The Centre for Climate Change Economics and Policy (CCCEP): Mid-Term Review

Executive Summary

CCCEP was established in October 2008 with the aim of advancing public and private action on climate change through rigorous, innovative research. We have already made core contributions on several topics, including: the use of climate models in decision-making; different routes to effective global climate governance; the identification of 'vulnerability hotspots' and priorities for adaptation; econometric evaluation of mitigation policies; the design and operation of carbon markets, and; new methods to close the gap between model-based projections and field-based observations. We are currently four years into our first five years, with a range of projects still underway, whilst others – due to long lead times – have yet to generate their final outcomes and impacts. Nonetheless, to date we have published 11 books, 277 journal articles and chapters in books, with another 64 in review.

We have built capacity in the climate-research community, bringing in scholars from other disciplines, mentoring post-doctoral staff, starting new doctoral-training programmes and training over 50 PhD students, and establishing new courses for undergraduate and postgraduate students and for executives. We have actively engaged with key decision-makers at all stages of the research process, influencing the UN climate negotiations at a high level, working closely with the World Bank and other international organisations, engaging heavily in UK climate policy on critical issues such as the fourth statutory carbon budget, impacting on policy-making in many other countries and engaging with private decision-makers, e.g. through our collaboration with Munich Re. To help us deliver all of this, we have raised c. £28m in leveraged funding.

To guide our thinking for Phase Two, we have engaged in extensive consultations over the last 12 months. Two key points have emerged from these. The first is the need to address the changing context for climate research, particularly taking into account the financial crisis and recession, the continuing absence of an over-arching global climate treaty and the impacts of recent controversies relating to climate science. The second is the need to develop more integrated and joined-up approaches to climate decision-making, breaking down barriers between, for example, modellers and field workers, and between adaptation and mitigation specialists.

We therefore propose five inter-related research themes for Phase Two that tackle the most pressing issues and that give CCCEP – with its particular focus and track record – the best chance of pushing forward both the academic debate and the scope for practical progress on climate change in the coming years:

1. Understanding green growth and climate-compatible development;
2. Advancing climate finance and investment;
3. Evaluating the performance of climate policies;
4. Managing climate risks and uncertainties and strengthening climate services;
5. Enabling rapid transitions in mitigation and adaptation.

Beyond the planned scientific programme, we propose a CCCEP Innovation Fund, with the aim of stimulating, developing and disseminating innovative ideas from both the academic and practitioner communities.

Our plans for Phase Two build on the solid institutional foundations of Phase One, including CCCEP's position at LSE/Leeds, its management structure and its key staff. However, we also plan to refresh the team. Finally, we will continue to engage with key stakeholders throughout the research process and to exploit a range of pathways to impact.

Part I: Review of Phase One

1. Introduction

CCCEP was established in October 2008 with core funding from ESRC for an initial five-year phase. It is jointly hosted by the LSE, where it is embedded in the Grantham Research Institute on Climate Change and the Environment (GRI), and the University of Leeds, where it is embedded in the Sustainability Research Institute (SRI). Together, GRI and SRI have secured c. £28 million in leveraged funding for research and engagement.

CCCEP was established against the backdrop of the *Fourth Assessment Report* of the Intergovernmental Panel on Climate Change (IPCC) and the *Stern Review on the Economics of Climate Change* (Stern 2007). Members of the Centre contributed to both, but were in particular at the core of the Stern Review team. In their different ways, these reports highlighted the risks of business-as-usual climate change, compared with the benefits of mitigation and adaptation. At the time, there was much impetus behind the idea of a 'global deal' on climate change and there was widespread public and political concern about climate change, leading to support for policy action at least in the EU and UK.

Therefore CCCEP sought in its first phase to: 1) advance climate policy and increase the capacity of public and private decision-makers to manage climate change, and; 2) support a new global deal on climate change through formal international negotiations and a wider set of linked activities. We sought to achieve these objectives by conducting rigorous, innovative and interdisciplinary research that linked science and social science and that combined quantitative and qualitative approaches, and by making engagement of users and beneficiaries a central element of our work.

This document reviews our achievements to date. At the time of writing, we are less than four years into our first five-year programme of work. Many of our projects are hence ongoing, while those projects that are complete are, due to the sometimes long lead-times in question, yet to generate their final outputs and impacts. Nevertheless, we do feel that we have made a strong contribution to knowledge and to the management of climate change in public policy, in business and beyond.

Highlights of Phase One so far include:

Improving the use of climate models in decision-making and closing the loop between climate-model users and the modellers themselves

We have brought together climate scientists, economists, philosophers and other social scientists to improve understanding of the predictive capabilities and practical value of climate models, to develop and deploy theories and methods of planning and decision-making under uncertainty that are appropriate to our confidence in climate prediction, and to feed lessons learned back into the modelling community and how it conducts its research: i.e. to 'close the loop'. Our research in this area has thrown the spotlight on fundamental uncertainties in climate modelling that stem from model mis-specification, uncertainties that will be difficult to resolve in the near future. Building on this insight, it has applied to climate mitigation and adaptation state-of-the-art economic theories of decision-making under uncertainty, and has moreover begun to develop new decision theories of general scope. The research has not only been of strong interest to academics; we have made a core contribution to adaptation planning by the UK government, as well as providing advice in other countries and contexts, including to the US Congress, developing countries facing adaptation challenges, and institutional investors asking how to allocate their assets strategically under uncertainty about climate change and the direction and form of climate policy.

Highlighting the role of institutions in shaping our responses to climate change

Phase One has also aimed to build a fuller and more robust understanding of the causes and consequences of climate change, and of the actual and potential responses to it, drawing on insights

from areas including politics, law, international relations, public policy and management, geography, anthropology, development studies, business and management studies, and accounting and finance. Our research in this area has repeatedly highlighted the role that institutions play in shaping our responses to climate change. For example, our research on the formal international negotiations from an international-relations perspective has examined how institutions, institutionalised modes of behaviour and their change have affected the scope for agreement. Our analysis has yielded a 'building blocks' strategy to global climate governance. In geography and development studies, we have shown how appropriate institutional capacities can enable participatory approaches to climate-compatible development, but we have also detailed how limited institutional capacities undermine the ability of communities to adapt to climate change. And in areas linked to politics, policy, business and finance, we have examined how institutions have enabled the emergence of carbon markets, whilst also limiting the ability of different actors to respond effectively or efficiently to them.

Understanding the functioning of carbon markets in theory and in practice

Our research and engagement activities on the design and operation of carbon markets have built a unique bridge between academic theory and applied market practice. Using a range of techniques – from standard micro-economics to financial modelling and novel laboratory experiments – we have advanced understanding of the design of cap-and-trade schemes, including such issues as the application of price ceilings and floors, and how to link different schemes in operation around the world (e.g. national Emissions Trading Schemes with the Clean Development Mechanism). This work has also exploited its position between theory and practice to shed light on carbon-market dynamics; on what, for example, explains the short- and long-term behaviour of the allowance price in the European Union Emissions Trading Scheme (EU ETS). There has been strong interest in this work around the world. Our research on market design, for instance, was used as background material in a UK government review into global carbon markets, while we have advised policy-makers involved in the design of new Emissions Trading Schemes in Australia, China, Mexico and South Korea.

Bridging the gap between macro modelling and micro, case-based research

On methodology, one of CCCEP's distinctive aims was to bridge the gap between the model-based approaches prevailing in climate science and economics at the time of our inception, which were largely carried out at the macro scale and based on simulation (e.g. general circulation models of the climate and computable general equilibrium models of the economy), and the micro-scale, case-study approaches that are more prevalent in other social sciences. Concerns surrounded the validity of macro models and their relevance to specific contexts, at the same time as the generalisability of findings from case studies was questioned. In responding to this, our research on food security and 'vulnerability hotspots' developed and applied a research strategy, which combined global, regional, national and local levels of analysis, as well as top-down and bottom-up research efforts, thereby integrating socio-economic data, climatic/meteorological models and crop models. Similarly our work analysing the effects of existing mitigation policies like the UK Climate Change Levy and the EU ETS on the innovation, performance and competitiveness of firms has been distinctive in its use of business surveys and the matching of large datasets to provide a large-sample econometric analysis of the issue, more generalisable and less at risk of selection bias than case studies, yet more closely based on real data than simulation modelling.

Actively engaging with policy-makers and key decision-makers in business and beyond

Engagement of users and beneficiaries has been a central element of our work in Phase One. We have exerted high-level influence on the official international climate negotiations under the United Nations Framework Convention on Climate Change (UNFCCC), advising leaders on global emissions paths consistent with limiting the rise in global warming to 2°C and laying out the main points of an agreement on finance for developing countries. We have worked closely on a number of occasions with the World Bank (e.g. on climate finance), with the OECD (e.g. on the design of

mitigation policies and on the provision of low-carbon skills) and with other international organisations. We have been heavily engaged in UK climate policy across a range of central-government departments, agencies, in parliament and down to regional and local government, on critical issues such as the fourth statutory carbon budget, the first national Climate Change Risk Assessment, the development of onshore wind energy and the promotion of low-carbon cities. Our work has had an impact on policy-making in many other countries and we have also been engaged with private decision-makers, for example through our collaborative research programme with Munich Re, which through access to industry data and expertise has enabled novel research of strong interest to the insurance industry.

