and trajectories in rural Botswana", *Ecology and Society*, **15(4)**, 3.
- Twyman, C., E.D.G. Fraser, L.C. Stringer, C. Quinn, A.J. Dougill, F. Ravera, T.A. Crane, and S.M. Sallu, 2011. "Climate science, development practice, and policy interactions in dryland agroecological systems", *Ecology and Society* **16(3)**, 14.

2a. Politics, institutions and international cooperation on climate change

Robert Falkner, John Vogler and collaborators

Working primarily from international relations/studies, this project has examined shifts in international political structures to understand how they have shaped negotiations on a post-Kyoto climate agreement. The project examined trends that influence the strategic environment within which climate policy is negotiated, such as the rise of China, India and Brazil as new powers, the United States' reluctance to engage in environmental multilateralism, and the EU's efforts to exert leadership in climate-change diplomacy. A key academic contribution of this project has been to bust long-established myths about international climate policy, and to identify a more pragmatic alternative. The research argues for a realistic assessment of the possibilities for climate diplomacy and suggests that a 'building blocks' strategy could help to make progress in global climate governance (Falkner, Stephan et al. 2010). This building blocks strategy would involve negotiating a series of partial climate agreements, for example on specific greenhouse gases, on specific sectors, or within regions, instead of pursuing a grand international treaty. Agreement on more confined issues is easier to muster, and over time these partial agreements accumulate to form the foundations of global climate governance (see also Paavola 2012).

Key project outputs

- Advised the UK Secretary of State for Energy and Climate Change on the country's post-Copenhagen climate strategy.
- Special issue of *International Affairs* edited by R. Falkner and B. Lee (volume **88**, issue 3, 2012) on "Rio+20 and the global environment: reflections on theory and practice".
- Falkner R., H. Stephan and J. Vogler, 2010. "International climate policy after Copenhagen: towards a 'building blocks' approach", *Global Policy*, **1**, 252-262.
- Paavola J., 2012. "Climate change: the ultimate 'Tragedy of the Commons'?" In D. Cole and E. Ostrom (eds.), *Property in Land and Other Resources*. Cambridge, MA: Lincoln Institute for Land Policy.
- Vogler, J., 2010. "The institutionalisation of trust in the international climate regime", *Energy Policy*, **38**, 2681-87.

2b. Effective climate-change governance without the state

Andrew Gouldson and Rory Sullivan

We live in an era where corporations have enormous reach and influence, and where it appears that government powers are diminishing at the same time as the powers of markets and corporations are increasing. The ways in which corporations are governed are therefore critically important – do we live in a runaway world where corporate powers are uncontrollable, or are there opportunities to harness the powers of private corporations more fully, so that they better deliver, or contribute to, public-interest objectives? If the answer is the latter, then how can this power be harnessed and what sort of contribution can this actually make to public-interest goals?

This research starts from the premise that governance is not a simple mechanical process, where actors exert pressure and corporations respond; we argue that governance is a far more dynamic and complex process, where companies themselves are key actors in the governance process, and where the effectiveness of any governance intervention is influenced by a whole series of factors internal and external to the corporation. Based on comprehensive empirical research, including interviews with CEOs of some of the world's largest corporations, with key global and national NGOs, investors, corporate responsibility experts, politicians and regulators, this research provides a comprehensive account of how different governance interventions, frameworks and regimes shape corporate strategies, behaviour and performance on energy and carbon. It explains who the key actors (internally and externally) are, how these actors may be influenced, what needs to be provided for influence to be effectively exerted, what outcomes can be achieved, and how governance mechanisms and processes evolve over time. It also examines the significance of these findings for broader debates on governance beyond the state. In particular, the research highlights how external governance pressures have to align with internal governance conditions in companies for significant change to take place. This leads us to question the extent to which we can rely on non-state forms of governance to deliver improvements in corporate carbon performance, when or if the business case for change dries up.

Key project outputs

- Gouldson, A. and R. Sullivan, 2011. "Ecological modernisation and the spaces for feasible action on climate change". In M. Pelling, D. Manuel-Navarrete and M. Redclift, (eds.) *Climate Change and the Crisis of Capitalism*. London: Routledge.
- Gouldson, A. and R. Sullivan, submitted. "Ten years of corporate action on climate change: what do we have to show for it?" *Energy Policy*.
- Sullivan, R. and A. Gouldson, submitted. "Long-term corporate climate change targets: what could they deliver?" *Environmental Science and Policy*.