Building capacity, by bringing in leading disciplinary scholars, by training doctoral students and by innovating teaching from the undergraduate through postgraduate to executive levels

An explicit aim of Phase One has been to draw into the climate field some of the leading disciplinary scholars in the social sciences, with a view to building inter-disciplinary research capacity. We have reached out to, and supported research from, leading economists in related LSE departments and research centres such as the International Growth Centre and the Centre for Economic Performance, and we have drawn in scholars from other social sciences arguably under-represented in climate research, such as human-rights law, moral philosophy and the philosophy of science. We have trained over 50 PhD students to date, and at both LSE and Leeds we have developed new doctoral training programmes and new modules and courses from the first-year-undergraduate level, through Masters degrees, to executive education.

The changing context for climate policy and looking forward to Phase Two

The context for climate policy has changed substantially since the launch of CCCEP. An over-arching global agreement on climate change has remained elusive, controversies around climate science have cast a shadow on the credibility of research and the financial crisis and economic downturn have altered political priorities and economic possibilities. We have taken these changes into account in our research programme wherever possible and we have used leveraged funding and the responsive resources at our disposal to respond. Our plans for Phase Two seek to engage directly and more comprehensively with these significant developments and are set out in the second part of this Case for Support.

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2. Achievements of the Scientific Programme

Table 1 summarises our scientific programme on ESRC funds in Phase One. It has been complemented by leveraged funds, including a fifth CCCEP programme on the economics of climate change for the insurance industry, funded by the reinsurance company Munich Re. In this section we provide more details of the achievements of our scientific programme, including a brief mention of work carried out using a combination of responsive resources from ESRC core funding and leveraged funds. Inevitably, however, we must remain selective throughout.

Table 1. Schedule of programmes and projects in CCCEP Phase One.

Research programme	Year 1	2	3	4	5
1. Developing climate science and economics	1a. Improving the use of evidence from climate models		1b. Risk, uncertainty and the economic evaluation of climate-change policies		
	1c. "Closing the loop": Interpreting user needs and facilitating co-evolution through participatory appraisal				
2. Climate-change governance for a new global deal	2a. Politics, institutions and international cooperation on climate change		2b. Effective climate-change governance without the state		
	2c. Human rights and climate change		2d. Equitable mitigation and adaptation		
3. Adaptation to climate change and human development	3a. Vulnerability hotspots: linking food security and climate change			3c. Linking adaptation and development	
	3b. Understanding and estimating the impacts of climate change on human development: India			3d. Adaptation in the water sector	
4. Governments, markets and climate-change mitigation	4a. Climate-change policies: innovation, performance and competitiveness			4b. Innovation-friendly climate policies and systems change	
	4c. Enabling carbon markets: carbon accounting, benchmarking and disclosure				
	4d. Enabling carbon markets: efficient carbon trading systems and finance				

Programme 1. Developing climate science and economics

Programme 1 has been motivated by the rise of climate models in both science and economics. Quantitative climate predictions have come to underpin calls to mitigate climate change, as well as forming the basis of adaptation planning. Climate scientists have developed probabilistic forecasts, and this has started to change the way economists frame climate policy, from an investment problem turning on the discount rate to an insurance problem depending on risk and uncertainty. Yet fundamental questions remain about the evidence from climate models, in particular whether the probabilities they yield are robust and, if not, how to make decisions in the face of uncertainty. Thus we aimed to *improve understanding of the uncertainties in climate models and advance the state of the art in climate economics, in turn helping decision-makers better manage climate risks and uncertainties*.

Project 1a 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 the core focus of Project 1a 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.

Research in Project 1b on *Risk, uncertainty and the economic evaluation of climate-change policies* 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).

Research in Project 1c 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).

Selected key publications from Programme 1

Barrieu, P. and B. Sinclair-Desgagné, 2010. "Economic policy when models disagree". *CCCEP Working Paper 5*.

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.

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.

Lopez, A., L.A. Smith and E. Suckling, 2011. "Pattern scaled climate change scenarios: are these useful for adaptation?" *CCCEP Working Paper 80*.

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*.

Oreskes, N., D.A. Stainforth, and L.A. Smith, 2010. "Adaptation to global warming: do climate models tell us what we need to know?" *Philosophy of Science*, **77(5)**, 1012-1028.

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.

Ranger, N. and F. Niehoerster, in press. "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.

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.

Programme 2. Climate-change governance for a new global deal

Programme 2 has sought to shed light on the slow progress in international climate negotiations, despite broad scientific agreement on the causes and impacts of climate change and on the benefits of early emissions reductions. The research considered that the greatest challenges in the international negotiations on the issue are the negotiation system itself, the wider political and institutional context within which the system is embedded, and the equity implications of governing climate change. For these reasons it has *examined the international setting for climate negotiations, alternatives to state-based governance of climate change, and the human-rights and social-justice aspects of governing mitigation and adaptation.*

Working primarily from international relations/studies, Project 2a 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).

Project 2b, *Effective climate-change governance without the state*, has examined the origins of non-state forms of climate governance and their influence on corporate actors. The research examines the ways in which non-state governance interventions emerge and combine to create wider governance frameworks, and the ways in which these frameworks co-exist with and influence wider governance regimes. The project undertook comprehensive empirical research on the governance factors that shape the behaviour of many large corporations from a bottom-up perspective, first seeking to understand the evolution of their carbon strategies and performance, and then seeking to understand the influence of various governance forms (e.g. government policy, investor pressures, customer and community expectations, and media coverage). The research highlights how external governance pressures have to align with internal governance conditions in companies for significant change to take place. The research then suggests several scenarios for the evolution of non-state governance. The scenario likely to lead to the most significant changes is based on strong and well-aligned external governance pressures, together with strong and receptive internal governance conditions, based particularly on the presence of a business case for change that is stimulated by high or volatile energy prices and the continued availability of low-carbon options. If any of these conditions are absent, then we suggest that there will be a shift from a relatively consensual governance regime that leads to steady progress, to a more fractured or contested governance regime that could engender more resistance than change. 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.

Project 2c, *Human rights and climate change*, 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.

Project 2d has examined 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).

Selected key publications from Programme 2

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.

Falkner, R. and B. Lee (eds.) 2012. "Rio+20 and the global environment: reflections on theory and practice", *International Affairs*, **88**(3).

Falkner, R., H. Stephan and J. Vogler, 2010. "International climate policy after Copenhagen: towards a 'building blocks' approach". *Global Policy*, **1**, 252-262.

Gouldson, A., 2008. "Understanding business decision-making on the environment". *Energy Policy*, **36**, 4618–4620.

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.

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.

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*.

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.

Vogler, J., 2010. "The institutionalisation of trust in the international climate regime". *Energy Policy*, **38**, 2681-87.

Sullivan R. and A. Gouldson, 2012. "Does voluntary carbon reporting meet investors' needs?" *Journal of Cleaner Production*, **36**, 60-72.

Programme 3. Adaptation to climate change and human development

Adaptation has arguably been under-emphasised in climate research, compared with mitigation. There is an extensive literature on the physical and natural impacts of climate change, but important knowledge gaps remain about people's ability to adapt to these impacts, the links between adaptation and development, and what constitutes 'good' adaptation from a normative point of view. Programme 3 has sought to contribute to plugging all of these gaps, with a particular focus on the links between climate change and adaptation in developing countries. *Research has investigated the potential for climate-friendly forms of development, and development-friendly forms of adaptation to climate change*.

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 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).

Research in Project 3b on *Understanding and estimating the impacts of climate change on human development in India* has in particular examined heat-related mortality in rural and urban areas. Using robust econometric techniques, the research 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.

Project 3c 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.

Adaptation practitioners often equate the lack of adaptive capacity with ‘poor institutions’, without investigating what the institutional deficiencies are and what kinds of institutions would foster adaptation. Project 3d on *Adaptation in the water sector* 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.

Selected key publications from Programme 3

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.

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.

Bowen A., S. Cochrane and S. Fankhauser, 2011. "Climate change, adaptation and growth". *Climatic Change*, **113(2)**, 95-106.

Burgess R.O., O. Deschenes, D. Donaldson and M. Greenstone, 2012. "Weather and death in India: mechanisms and implications of climate change". *Mimeo.*

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.

Simelton E., E.D.G. Fraser, M. Termansen, T.G. Benton, S.N. Gosling, A. South, N.W. Arnell, A.J. Challinor, A.J. Dougill and P.M. Forster, 2012. "The socioeconomics of food crop production and climate change vulnerability: a global scale quantitative analysis of how grain crops are sensitive to drought". *Food Security*, **4**, 163-179.

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.