2c. Human rights and climate change

Margot E. Salomon and Chaloka Beyani

This project has examined the conceptual and normative contributions that the theory and international law of human rights could offer in evaluating the impacts of climate change. In doing so, it has also conducted underpinning research on the impacts of climate variability and climate change on migration.

The research provides a critique of how legal scholars have justified the extension of the role of international human-rights law to future generations, and it suggests alternative ways of handling these issues (Salomon 2011). It considers how we might best interpret and apply to climate change certain substantive rights such as peoples' rights to their natural resources. A key finding of the research is that the norms and mechanisms of international law are only partially suited to address the nature of contemporary harms such as climate.

Work on this project further supported CCCEP's Chaloka Beyani in contributing to the formulation and adoption of a new Constitution for Kenya, in particular the chapter on Land and Environment, as well as in his role as the UN Special Rapporteur on the Human Rights of Internally Displaced Persons, as part of which he presented a report on the issue of climate change, human rights and internally displaced persons to the UN Human Rights Council. CCCEP Research Assistant Radha Govil also co-authored a high-profile UNHCR report on vulnerability to climate change and migration in the Horn of Africa.

Key project outputs

- Input into the new Constitution for Kenya on Land and Environment.
- Afifi, T., R. Govil, P. Sakdapolrak and K. Warner, 2012. *Climate Change, Vulnerability and Human Mobility: Perspectives of Refugees from the East and Horn of Africa*. UN Refugee Agency (UNHCR) and the United Nations University for Environment and Human Security.
- Salomon, M.E., 2011. "Why should it matter that others have more? Poverty, inequality, and the potential of international human rights law", *Review of International Studies*, **37**, 2137-2155.
- UN General Assembly, Human Rights Council, 2011. *Report of the Special Rapporteur on the Human Rights of Internally Displaced Persons, Chaloka Beyani*. New York, United Nations.

2d. Equitable mitigation and adaptation

Jouni Paavola, Luc Bovens and collaborators

This ongoing research project examines the implications for distributive and procedural justice of climate mitigation and adaptation, both conceptually and empirically. It has included collaborative work between moral philosophers and economists on the ethics of carbon markets (Caney and Hepburn 2011) and on the allocation of international emissions rights under a climate treaty or similar institution (Bovens 2011). Paavola's research examines social-justice and carbon-market projects. Most existing research on projects undertaken under the UN programme on Reducing Emissions from Deforestation and Forest Degradation (REDD) and under the Clean Development Mechanism (CDM) has relied on project-development documents when assessing their contribution to mitigation and to local sustainable development. The novelty of this project partly lies in seeking to generate field-based evidence on the contribution of these projects to sustainable development locally. While the main project is still on-going, the results from completed pilot projects suggest that the ability of local communities to develop or participate in carbon-market projects is limited (Mustalahti, Bolin et al. 2012). This will in turn limit the potential of such projects to contribute to local sustainable development. The results also highlight that economic incentives can undermine the additionality of such projects in terms of emissions reductions (Rendon-Thompson, Paavola et al. in press).

Key project outputs

- Bovens, L., 2011. "A Lockean defense of grandfathering emission rights". In D. Arnold (ed.), *The Ethics of Global Climate Change*. Cambridge: Cambridge University Press, 124-144.
- Caney, S. and C.J. Hepburn, 2011. "Carbon trading: unethical, unjust and ineffective?" *Royal Institute of Philosophy Supplement*, **69**, 201-234.
- Mustalahti, I., A. Bolin, A. Boyd and J. Paavola, 2012. "Can REDD+ reconcile local priorities and global mitigation benefits? Lessons from Angai Forest, Tanzania", *Ecology and Society*, **17(1)**, 16.
- Rendon-Thompson, O.R., J. Paavola, T.R. Baker, J.P.G. Jones and J.R. Healey, in press. "Reducing emissions from deforestation and forest degradation (REDD) in developing countries? Findings from Six Peruvian Projects", *Ecology and Society*.