Programme 4. Governments, markets and the mitigation of climate change

This programme focuses on mitigation and the transition to a low-carbon economy. *It analyses variations in the carbon intensity of supply and demand, identifying those areas of the economy that are most and least able to innovate in response to climate policies. It examines strategies that foster innovation in the transition to a low-carbon economy and it supports the further development of efficient policy instruments for mitigation, especially carbon markets.*

Research in Project 4a 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).

In Project 4b we examine 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.

Research on Project 4c 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.

Research on Project 4d 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.

Selected key publications from Programme 4

Calel, R. and A. Dechezleprêtre, 2012. “Environmental policy and directed technological change: evidence from the European carbon market”. *CCCEP Working Paper 87.*

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*.

C.J. Hepburn, C.J. and S. Fankhauser, 2010. “The design of carbon markets part II: carbon markets in space”. *Energy Policy*, **38(8)**, 4381-4387.

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.

Gouldson, A., P. Newell, and I. Bailey, 2011. “Ecological modernisation and the governance of carbon: a critical analysis”. *Antipode*, **43(3)**, 682-703.

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, forthcoming. “Emissions trading with profit-neutral permit allocations', with Quah and Ritz”, *Journal of Public Economics*.

Jagger, N., T. Foxon, and A. Gouldson, in press. “Skills constraints and the transition to a low-carbon economy”. *Climate Policy*.

Martin, R., L.B. de Preux and U.J. Wagner, 2011. “The impacts of the Climate Change Levy on manufacturing: evidence from microdata.” *NBER Working Paper 17446*.

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.

Other research with responsive resources and leveraged funds

In this section we report some of the most important research conducted under the auspices of CCCEP using responsive resources and/or leveraged funds. These funds have proved especially useful in responding to advances in climate research and to the changing context for climate policy post 2008, as described above.

The economics of low-carbon cities

Our work on this topic, led by Andy Gouldson using his CCCEP-funded time as well as leveraged support from the Department of Energy and Climate Change (DECC) and the Centre for Low Carbon Futures, has examined whether the broad economic logic for action on climate change, as set out in the Stern Review, could be downscaled and applied at the local and especially city scale. The research has developed a new bottom-up methodology to examine the performance of thousands of low-carbon options and the scope for their deployment at the local level in the domestic, commercial, industrial and transport sectors. This work complements – and is informing the development of – top-down models and assessments, again reflecting our interest in multi-level approaches that ‘close the loop’ between models and outcomes. It has highlighted the potential for both cost-effective and cost-neutral decarbonisation in cities, and the employment-creating potential of such measures. In many ways then, it has established the practical potential for green (or at least low carbon) growth at the city scale.

One of the main academic achievements of the research has been to highlight – in a robust and empirically well-informed way – the potential for, and the limits of, decarbonisation through the wider deployment of existing technological and behavioural measures. In broad terms, it suggests that cities in the UK could achieve around a 40% cut in their carbon emissions through cost-effective interventions, and a slightly higher (i.e. up to 45%) cut through cost-neutral interventions. To achieve such change, the research has highlighted the importance of the institutional conditions shaping the flow of public- and private-sector finance into the decarbonisation of cities, and the need for a systems-based approach to the development of the new business models that could unlock investments and secure maximum carbon savings from these investments. More fundamentally, the work has revealed that deeper decarbonisation is likely to require structural changes in the way we design, run, live, work and consume in cities. The measures that could lead us to, say, 40-50% decarbonisation are unlikely to be the measures that will be needed to reach 80% decarbonisation.

Green growth

Green growth – including low-carbon, climate-resilient growth – is one of the most important agendas to emerge since CCCEP started work in late 2008. In many respects, a ‘traditional’ focus on mitigating and adapting to climate change provides insights into what might constitute climate-compatible growth and how it can be promoted. Therefore it has been readily possible to demonstrate the relevance to it of our core scientific and engagement programme. Yet the green-growth debate has arguably thrown the spotlight on to new issues too, especially the links between short-term macroeconomic problems of debt, unemployment and recession on the one hand and climate change on the other.

Using leveraged core funds from GRI and SRI, together with a small grant from ESRC and The Scottish Environmental Protection Agency, we evaluated the impacts of recession on greenhouse gas emissions and the trend towards a low-carbon economy, as well as outlining the case for a 'green stimulus', i.e. short-term measures to boost growth and employment that would also promote climate mitigation and adaptation. This led to a Policy Brief on the topic in 2009 ("*An outline of the case for a 'Green Stimulus'*" (Bowen, Fankhauser et al.)), which had a timely impact on the UK policy discussion before a critical government budget, as well as a report for the G20, a further Policy Brief in 2012 (Zenghelis) on restoring confidence and economic growth through green investment and innovation, and invitations to present the work all over the world, including for the OECD in Seoul, and in Copenhagen.

Over time our initial work on the green stimulus has begun to develop into a more sustained programme on green growth and climate-compatible development, which we plan to take forward in CCCEP Phase Two (see below). Already, we have played a role in providing a rigorous academic frame to the policy debate, with a guest editorial in *Global Environmental Change*, two research papers on the links between adaptation and growth in developing countries, a paper on China's growth for *World Economics*, and a working paper for the World Bank on green jobs. This work has also been presented widely, including at UK central-government departments (DfID, DECC and the Department for Environment, Food and Rural Affairs or DEFRA), an OECD conference in Berlin, the 2012 annual conference of the European Association of Environmental and Resource Economists, and a G20 seminar for Ministers' Deputies in Mexico.

Climate finance and investment

Related to our work on green growth has been an emerging focus on climate finance and investment at multiple levels. This has not only responded to the need for such work, created at the global level by the UN climate process and at regional, national and local levels by the investment needs of climate objectives, it has also shaped such processes. This is especially evident in our role supporting a global agreement on financing climate action in developing countries. We provided an early platform for discussions on the topic in 2009, leading to a collaborative report with public- and private-sector practitioners on "*Meeting the Climate Challenge: Using Public Funds to Leverage Private Investment in Developing Countries*". We went on, through Nick Stern's work, to lay out what eventually became the main points of an international agreement on funding for developing countries, written into the Copenhagen Accord. The background work for this is contained within a number of CCCEP Policy Papers. We also contributed a chapter on climate finance to the 2010 *World Development Report* by the World Bank.

Separately, a collaboration with the investment consultants Mercer resulted in a major new study in 2011 on the implications of climate change for the strategic asset allocation of institutional investors. The project involved more than a dozen pension and wealth funds, as well as the IFC, the Carbon Trust and the economics consultancy Vivid Economics. The report, which is one of the first of its kind in looking at the impacts of climate change for investment at the total-portfolio level, comes to the striking conclusion that the best way to hedge against climate risk, including the risks to investing in dirty assets if policy changes, is to invest more heavily in low-carbon and climate-sensitive assets. It has received significant attention in the financial-industry press. *Responsible Investor*, for example, described it as "the equivalent of a Stern review of investment at a portfolio level. Its analysis is thorough and creative, its findings startling and its conclusions uncompromising."

As detailed below under Knowledge Exchange, CCCEP researchers have also made a key advisory contribution to the design and establishment of the UK's pioneering Green Investment Bank and Nick Stern has been appointed to its advisory group.

The Munich Re Programme: Evaluating the economics of climate risks and opportunities in the insurance sector

The Munich Re programme within CCCEP has supported a wide range of research on understanding and forecasting climate risks, especially to the insurance industry, and on what role insurance can play, as a means of risk sharing, in promoting adaptation. Some of this work has strong synergies with our core scientific programme (Munich Re and ESRC have been equal partners in resourcing it); hence it is folded into our outline of scientific achievements above. Here we limit ourselves to additional, complementary parts of the programme.

Prominent among these is our work on understanding the effects of climate change and other long-term trends on losses from extreme weather events and other natural disasters. Thanks to our exclusive access to Munich Re's *Nat-CatService* database, we have been able to apply advanced quantitative techniques, including a new way to normalise loss trends for changes in wealth, and quantile regression. We provide some of the very first results suggesting climate change might have contributed to rising disaster losses, as well as offering conclusions on the best ways to minimise disaster risks in future.

Another project has looked at the impacts of climate change and climate policy on the insurance and financial sectors in emerging economies. This research has to date yielded a pair of working papers attempting to forecast the impact of climate change on insurance demand in the BRICS region, both of which are in preparation for journals (Ranger and Surminski 2011; Ranger and Williamson 2011). These papers are distinctive in adapting forecasting methodologies in use in the industry to take climate change and associated regulation into account; our collaboration with the Economics Research Team at Munich Re has been essential in doing so. It has also yielded a highly novel *Database of Disaster Risk Transfer Initiatives in Developing Countries*, populated in collaboration with the industry and now containing over 100 examples. The database has been developed with the aim of reviewing the status of risk-transfer tools in developing countries. What roles do the private and public sectors play in current initiatives? How have current initiatives been designed to support disaster risk reduction and climate-change adaptation? It is by far the most comprehensive and detailed record of insurance initiatives in developing countries available in the public domain. More details are provided below in our section on Knowledge Exchange, since this work has been the basis of sustained engagement with the UNFCCC SBI work programme on loss and damage and more broadly with the industry.