3a. Vulnerability hotspots: linking food security and climate change

Evan Fraser, Andrew Challinor and collaborators

Project 3a has sought to identify global 'vulnerability hotspots' in order to contribute to the international debate on adaptation priorities. Areas are vulnerable to climate change if they are both

(i) exposed to significant climatic stress and (ii) have a limited capacity to adapt. The project has conducted a global assessment to identify which of the world's food-producing regions are most vulnerable to climate change over the 21st century (Simelton, Fraser et al. 2012). The research breaks new ground methodologically by integrating socio-economic data, climatic/meteorological models and crop models (Fraser, Dougill et al. 2011). It focuses on cereal crops that provide 90% of calories globally and that are likely to be affected by droughts in a changing climate. The research uses a range of socio-economic/ecological data and statistical methods to establish proxy indicators of adaptive capacity. It then uses different socio-economic and climate projections to identify regions that are likely to be exposed to droughts and to have a limited capacity to adapt in the future. These are the vulnerability hotspots. Follow-up research has examined some of them in more detail (Antwi-Agyei, Fraser et al. 2012). Overall, the project constitutes an important step to better understand when, where, and why food systems are likely to be vulnerable to climate change in the future.

In related research, a CCCEP team worked with the World Bank to explore aggregate climate-change vulnerability indicators, broken down into measures of adaptive capacity and impact, as a tool that may help policy-makers to identify adaptation priorities. The research established that vulnerability to climate change in general, and adaptive capacity in particular, are strongly correlated with indicators of socio-economic development such as income, literacy and good institutions (Barr, Fankhauser et al. 2010). However, the links between vulnerability and development are complex and causalities are not always clear. Another related project collaborated with the UK Department for International Development (DfID) to tease out the exact links between adaptation, development and economic growth, and to estimate the combined costs of meeting both adaptation and development goals (Fankhauser and Schmidt-Traub 2011; Bowen, Cochrane et al. In press).

Key project outputs

- Expert advice to the Secretariat of the UN Convention to Combat Desertification.
- Three-dimensional framework for understanding vulnerability to climate change has been used by the Food and Agriculture Organization of the UN (FAO) as the basis of their future analysis of project support and implementation relating to climate adaptation.
- Antwi-Agyei P., E.D.G. Fraser, A.J. Dougill, L. Stringer and E. Simelton, 2012. "Mapping the vulnerability of crop production to drought in Ghana using rainfall, yield and socioeconomic data", *Applied Geography*, **32**, 324-34.
- Collaborative research with the World Bank on indicators of national climate-change vulnerability: Barr R.F., S. Fankhauser and K. Hamilton, 2010. "Adaptation investments: a resource allocation framework", *Mitigation and Adaptation Strategies for Global Change*, **15**, 843-858.
- Collaborative work with DfID on the links between adaptation, development and economic growth: Bowen A., S. Cochrane and S. Fankhauser, 2011. "Climate change, adaptation and growth", *Climatic Change*, **113(2)**, 95-106.
- Collaborative work with DfID on the links between adaptation and development goals: Fankhauser, S. and G. Schmidt-Traub, 2011. "From adaptation to climate resilient development: the cost of climate proofing the Millennium Development Goals in Africa". *Climate and Development*, **3**, 1-20.
- Fraser, E.D.G., A.J. Dougill, K. Hubacek, C.H. Quinn, J. Sendzimir, and M. Termansen, 2011. "Assessing vulnerability to climate change in dryland livelihood systems: conceptual challenges and interdisciplinary solutions", *Ecology and Society* **16**(3), 3.

3b. Understanding and estimating the impacts of climate change on human development in India

Robin Burgess and collaborators

This research project examines the links between climate-change impacts, adaptation and development by focusing on heat-related mortality in rural and urban India. Using robust econometric techniques, it has generated important new empirical results on the geographically differentiated effect of temperature. A 1ºC increase in average daily temperatures is associated with a 10% increase in annual mortality rates, but only in rural parts of India. A key relationship seems to be that hot weather tends to depress agricultural productivity and wages, whereas urban wages are unaffected. Hot weather therefore impacts indirectly on farmers and farm workers (which represent the most vulnerable segments of the Indian population) in a way that it does not do for urban residents. The research finds little evidence of direct effects of hot weather (heat stress) on mortality, which is often the focus of attention in rich countries. When comparing results from India with estimates for the United States, the research finds that the effects in India are about ten times larger. Populations in both urban India and rich countries like the US appear to be better able to protect themselves against the detrimental effects of hot weather, because they have incomes that are less weather-dependent and greater access to resources enabling them to protect themselves. The results are important in understanding the impacts of climate change on mortality and for adaptation policies. They have been presented widely, including at Chicago, Delhi, Oxford and the World Bank, and a paper is in preparation for submission to one of the top economics journals.