Selected key publications from responsive research and leveraged funds

Barthel, F. and E. Neumayer, 2011. "Normalizing economic loss from natural disasters: a global analysis". *Global Environmental Change*, **21(1)**, 13-24.

Barthel, F. and E. Neumayer, 2012. "A trend analysis of normalized insured damage from natural disasters". *Climatic Change*, **113(2)**, 215-237.

Bowen, A. and S. Fankhauser, 2011. "The green growth narrative: paradigm shift or just spin?" *Global Environmental Change*, **21(4)**, 1157-1159.

Bowen, A. and N. Stern, 2010. "Environmental policy and the economic downturn". *Oxford Review of Economic Policy*, **26(2)**, 137-163.

Gouldson, A., N. Kerr, C. Topi, E. Dawkins, J. Kuylenstierna and R. Pearce, 2012. "The economics of low carbon cities: approaches to a city-scale mini-Stern Review." In R. Simpson and M. Zimmerman (eds.), *The Economy of Green Cities: A World Compendium on the Green Urban Economy*. Springer.

Gouldson, A., N. Kerr, C. Topi, E. Dawkins, J. Kuylenstierna, R. Sullivan and P. Webber, forthcoming. "The economics and financing of low carbon cities". *Building Research and Information*.

Guyatt, D., et al., 2011. *Climate Change Scenarios: Implications for Strategic Asset Allocation*. London: Mercer.

Ranger, N. and S. Surminski, 2011. "A preliminary assessment of the impact of climate change on non-life insurance demand in the BRICS economies". *CCCEP Working Paper 72*.

Stern, N., 2009. "Action and ambition for a global deal in Copenhagen". *CCCEP Policy Paper*.

Stern, N., 2011. "Raising consumption, maintaining growth and reducing emissions: the objectives and challenges of China's radical change in strategy and its implications for the world economy". *World Economics*, **12(4)**, 13-34.

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3. Knowledge Exchange and the Social and Economic Impact of CCCEP

Introduction

CCCEP was created to conduct innovative, rigorous research that would be based on active engagement with stakeholders throughout the research process, in order to secure its relevance and to give it the best possible chance of contributing to the advancement of climate policy and climate decision-making at different levels.

We believe that we have fulfilled these objectives in many areas. A wide range of perspectives from the public, private and voluntary sectors has been represented on our Steering Committee to guide our activities. Moreover, across the range of CCCEP programmes and projects, we have actively engaged in the co-production of knowledge and in the generation of research of real-world relevance. Our research is disseminated in multiple ways, yet in a coherent and targeted manner through our engagement strategy.

As a result, we feel that our research satisfies all of the necessary conditions for a significant impact on policy and decision-making, although clearly other factors generally outside our control determine whether these necessary conditions are also sufficient for impacts to be secured. Table 2 summarises the range of user groups with which we have actively engaged in Phase One – further details on the specific nature and influence of many of these engagements are given below. Details of our engagement strategy, of the media coverage arising from CCCEP Phase One and of our website usage are given elsewhere in this submission.

Whilst we recognise that impact is not always well captured by measuring outputs – an observation that has guided and will continue to guide our engagement strategy – in addition to our academic publications, we have published 40 policy/industry briefs and papers (each supported with a range of engagement activities), organised/participated in 16 'side-events' at major UN conferences on climate change and the environment, and launched three reports in the UK Parliament. We have 14 authors and expert reviewers contributing to the development of the 5th Assessment Report of the IPCC and we have given evidence to UK Parliamentary Select Committees (i.e. principally the Energy and Climate Change Committee and the Environmental Audit Committee) and government inquiries on at least 12 occasions. We have also contributed/featured in 23,553 articles in national and international newspapers and other media outlets.

We have explored a number of other important pathways to impact. For example, CCCEP members sit on key committees and act as expert advisors to organisations including the UN High Level Advisory Group on Climate Change Finance (Stern), the World Bank and Asian Development Bank (Bowen), the China Centre for International Cooperation on Environment and Development (Gouldson), the European Environment Agency (Paavola), the UK Committee on Climate Change and its Sub-Committee on Adaptation (Fankhauser), and the DECC and DEFRA Expert Advisory Panels on the Social Sciences (Gouldson) and Economics (Atkinson and Hepburn). We have a funded programme from Munich Re, while we are involved in strategic alliances with organisations such as the Global Green Growth Institute (GGGI) and the Met Office.

Table 2. Summary of CCCEP's external engagements in Phase One

Area/level of engagement		Examples
Government and the public sector	International	UNEP, UNFCCC, UNCCD, UNHCR, World Bank, EBRD, ADB, EIB, FAO, IPCC, OECD, World Economic Forum, G20, Commonwealth Secretariat…
	European	Council of Europe, European Commission, European Parliament, European Environment Agency…
	National (UK)	FCO, Treasury, Prime Minister's Office, DECC, DEFRA, DFID, BIS, DCLG, All Party Parliamentary Group on Climate Change, Committee on Climate Change, Welsh Assembly, Scottish Executive, Scottish Environmental Protection Agency, Environment Agency for England and Wales, the Met Office…
	National (others)	Governments of Australia, Botswana, Brazil, China, Democratic Republic of Congo, France, Germany, Hong Kong SAR, India, Kenya, Malawi, Mexico, Mozambique, Namibia, Netherlands, New Zealand, Norway, South Africa, South Korea, USA, Zambia, Zimbabwe…
	Sub-national	Local government in Bihar, West Bengal, Lima, North Jutland, Aalborg, Helsinki, Leeds City Region, Sheffield City Region, Hull and Humber City Region and other local authorities and city councils in the UK...
NGOs and civil society	International	Association of Small Island States, World Agro-Forestry Council, Asian Development Research Institute, Global Green Growth Institute, International Council for Local Environmental Initiatives, Christian Aid, Climate Strategies, The Climate Policy Initiative, ClimateWise, Globe International, Royal Institute for International Affairs, Stockholm Environment Institute, the Prince of Wales' International Sustainability Unit…
	European	Atomium Culture, European Climate Change Foundation, Sandbag…
	National (UK)	Friends of the Earth England and Wales, Business in the Community, Prince's Mayday Network, Carbon Disclosure Project, Energy Savings Trust, Climate and Development Knowledge Network, Oxfam…
	National (others)	China Beijing Environment Exchange, China Centre for International Cooperation on Environment and Development, WWF Hong Kong, US Environmental Defense Fund, The Swedish Foundation for Strategic Environmental Research (MISTRA), Finnish Environment Institute (SYKE), Pakistan Institute for Development Economics, Korean Green Technologies Centre, Korean Energy Economics Institute, Germanwatch…
	Sub-national	IPPR North, Business in the Community Yorkshire and Humber, Café Economique…
Business	Businesses	Arup, Asda, Bloomberg, Climate Bridge, Cooperative Group, CO2 Sense, Deloitte, EDF, EoN, IDEACarbon, John Lewis Partnership, Lloyds of London, Marks and Spencer, Marksman Consulting, McKinsey, Mercer, Morrisons, Munich Re, RMS, Sainsbury's, Shell, Skanska plc, Tesco, Vivid Economics, Willis Re...
	Business Associations	Association of British Insurers, Carbon Market & Investor Association, Confederation of British Industry, European Association of Mutual Insurers, German Insurance Association GDV, International Emissions Trading Association, Munich Climate Insurance Initiative.

Much CCCEP research is applied in its nature and has sought to generate impact in different forms. Rather than presenting details of all of our engagements and impacts, we will present here highlights from a smaller number of projects.

Highlights

Engagements with the United Nations and other international organisations

CCCEP Phase One sought to conduct research on, and provide evidence to support, a new global deal on climate change. In support of this goal, we have played a very active role in the work of the UNFCCC, including contributing to three of the Conferences of the Parties (COPs) to the UNFCCC that have taken place since we were established in the Autumn of 2008. We have also engaged with other relevant UN environmental agreements and conferences, including the recent 'Rio+20' UN

Conference on Sustainable Development, as well as several of the major international institutions, including the World Bank and OECD.

In the lead-up to the UNFCCC COP in Copenhagen in 2009, members of CCCEP provided information and advice to ministers and negotiating parties in the UK and beyond. Nick Stern, supported by a collaborative effort between CCCEP researchers and colleagues in the UK Government (i.e. in the Met Office and DECC), laid out the options for paths of global annual emissions that would have a reasonable chance of avoiding a rise in global mean temperature of more than 2˚C (see the CCCEP Policy Brief by Bowen and Ranger 2009). Stern was also responsible for laying out the main points of an agreement on climate finance for developing countries, and the paper produced to accompany his speech at LSE on 1st December 2009 contained many of the elements of an international agreement on the issue, which were subsequently reflected in the Copenhagen Accord. He subsequently joined the High Level Advisory Group on Climate Change Finance, which was launched by the UN Secretary General in February 2010.

For the next COP in Cancun in 2010, Stern acted as an adviser to a number of world leaders, including then French President Sarkozy and the late Ethiopian Prime Minister Meles Zenawi. He was also a member of EU Commission President Barroso's advisory group on energy and climate change. With support from Centre staff, two key policy papers were published by Nick Stern on China's carbon-reduction opportunities (Stern 2010a; Stern 2010b). Other staff also made independent contributions to the Cancun process, for example as part of an expert review group for UNEP (Bowen and Ranger), or through a roundtable that we organised at the Agriculture and Rural Development Day, focusing on climate finance for agriculture (Quinn and Stringer).

At the 2011 COP in Durban, CCCEP ran an official side-event with the International Council for Local Environmental Initiatives on the economics of low-carbon cities (Gouldson). This led to our work being voted one of the most transformative ideas presented at the COP. We also ran an unofficial side-event with the International Emissions Trading Association on the economics of low-carbon development. A joint study on climate-change legislation with Globe International, the international legislators' organisation, was launched with the UNFCCC Executive Secretary, Christiana Figueres, the World Bank Special Envoy for Climate Change, as well as government ministers from the UK, Indonesia and China. CCCEP's Swenja Surminski launched findings from the research project "Building effective and sustainable risk transfer initiatives in low- and middle-income economies" at an UNEPFI side-event. Nicholas Stern was again active in the run-up to the Durban COP and at Durban itself. For example, he advised Todd Stern, the Special Envoy for Climate Change at the US State Department, on prospects for global emissions in 2020 and 2030 in developed and developing countries.

Beyond the COPs, we have made several other contributions to the UNFCCC. We have collaborated with its work programme on Loss and Damage by writing a technical report on methodologies for loss and damage assessment (Surminski and Lopez), as well as giving an invited expert presentation to the UNFCCC's Loss and Damage work meeting in Tokyo in March of this year (Surminski). In 2011, CCCEP submitted a consultation response to UNFCCC on "Open Questions about How to Address 'Loss and Damage' from Climate Change in the Most Vulnerable Countries: a response to the Cancún Adaptation Framework" (Ranger, Surminski), which was published as a CCCEP Policy Paper.

Outside the UNFCCC as a whole, we have contributed to the sustainability agenda through the Rio+20 conference, where we ran a side-event with the OECD and the Stockholm Environment Institute on the economics and financing of low-carbon cities (Gouldson). We participated in the Nagoya COP of the Convention on Biological Diversity and helped forge the Legislators' Protocol on Natural Capital (Fankhauser). We support the UN Convention to Combat Desertification through Lindsay Stringer's role as an expert advisor to the Secretariat, and in the field of human rights Chaloka Beyani serves as Special Rapporteur to the UN on the Human Rights of Internally Displaced Persons. CCCEP's work on risk transfer in developing countries, mentioned just above in

relation to the UNFCCC Loss and Damage work programme, is also contributing to UNISDR's efforts to improve responses to extreme events. Surminski presented at a UNISDR workshop on loss accounting and contributed to UNISDR's *Global Assessment Report* work.

We have worked closely with the World Bank, the OECD and regional development banks on a number of projects, including the 2010 *World Development Report* (Fankhauser), the World Bank's *Green Growth Knowledge Platform* (Bowen), and major climate-change reports by the Asian Development Bank (Bowen), the European Bank for Reconstruction and Development (Fankhauser, Bowen) and the European Investment Bank (Fankhauser). We also participated in an OECD review of UK environmental policies (Bowen and Rydge) and various OECD expert meetings on adaptation and green growth (Bowen, Fankhauser and Surminski).

Engagements with the UK Government

As Table 2 shows, CCCEP has engaged with a wide range of UK government departments, agencies and committees.

In the Foreign and Commonwealth Office, we have organised events on climate change, green growth, low-carbon cities and low-carbon finance in Washington DC, Seoul and Hong Kong, and we have supported FCO-organised study tours and briefings for Chinese government officials.

In the DfID, we have formed the core of the newly created Environment and Climate Change Research Programme of the DfID-funded International Growth Centre, which is headquartered at LSE (Burgess). We have also had an ESRC-supported internship in DfID (Tompkins), helping to develop policies for climate-compatible development. We have conducted research for the department on climate-change adaptation and growth (Bowen and Fankhauser) and, through its Climate and Development Knowledge Network, on climate-compatible development in southern Africa (Dougill, Stringer). We have collaborated on a policy paper on incorporating climate uncertainty into planning and policy-making processes in developing countries (Ranger and Garbett-Shiels 2011); the collaboration was enabled by appointing a DfID advisor (Garbett-Shiels) as a Visiting Fellow of CCCEP.

We have engaged with the Treasury on the issue of a green recovery and green growth through seminars, briefing papers and informal contacts (Stern and Zenghelis) and have participated in the Treasury's regular pre-budget consultations (Bowen).

In DECC, we took part in an informal group to advise the department and the then Secretary of State Ed Miliband MP on the UK's post-Copenhagen climate strategy (Falkner). We fed evidence into the stakeholder process organised by DECC as it considered changes to the UK Climate Change Agreements (Martin) and as it considered underpinning the carbon price (Fankhauser and Hepburn). We conducted work on the economics of low-carbon cities for DECC through its local carbon frameworks pilot scheme (Gouldson), and provided background research for the Lazerowicz Review on global carbon trading (Fankhauser, Hepburn).

In DEFRA, we have taken part in an informal group advising the department as it explores the potential for better regulation and works through the 'red tape' challenge (Gouldson). We have been closely involved in reviewing and advising on the UK's first Climate Change Risk Assessment (Ranger, Smith and Surminski) and the subsequent study on the Economics of Climate Resilience (Surminski), both of which will form the basis of the forthcoming National Adaptation Programme. We also participated in DEFRA's Academic Panel on Environmental Economics (Atkinson and Hepburn) and on social sciences (Gouldson).

In the Department for Business, Innovation and Skills, we have supplied evidence to shape the Green Economy Roadmap (Gouldson), advised on the Green Investment Bank and participated in its academic panel (Fankhauser).

In the Department for Communities and Local Government, we have provided tools to be disseminated to local authorities through the 'environment tools' website, and we have given the Chief Scientist's Seminar on the economics and financing of low-carbon cities (Gouldson).

We have a close relationship with the Committee on Climate Change, where a CCCEP researcher serves as an inaugural member on both the main Committee and the Adaptation Sub-Committee (Fankhauser). The Committee's Chief Executive has also been appointed a CCCEP Senior Visiting Fellow. We have provided background research for the CCC's inaugural report (Dietz), its innovation report (Dechezleprêtre and Martin), and helped the Adaptation Sub-Committee devise its assessment methodology (Ranger et al. 2010). We also collaborated closely with the CCC in our work on low-carbon cities, where we informed its guidance to local authorities on carbon targets and carbon-reduction strategies (Gouldson).

Other engagements include with the Environment Agency on adaptation planning and more broadly on strategic environmental appraisal (Dietz and Ranger), and with the electricity regulator Ofgem on strategic appraisal of energy systems (Dietz).

Project Specific Engagements and Impacts

Project 1a. Improving the use of evidence from climate models (Ranger and Smith)

Our engagement work in this area has focused on the interpretation of climate-model output and its implications for policy. Research on the viability of, and pathways towards, a goal of no more than 2°C of global warming, which was co-produced with DECC and the Met Office, was a key input to the UK's negotiating position on 2020 and 2050 emissions targets at the Copenhagen COP to the UNFCCC in December 2009. Related research on a stricter 1.5°C goal for global warming, called for by some countries/negotiating blocs including the Association of Small Island States (AOSIS), further formed an important input to the negotiating position of parties to the COP discussions in Cancun in 2010. It revealed that the proposal to review the 1.5°C goal in 2015, outlined in the Copenhagen Accord, may be too late to allow the emissions cuts necessary to achieve the goal itself.

Our pathways to impact for this research formed of a number of key steps. Firstly, we held one-to-one meetings with policy stakeholders, including in DECC and AOSIS. Secondly, we produced two Policy Briefs (Bowen and Ranger 2009 and Ranger et al. 2010) and associated media communications, including a press release and a press launch event. We also presented the findings at numerous policy workshops, side-events and conferences, including a workshop organised by DECC and the FCO in Washington DC in September 2010 and a side-event at the UNFCCC meeting in Bonn in August 2010. We also made contributions to external policy-focused reports, for example the UNEP *Emissions Gap* report in December 2010.

Other engagement activities based on Project 1a include the input of CCCEP experts on climate modelling (Smith and Stainforth) to the UK Climate Impacts Programme 2009 and the subsequent Climate Change Risk Assessment, where we cautioned strongly against the *over*-interpretation of spatially detailed climate forecasts decades into the future, and our input to discussions on climate policy within the US federal government, where Smith held numerous meetings with congressmen, senators and agency officials with the help of responsive-mode background research by CCCEP staff including Du and Lopez. Of note is a showcase of our work on climate models and uncertainty through an exhibit at the Royal Society Summer Exhibition in July 2011 (Stainforth), which reached a very broad audience, attracting more than 13,000 visitors from public policy, business, schools and the general public.

Project 3a. Vulnerability hotspots: linking food security and climate change (Fraser et al.)