Key project outputs

- Burgess R.O., O. Deschenes, D. Donaldson and M. Greenstone, 2012. "Weather and death in India: mechanisms and implications of climate change", *Mimeo*.
- Keynote lectures at the Pakistan Institute for Development Economics Silver Jubilee Conference 2010, the Asian Development Research Institute in Bihar, and the ISI Development and Growth 2010 Conference in Delhi.
- Reported in the *Hindustan Times* and ESRC's *Britain in 2010*.
- High-level discussion with the Minister of Rural Development of India, Jairam Singh.
- Co-author Michael Greenstone used the paper's findings to motivate US policy-makers to combat climate change while Chief Economist of Obama's Council of Economic Advisers.

3c. Linking adaptation and development

Lindsay Stringer, Emma Tompkins and collaborators

This project examines the links between adaptation, mitigation and development within livelihood portfolios in East African coastal communities, in an effort to shed light on climate-compatible development. The potential for 'triple-wins' across adaptation, mitigation and development is often noted in the literature, but is supported by limited evidence. This on-going project seeks to generate a novel empirical evidence base demonstrating whether, under what conditions and to what extent climate-compatible development is a realistic goal within livelihood portfolios that span agriculture, forestry, tourism and fisheries. It also seeks to identify any tensions and trade-offs. Preliminary findings from elsewhere in sub-Saharan Africa suggest that multi-stakeholder working across scales from the local to the regional is necessary to deliver carbon, ecosystem-service and poverty-alleviation benefits simultaneously, and that institutional coordination is paramount (Stringer, Dougill et al. 2012). Key contributions are likely to include novel insights into the ways livelihoods deliver adaptation, development and mitigation opportunities across sectors and levels.

Key project outputs

- Stringer L.C., A.J. Dougill, J.C. Dyer, F.K. Kalaba, D.D. Mkwambisi and M. Mngoli, 2012. "Challenges and opportunities for carbon management in Malawi and Zambia", *Carbon Management*, **3**, 159-173.
- Stringer L.C., A.J. Dougill, A.D. Thomas, D.V. Spracklen, S. Chesterman, C. Ifejika Speranza, H. Rueff, M. Riddell, M. Williams, T. Beedy, D.J. Abson, P. Klintenberg, S. Syampungani, P. Powell, A.R. Palmer, M.K. Seely, D.D. Mkwambisi, M. Falcao, A. Sitoe, S. Ross and G. Kopolo, 2012. "Challenges and opportunities in linking carbon sequestration, livelihoods and ecosystem service provision in drylands", *Environmental Science and Policy*, **19-20**, 121-135.
- Stringer, L., A. Dougill, et al., 2012. "Challenges and opportunities in linking carbon sequestration, livelihoods and ecosystem service provision in drylands", *Environmental Science & Policy,* **19-20**, 121-135.

3d. Adaptation in the water sector

Judith Rees, Susannah Fisher and collaborators

Adaptation practitioners often equate lack of adaptive capacity with 'poor institutions', without investigating what the institutional deficiencies are and what kinds of institutions would foster adaptation. This project addresses the lack of empirical evidence on institutions, adaptation and development, and looks at the potential for robust approaches to decision-making. Focusing on water planning in Indian cities, the research shows that there are still large gains to be made in the area of no-regrets measures that would significantly improve the resilience of the urban water supply to future climate changes. However, it also highlights the significance of institutional barriers that are preventing new ways of dealing with climate risks and associated uncertainties. This research will deepen understanding of aspects of adaptive capacity related to the use of climate information, institutions and planning, and how these are dealt with in a developing-country setting. The on-going project will also explore to what extent the principles of robust decision-making (avoiding lock-in, promoting climate-resilient development, and addressing near-time stresses) are compatible with the institutional frameworks for water management in developing countries, and their potential for addressing future climatic stresses in the water sector. The initial outputs of the project have been methodological papers, including a book chapter in a forthcoming publication on the AVOID project.

Key project outputs

- Fankhauser, S. and S. Fisher, 2012. "Adaptation to climate change: measures, costs and challenges". In S. Bailey et al. (eds.), *Can We Still Avoid Dangerous Climate Change*?
- Fisher, S., submitted. "The emerging geographies of climate justice", *Transactions of the Institute of British Geographers*.

4a. Climate-change policies: innovation, performance and competitiveness

Ralf Martin and collaborators

This project uses a variety of state-of-the art econometric techniques to analyse the relationships between climate policies, innovation and competitiveness. It includes a collaboration between CCCEP and the ESRC-funded Centre for Economic Performance at LSE. It focuses in particular on the effectiveness of mitigation policies in improving the carbon performance of firms, but it also analyses their impacts on innovation, employment and economic performance.