Our work in this area has had impacts at different levels. At the international level, our 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, and it informed the work of the World Agroforestry Centre on *How trees and people can co-adapt to climate change?* (van Noordwijk et al. 2011). It was presented at the Agriculture and Rural Development Day (ARDD) of the UNFCCC COP in Cancun, with CCCEP members convening and chairing a side-event on "Climate finance for agriculture" that has helped to guide the increasing emphasis on climate-smart agriculture as a route for triple-wins on (i) rural development, (ii) climate adaptation and (iii) mitigation. It has also been presented at the COP to the UNCCD, where it led to a formal decision to set up a working group to review the options for the provision of scientific advice focusing on desertification/land degradation and drought issues.

At the regional level, the research has led to the initiation of new regional partnerships that include Governments from seven Southern African Development Community (SADC) countries (Namibia, South Africa, Botswana, DRC, Zambia, Zimbabwe and Mozambique), as well as private–sector representatives. CCCEP researchers have given policy advice in both Malawi and Botswana that has fed into National Adaptation Plans.

At the local level, the research has provided a new process-based approach that is being disseminated by agricultural extension workers and that has fed back into the integration of scientific and local knowledge in monitoring and assessment processes nationally in Botswana.

Project 4d. Enabling carbon markets

Our work on carbon markets has been fruitfully coordinated by an LSE-wide "Carbon Market Group" that includes researchers, policy-makers and carbon-market practitioners. This has allowed us to remain close to decision-makers and influence developments both formally and informally. It has also allowed us to formulate research questions that are policy-relevant. Market practitioners were particularly interested in our research on market functioning and market dynamics. We have held several workshops, jointly with the Carbon Market and Investors Association, to facilitate the dialogue between market analysts (many of whom have a quantitative background) and CCCEP researchers.

Among UK policy-makers, our peer-reviewed research on market design was used as background material in a government review into global carbon markets (the Lazerowicz Review, named after the Brown Government's special representative on carbon markets at the time) and formed the basis of a submission to DECC during its consultation on a carbon-price underpin. The team was invited to present the research at a DECC seminar and it was communicated in informal contacts with officials. We also submitted evidence, based on the same research, to parliamentary select committees.

Internationally, a number of countries and regional governments are considering establishing carbon markets. Over the past couple of years they have shown a growing interest in learning from the European experience. CCCEP has engaged with decision-makers in many of these constituencies through informal seminars (e.g. study visits from Australian, Mexican and Chinese policy-makers), lecture tours (e.g. to China in the spring of 2010) and formal submissions to government inquiries (e.g. by the Australian Department for Climate Change and Energy Efficiency). We have also used our links to Globe International to directly reach parliamentarians engaged in drafting carbon-market legislation (e.g. in Korea and Mexico). For example, we contributed to a Globe policy paper on carbon markets that formed the basis of discussions between EU legislators and China's chief negotiator, Minister Xie Zhenhua, in October 2011.

The Munich Re Programme

The Munich Re Programme has been strongly focused on interaction and knowledge transfer between business, including of course the insurance industry, academia and the public sector.

Areas of particularly active engagement have included US hurricane risk (Ranger and Niehoerster), trends in insured and economic losses from natural catastrophes such as extreme weather events

(Neumayer and Ranger), uncertainty and pricing of insurance products (Barrieu, Dietz and Ranger), climate change and insurance demand (Ranger and Surminski), new product/market opportunities such as long-term insurance contracts (Ranger) and public-private partnerships in low- and lower-middle-income countries (Surminski), and the value of weather forecasts (Smith, Niehoerster, Lopez, Suckling and Jarman).

CCCEP researchers collaborated closely with the Economics Research Team at Munich Re to develop and apply an empirical framework for forecasting the impacts of climate change on the insurance sectors of the BRICS economies, based on insurers' own forecasting approaches (Ranger and Surminski). This was complemented by focused case-studies developed in close collaboration with the NGO Germanwatch, with EBRD, with BRIC businesses (Surminski and Williamson) and with stakeholders in the Indian agriculture and insurance sectors (Surminski and Fisher).

Another example is the project on "The Roles of the Public and Private Sectors in Building Effective and Sustainable Risk-Transfer Initiatives in Low- and Lower-Middle-Income Economies" (Surminski and Ranger). The aim has been to inform discussions between the insurance industry and public policy-makers on how climate finance can best leverage private-sector risk transfer. The project has been conducted in close collaboration with the wider insurance industry and the ClimateWise industry initiative, and with input from Munich Re, the Munich Climate Insurance Initiative and public-sector stakeholders (DfID and UNFCCC). The "Database of Disaster Risk Transfer Initiatives in Developing Countries", a key output of this project, was launched at a side-event at the Durban COP. Receiving significant media coverage, this tool has since been used by several stakeholders, including the World Bank, UNISDR, various NGOs and the insurance industry, in their efforts to gain a better understanding of the use of insurance for adaptation.

A final example is our work on quantification and interpretation of trends in economic and insured natural-catastrophe losses. We presented our findings to the business and policy communities at a specially arranged, high-profile symposium (Neumayer and Stern) that received significant levels of media coverage.

The Economics of Low Carbon Cities

CCCEP-supported research on the economics of low-carbon cities (Gouldson) was co-funded by DECC through the Local Carbon Framework Pilot Scheme and by the Centre for Low Carbon Futures. It was based on close collaborations with the Committee on Climate Change, and was conducted for the newly formed Leeds City Region Local Enterprise Partnership. In terms of pathways to impact, the research formed the basis of official side-events at the UNFCCC COP in Durban (where it was voted one of the most transformative ideas to be presented) and at the Rio+20 Earth Summit. It has also been presented in the US, Mexico, China, Hong Kong, India, Korea, Japan and around the EU. Within the UK, the research was launched in Parliament by the All Party Parliamentary Group on Climate Change. It has also been presented to DECC, DCLG, the CCC, the Welsh Assembly Government, the Scottish Government, to local authority chief executives and council leaders and officers on numerous occasions and to several large business audiences. It has been reported in the *Financial Times*, the *Guardian Online* (4 times), and on a range of occasions in the print and broadcast media in different cities.

At the local level, the research has provided the evidence base that directly underpins a new low-carbon strategy for the Leeds City Region, and it provides the model that underpins an application for £100m of retrofit funding for the City Region. It has also directly informed the development of a new economic strategy for Sheffield and a new low-carbon energy strategy for Calderdale Council. It also led to Gouldson being appointed as a non-executive director of a not-for-profit community interest company (CO2 Sense), which has set up an innovative rolling investment fund that has thus far invested £14m in a range of low-carbon projects. Formal evaluations of the impacts of the research in 10 case-study local authorities (funded by HEFCE) show that it has provided local authorities with a robust economic and financial evidence base that they are using to promote the low-carbon agenda, and that it has moved the climate-change agenda in local government beyond

its traditional territory in environment and sustainability into the mainstream of policy-making on employment, economic development, business, finance, energy and urban regeneration.

At the national level, the method developed by the research is being promoted by DECC, DCLG, the Local Government Group and the Energy Savings Trust as part of their 'Environment Tools' website, which makes key decision-making tools available to local government to support their environmental and low-carbon initiatives. It has also directly informed the strategic guidance on low-carbon transitions issued to local authorities by the Committee on Climate Change. The research is now being replicated internationally, and it is also directly informing a programme funded by the China Council for International Cooperation on Environment Development (which reports to the next Chinese Premier) that is assessing the routes through which the environmental impacts of rapid urbanisation and industrialisation in western China can be reduced.

4. Key Performance Indicators: summary

Output	Number achieved
Books and Edited Books	11
Book Chapters	65
Journal Articles (submitted and accepted)	341
Policy Briefs and Papers	33
Working Papers/Technical Papers/Mimeos/Reports	135
Public Lectures Hosted	45
Seminars Hosted	78
Workshops, Symposia, Policy Roundtables Hosted	17
Media Articles mentioning CCCEP	23,553
Funding Applications made	72
PhD Students	56
Visiting Fellows and Visitors	53
Website visits (average monthly visits to website/average monthly unique visitors)	2200/1800

5. Capacity building, training and development activities

In service of our thematic objectives in Phase One to advance climate-change policy and increase the capacity of decision-makers to respond to climate change, we identified three capacity-building objectives. First, we aimed to improve the capacity of stakeholders to make better decisions on climate change. Second, we aimed to bring in the expertise of researchers and social-scientific disciplines yet to make a significant contribution to climate research. Third, we aimed to provide research training and career-development opportunities for Masters and PhD students, post-doctoral fellows and young researchers. As we explain here, we believe we have been effective in meeting these objectives.

More broadly, we have sought to contribute to the growth and strengthening of the UK research community on climate change and to build inter-disciplinary research capacities within the community, focusing particularly on the links between physical and natural science, economics and the social sciences. It is quite clear that UK climate research has advanced in recent years and there are many candidate explanations for this. Nevertheless, we would claim that we have been influential in building the capacity of this community in a number of key areas.