Research on the UK Climate Change Levy, for example, has compared fully-taxed firms with firms that were partially tax-exempt. It has found that fully-taxed firms exhibited significantly lower

energy consumption and thereby stronger emission reductions than partially-exempt firms, crucially *without* any negative effects on employment or productivity (Martin, de Preux et al. 2011). In related research, we conducted interviews with managers in almost 800 manufacturing firms across six European countries on issues surrounding the EU ETS as well as climate policy more widely, using a new interview approach that has recently emerged in the management literature. Amongst our results, we found that few firms expect the ETS to be relevant to their location decisions up to 2020, and, while there are some sectors where jobs might be at risk, we developed a new optimal free permit allocation algorithm to show how this risk could be mitigated without impacting on the effectiveness of the scheme.

To further analyse the impacts of climate policy on innovation, we have constructed one of the most comprehensive databases of clean-technology patents worldwide, with nearly one million patents recorded in over 80 countries. By analysing this dataset, we find that there are strong path-dependencies in innovation that arise as firms build on their knowledge stock to develop new technologies. This implies that stronger policies will be needed as time goes by, since the stock of knowledge in 'dirty' technologies is to this point much larger than the stock of knowledge in 'clean' technologies. We have also found using sophisticated 'matching' techniques linking 8.5 million European companies with their patenting history that the EU ETS has so far had at best a very limited impact on low-carbon innovation (Calel and Dechezleprêtre 2012).

Key project outputs

- Aghion, P., A. Dechezleprêtre, D. Hemous, R. Martin, and J. Van Reenen, 2011. "Carbon taxes, path dependency and directed technical change: evidence from the auto industry", *Mimeo*.
- Bloom, N., C. Genakos, R. Martin and R. Sadun, 2010. "Modern management: good for the environment or just hot air?" *The Economic Journal*, **120**(54), 551-572.
- Calel, R. and A. Dechezleprêtre, 2012. "Environmental policy and directed technological change: evidence from the European carbon market". *CCCEP Working Paper 87.*
- Martin, R., M. Muûls, L. de Preux and U. Wagner, 2011. "Anatomy of a paradox: management practices, organizational structure and energy efficiency", *Journal of Environmental Economics and Management*, **63**(2), 208-232.
- Martin, R., L.B. de Preux and U.J. Wagner, 2009. "The impacts of the Climate Change Levy on business: evidence from microdata", *CCCEP Working Paper 7* and *NBER Working Paper 17446*.
- Perkins, R.M. and E. Neumayer, submitted. "Do recipient country characteristics affect international spillovers of CO2-efficiency via trade and foreign direct investment?" *Climatic Change*.
- Presentations at the UK Department of Energy and Climate Change (DECC), the World Bank, the French Environmental Protection Agency (ADEME), the French Finance Ministry, the Environmental Defense Fund (New York), the European Commission and the European Parliament.

4b. Innovation-friendly climate policies and systems change

Timothy Foxon, Andrew Gouldson and collaborators

This project – which is ongoing – examines the changing roles of governments and markets in low carbon transitions. Focusing on the critical issue of low-carbon skills, the research has examined the causes and consequences of skills shortages, and the ways in which they can be overcome (Jagger, Foxon et al. in press). It suggests that, whilst skills shortages could influence the speed, cost and employment intensity of the transition to a low-carbon economy in various ways, the recession has meant that there is ample supply of construction skills, which represent the most important area of

potential shortage. However, the construction sector has historically struggled with skills shortages following recessions and there is no reason to believe that this will not be the case in the future. These expected shortages could impact on the economics of new power-generation capacity, especially in the nuclear industry, which has in the past been particularly susceptible to such shortages that have caused delays and cost over-runs. The research then moves on to consider innovative forms of policy and governance that could be deployed to tackle low-carbon skills, relating for example to the UK's 'Green Deal' policy. Our work has naturally been of strong interest to policy-makers and we recently presented it to the OECD Green Skills Forum and to the UK Department of Business, Innovation and Skills.

Key project outputs

- Presentation to the OECD Green Skills Forum on "Licensing and Certification to Increase Skills Provision Amongst Low Carbon SMEs in the UK", and to the UK Department of Business, Innovation and Skills.
- Jagger, N., T. Foxon, and A. Gouldson, in press. "Skills constraints and the transition to a low-carbon economy". *Climate Policy*.

4c. Enabling carbon markets: carbon accounting, benchmarking and disclosure

Andrew Gouldson and collaborators

This on-going research project focuses on the potential contribution of new forms of carbon accounting and disclosure. The research, which is ongoing, uses statistical techniques and a rich but difficult-to-analyse dataset of firm-level emissions to look at whether or not the myriad targets, systems and processes that companies are putting in place actually influence performance. This work will play a key role in informing the extent to which we can rely on voluntary forms of carbon governance. More particularly, it considers the limits of voluntary carbon reporting in enabling the emergence of new forms of carbon governance. The research has so far found that voluntary carbon disclosures have failed to change investor behaviour, but it also finds that mandatory carbon reporting (as recently proposed by the UK government) is unlikely to resolve all of the issues. A combination of mandatory and voluntary disclosure is likely to be most effective. The project has encountered significant difficulties in accessing the required data, a theme that is common to much empirical work on corporate carbon emissions. A related project is therefore documenting the practical and methodological difficulties faced in the econometric evaluation of carbon policies, including accounting/disclosure activities, and will make practical recommendations on the collection of emissions data for research and monitoring purposes.

Key project outputs

- Gouldson, A., P. Newell, and I. Bailey, 2011. "Ecological modernisation and the governance of carbon: a critical analysis". *Antipode*, **43(3)**, 682-703.
- Sullivan R. and A. Gouldson, 2012. "Does voluntary carbon reporting meet investors' needs?" *Journal of Cleaner Production*, **36,** 60-72.

4d. Enabling carbon markets: efficient carbon trading systems and finance

Samuel Fankhauser and collaborators

This project has made a substantial contribution to the understanding of carbon markets, building a unique bridge between academic theory and applied market practice. Using a range of techniques – from standard microeconomics to financial modelling and novel laboratory experiments – the research has informed our understanding of issues relating to instrument selection (principally cap-and-trade versus carbon taxation) and complementary policy mixes, including for example how

different policies interact and the design of carbon price ceilings and floors (Fankhauser and Hepburn 2010; Hepburn and Fankhauser 2010).

The research has also examined the market dynamics and price volatilities that have had a defining influence on the performance of the EU ETS. For example, the research has considered the impacts of carbon markets on technological change, and the potential for well-designed market schemes to influence the level and timing of technological change. Lab experiments conducted jointly with the University of Zurich shed light on trading behaviour. The research finds that the observed market price of emission permits does not necessarily reflect marginal abatement costs, as theory would suggest. Experimental subjects trade permits at a (sometime relatively high) premium (Chesney, Taschini et al. 2011).

The research has also considered the opportunities for linking the different Emissions Trading Schemes that are now in operation or being considered around the world. Linking these schemes together would make economic sense, since larger markets mean more buyers with access to more low-cost abatement opportunities in different geographical locations and also opportunities for firms to reduce high compliance costs. However, existing schemes are highly diverse in terms of scope, size and structure, which could present a significant barrier to linkage. The research has examined the implications of these issues and practical ways in which barriers can be overcome. The research also considers links between carbon markets such as the EU ETS and international schemes such as the CDM. As well as examining optimal ways of linking the ETS and the CDM, the research has examined the functioning of the CDM (Fankhauser and Martin 2010) and the extent to which it meets its sustainable-development goals.

Key project outputs

- Chesney M., L. Taschini and M. Wang, 2011. “Experimental comparison between markets on dynamic permit trading and investment in irreversible abatement with and without non-regulated companies”, *CCCEP Working Paper 51*.
- Fankhauser, S. and C.J. Hepburn, 2010. “The design of carbon markets part I: carbon markets in time”, *Energy Policy*, **38(8)**, 4363-4370.
- Fankhauser, S., C.J. Hepburn and J. Park, 2010. “Combining multiple climate policy instruments: how not to do it”, *Climate Change Economics*, **1(3)**, 209-225.
- Fankhauser, S. and N. Martin, 2010. “The economics of the CDM Levy: revenue potential, tax incidence and distortionary effects”, *Energy Policy*, **38(1)**, 357-363.
- Gruell, G. and L. Taschini, 2011. "Cap-and-trade properties under different hybrid scheme designs”, *Journal of Environmental Economics and Management*, **61(1)**, 107-118.
- Hepburn, C., J. Quah and R. Ritz, in press. “Emissions trading with profit-neutral permit allocations', *Journal of Public Economics*.
- Expert input to the *Lazerowicz Review* of global carbon markets, and to the DECC on the carbon-price underpin.
- Advising governments of Australia, China, Mexico and South Korea on the establishment of cap-and-trade schemes.