Improving the capacity of stakeholders to understand how physical and economic models of climate change can support decisions

Our scientific programme and engagement activities have made a strong contribution to improving the capacity of stakeholders to understand how physical and economic models of climate change can support decisions. Programme One has played a central role in this, given its explicit focus on an improved understanding of the predictive skill of climate models and how they should consequently be used in decision-making: on 'closing the loop' between modellers and model users. Examples from this programme include our work on modelling vulnerability to climate change in African dry-land communities, and our Policy Brief to the UK Committee on Climate Change, and associated work with other government departments and agencies including DEFRA, on *Adaptation in the UK: a Decision-Making Process* (Ranger, Millner et al. 2010). There has been strong interest from many quarters in expanding the scope of our work in this area, resulting in, for example, recent visits to the US Congress and a collaborative Policy Paper with DfID on using climate models to help developing countries adapt to climate change. However, Programme One is not the only area of research that has contributed to our objective of better use of physical/economic models in decision support. Our impactful work on 'vulnerability hotspots' draws on insights about the reliability and validity of model-based climate forecasts, while our work on 'enabling carbon markets' has achieved a parallel closing of the loop between, on the one hand, economists and financial researchers seeking to understand and model the functioning of carbon markets and, on the other hand, practitioners in the market. More details on all of this are given above.

Building research capacity by bringing in fresh perspectives and leading disciplinary scholars

Our scientific programme in Phase One was designed to import fresh perspectives from researchers and social-scientific disciplines that had not yet made a significant contribution to climate research. For this reason, our team included *inter alia* recognised experts in the philosophy of science, moral philosophy, human-rights law and statistics/finance. Even in disciplines that were already reasonably well represented in climate research, we sought to build capacity by reaching out to leading researchers who had yet to apply their skills to the area. Examples include Robin Burgess' econometric work on the impacts of weather on mortality in India and Ralf Martin's econometric analysis of the impacts of climate-mitigation policies on business performance, drawing on established techniques and datasets developed within LSE's Centre for Economic Performance.

We have been active participants in the community of climate researchers by publishing extensively in the leading journals in the field such as the *Journal of Environmental Economics and Management*, *Ecological Economics*, *Energy Policy*, *Global Environmental Change*, *Climatic Change* and the *Journal of Climate*. LSE now hosts one of the largest groups environmental economists anywhere in the world and Leeds is similarly now home to one of the largest groups of ecological economists working on climate change.

We have strengthened the capacity for, and the quality of, inter-disciplinary research on climate change by bringing together in our scientific programme expertise from a range of disciplines. We hope this will have a viral effect, with involved individuals taking insights from our inter-disciplinary work back into their disciplinary communities. While it remains challenging to publish applied research in general-interest disciplinary journals, we have begun to be able to do so. Over the past few years, our research articles have appeared in for example *International Affairs,* the *Journal of Public Economics*, *Philosophical Transactions of the Royal Society A*, *Physics Letters A*, and the *Review of International Studies*. At the same time, it has sometimes proved hard to prevent members from returning back to their disciplinary communities to address issues other than climate change. At times, the academic incentive system does not reward inter-disciplinary work enough. We also recognise that we could exploit the synergies between programmes and projects better – for example between adaptation and mitigation. This has led to our decision to investigate cross-cutting research themes in our Phase-Two scientific programme as a way to foster inter-disciplinary work (see below).

Training students and innovating teaching products from the undergraduate to doctoral and executive levels

More conventional capacity building has taken place through our teaching and research training. Although Leeds and LSE ran related Masters and PhD programmes prior to the inception of CCCEP in 2008, both have since expanded their offerings substantially, adding specialist pathways on climate change that are directly linked to CCCEP. Leeds started its MSc Sustainability (Climate Change) in 2008; the programme now admits 10-15 students each year and has to date hosted 50 students in total. CCCEP members contribute "Climate Change: Physical Science", "Climate Change Mitigation" and "Climate Change: Impacts and Adaptation" modules to this programme. The three modules are also popular among students following other MSc and MRes programmes at Leeds; indeed they typically make up the majority of students on the modules. LSE opened a new MSc in Environmental Economics and Climate Change in 2011, with an initial intake of 24 students expected to grow substantially in the coming years. CCCEP members contribute a module called "Climate Change: Science, Economics and Policy" to the programme, which is also open to students on other MSc programmes, who again make up the majority of the intake. CCCEP members at LSE also contribute lectures and seminars to other Masters modules and programmes, including the MSc in Management and Regulation of Risk. They contribute a module on 'Managing Climate Change' to 'LSE100', an ambitious course mandatory for all c. 1300 first-year undergraduates at the School. Finally, CCCEP members at LSE have been running an Executive Summer School on 'Climate Change Economics and Governance' for the past three years, during which we have taught about 50 professionals from organisations as diverse as UNDP, Whole Foods Market and the Japan Bank for International Cooperation.

CCCEP Phase One provided funding for seven PhD studentships, using both ESRC funds and the in-kind contributions of the two universities. However, a wide interest in CCCEP's research programme has allowed SRI and GRI to admit an additional 50 research students working on climate-related topics. All of these doctoral students are associates of CCCEP and represent a substantial contribution to our capacity building. During CCCEP Phase One, Leeds (as part of the White Rose Group) and LSE have also been awarded ESRC Doctoral Training Centre (DTC) status, with environment and climate change forming key themes in each DTC. Leeds also won a related EPSRC DTC in Low Carbon Technologies, with members of CCCEP playing an important role in managing the DTC and supervising its students, and ensuring that economic and social-science perspectives are complementing science, technology and engineering in the training of 50 PhD students in a period from 2009. Leeds also participated in an EU-funded Marie Curie Research Training Network of 10 institutional partners to offer inter-disciplinary training on environmental governance to 11 doctoral students and early-career researchers. At LSE, the integration of climate change into disciplinary research has been achieved by placing CCCEP-funded and associated students in a range of departments, including Geography and Environment, International Relations and Statistics. GRI has also hosted several visiting research students from universities including Geneva and Verona.

We have sought to integrate our research students fully into CCCEP's activities. They participate actively in our seminar series and other events as audience and speakers. Many of them are publishing their research in our working-paper series, and co-authoring research articles with our staff. We consider that the most successful PhD training has happened where students have been closely aligned with a Phase-One project – this is a model we plan to develop further for PhD studentships in Phase Two. In Phase One, we organised tailored events for PhD students including a symposium and methods-training workshops. Our experience is, however, that it is more effective – and more in demand – to support students in attending established, specialist summer schools and conferences.

Developing research careers

Finally, we have contributed to the development of a number of early-career researchers, as well as CCCEP's members and associates more broadly. In Phase One we have directly employed 12 post-doctoral researchers, and through leveraged funds we have employed many more. All of these researchers have been mentored, passed through the relevant staff career-development schemes and encouraged to receive training from the staff development units at both Leeds and LSE. Some of our researchers have now moved on to more senior posts around the world, in academia and beyond. Dr Hannes Stephan has taken up a post-doctoral appointment in the Department of Political Science at Lund University in Sweden, Dr Antony Millner took up a prestigious Ciriaci Wantrup fellowship at UC Berkeley, while Dr Oliver Walker is leaving for a lectureship in Economics at Cambridge. Beyond academia, Dr Elisabeth Simelton has become a Manager of the Agroforestry for Livelihoods of Smallholder Farmers in Northwest Viet Nam (AFLI) project for the International Agroforestry Centre (ICRAF), while Dr Max Fehr has taken up a financial analysis job in the City of London.

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6. Direction and management

Institutional setting

CCCEP is a partnership between the London School of Economics and Political Science (LSE) and the University of Leeds. The partnership developed with the aim of bringing together LSE's strengths across the social sciences with expertise on the physical, natural and social science of environmental change developed at Leeds in its Sustainability Research Institute (SRI). The partnership also facilitates a broader geographical engagement with UK policy- and decision-makers, in particular ensuring that it is not confined to London and the South East.

At LSE, CCCEP is embedded within the Grantham Research Institute on Climate Change and the Environment (GRI), established around the same time as CCCEP in 2008. The Institute has been core-funded by the Grantham Foundation for the Protection of the Environment until 2018 (the ten-year grant being worth roughly £12.5 million). Thus it provides a basis of leveraged support for CCCEP that will run throughout Phase Two. In addition to the Grantham Foundation's support, the Institute also receives millions of pounds of leveraged funding from other sources, including the Global Green Growth Institute (GGGI), Munich Re and various consortium projects under the EU's Seventh Framework Programme. LSE itself supports the Institute in various ways, including its in-kind contribution to CCCEP, worth £430,000 in Phase One (not including its contribution to the Full Economic Cost of the Centre), projects funded by the LSE's Higher Education Innovation Fund, and a new revenue stream from the MSc in Environmental Economics and Climate Change.

To ensure that CCCEP's activities have been fully integrated with GRI, the Institute's Chair and Directors have also been CCCEP's Chair and Directors. The Institute Manager is also the CCCEP Manager and her administrative support is available to CCCEP. In addition, GRI's large Policy and Communications team, described below in our engagement strategy for Phase Two, has and will continue to offer its support to CCCEP in engaging users and beneficiaries of its research. In the wider context of LSE, CCCEP enjoys collaborative research links with a number of world-class departments and centres, including the Centre for Economic Performance on green growth and competitiveness, the ESRC-funded Spatial Economics Research Centre on the links between economic geography and climate policy, the Centre for the Analysis of Time Series (CATS) on the predictive skill of climate models and climate science, the International Growth Centre (IGC) on climate-compatible development, and the Asia Research Centre, which provides links with China and India. Several of these research centres have recently been co-located in the LSE's new 'Towers Research Hub'. These many links ensure that CCCEP has a tremendous pool of expertise upon which to draw and reinforce its interdisciplinary.

At Leeds, CCCEP is embedded within the Sustainability Research Institute (SRI) in the School of Earth and Environment (SEE). SEE is one of the largest of its kind in the UK with over 90 members of academic staff. SRI is the environmental social science unit within SEE, with 35 faculty and teaching staff, 25 research staff and 65 research students. SRI is home to four research groups: Business and Organisations for Sustainable Societies; Economics and Policy for Sustainability; Environmental Change and Development; and Social and Political Dimensions of Sustainability. The University of Leeds and SEE have supported CCCEP through their institutional co-contribution of over £250,000 and in other ways. SRI is also partner to several major research initiatives in addition to CCCEP, including the Centre for Low Carbon Futures (CLCF), the UK Energy Research Centre (UKERC), the ESRC Sustainable Behaviours Research Group, and over half a dozen FP7 projects, some of which are just starting. Thus it has substantial leveraged funding for research that will complement the research programme of CCCEP in Phase Two.

To ensure that CCCEP's activities have been fully integrated with SRI and SEE in Leeds, the Director of SRI has been Deputy Director of CCCEP in Leeds, and the Director of CCCEP in Leeds was formerly the Director of SRI. The Head of SEE has in turn been co-investigator in Programme One. In Leeds, CCCEP has had a dedicated part-time Administrator and the Centre has been able to use the services of a Faculty of Environment Press Officer. CCCEP enjoys collaborative research links with major centres of excellence at the University of Leeds, such as the Africa College, water@leeds and the Schools of Engineering and Geography (on topics related to adaptation), the Centre for Integrated Energy Research (CIER) and the School of Biology (on topics such as mitigation, biofuels and carbon sequestration). We also collaborate with researchers based in the National Centre for Atmospheric Science (NCAS, funded by NERC) at SEE, to make use of their expertise on climate-impacts modelling and our expertise on adaptation.

Centre Management

CCCEP's management structure is summarised in Figure 1. LSE is the lead institution, carrying financial and reporting responsibilities, as well as coordinating our engagement activities.

Management Group

The Management Group is chaired by *Professor Lord Nicholas Stern of Brentford*. Stern is the first holder of the IG Patel Chair at LSE, in the Departments of Economics and Government, and he chairs both the Asia Research Centre and GRI. He has recently been appointed the new President of the British Academy. His vast experience and his network of academic and non-academic contacts are an important asset of CCCEP. Thus his role in the Centre has been to provide academic leadership and to lead on engagement with policy-makers and businesses. He also chairs CCCEP's Steering Committee.

CCCEP has been directed by *Professor Judith Rees* at LSE and by *Professor Andrew Gouldson* at Leeds in Phase One. Rees was the first Director of GRI and has recently been appointed the first female President of the Royal Geographical Society. From April 2011 to September 2012 she was Acting Director of LSE, and in her absence *Dr Simon Dietz* became both Acting Co-Director of GRI (with Professor Sam Fankhauser) and Acting Director of CCCEP, having previously served as Deputy Director of both. Gouldson is Professor of Sustainability Research and a previous Director of SRI at Leeds. He has been supported in Leeds by Deputy Director *Professor Jouni Paavola,* who is the current Director of SRI.

Also part of the Management Group is *Bob Ward*, the Policy and Communications Director of GRI, whose presence ensures engagement opportunities are maximised, and *Professor Leonard Smith*, Director of CATS at LSE and co-leader of Programme One on climate models. The Management Group meets frequently and is responsible for taking and implementing strategic decisions, assessing progress against Key Performance Indicators, approving proposals for new work, ensuring that synergies between programmes and projects are fully exploited, and that engagement takes place in a timely and effective manner.

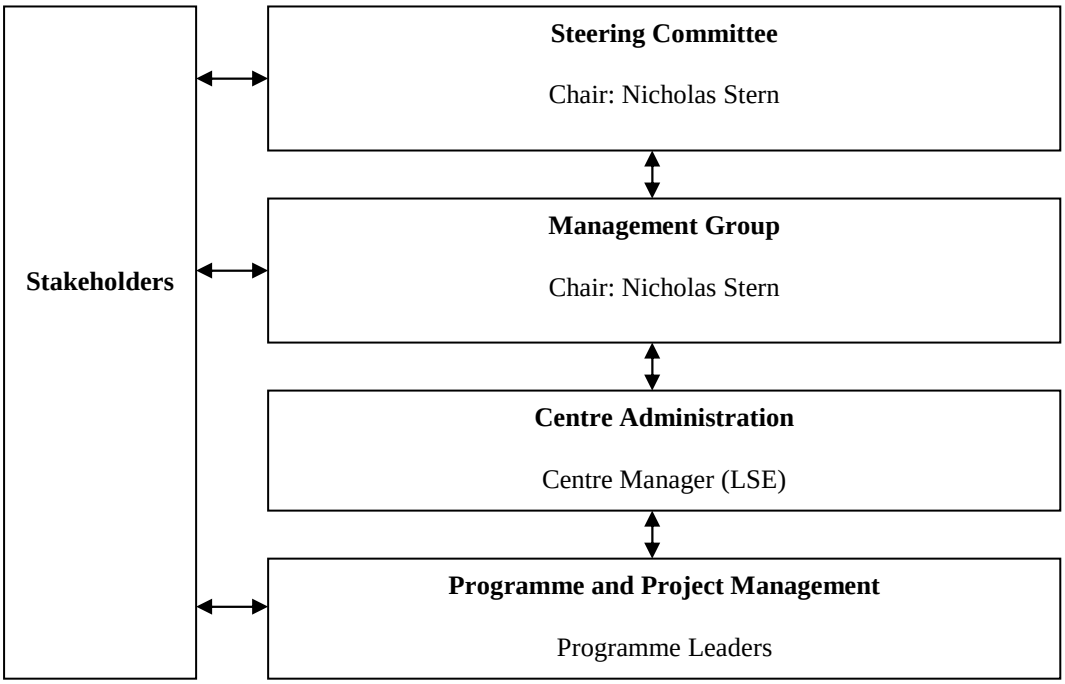
Steering Committee

The Management Group is advised by a Steering Committee, which includes leading academics, policy-makers, business people and representatives from the voluntary sector. Current members of CCCEP's Steering Committee include representatives from WWF, the World Bank and OECD, as well as leading academics from the UK and continental Europe. Related ESRC investments are represented on the Committee, as is the UK Research Councils' Living With Environmental Change (LWEC) initiative.

Administration

The Centre employs a full-time Manager, who is supported by two Administrative Assistants at LSE and at Leeds by one further administrator. CCCEP's Manager is funded by LSE's in-kind contribution, and to maximise coordination with GRI she also performs this role for the Institute. The administrative team is in turn able to draw on the central research-support infrastructure at LSE and at Leeds.

Figure 1. Organisational structure of CCCEP



Programme and project management

The leaders of each research programme are members of the Management Group, which helps to ensure coordination across programmes and consistency in the Centre's activities. Programme leaders take responsibility for intellectual leadership, programme and project coordination, research aspects of engagement, and output quality-control. In collaboration with project leaders, they are also responsible for the recruitment of additional research staff and PhD students and for ensuring that they receive the necessary career development and research training, drawing on the well-established and successful staff development/doctoral programmes at both institutions. Project leaders are responsible for project delivery, the day-to-day management of research staff and students, project budgetary control and ethical compliance.

Project researchers

Across our portfolio of research projects, CCCEP comprises an interdisciplinary mix of some of the world's leading scholars. Beyond the Management Group, our projects in Phase One have been led by:

- *Pauline Barrieu*, Reader in Statistics at LSE and Co-Director of CATS. Her research interests focus on the interface between finance and insurance;
- *Chaloka Beyani*, Senior Lecturer in International Law at LSE, specialising in human-rights and migration issues related to climate change;
- *Robin Burgess*, Professor of Economics and Director of the IGC at LSE. His research interests include development, public and environmental economics;
- *Andrew Dougill*, Head of the School of Earth and Environment at Leeds, and Professor of Environmental Sustainability. His research spans a range of disciplines from soil science and ecology to development studies and human geography;
- *Robert Falkner*, Reader in International Relations at LSE, specialising in international environmental politics and governance;
- *Piers Forster*, Professor of Physical Climate Change at Leeds and Royal Society Wolfson Merit Award holder, specialising in climate science and modelling;
- *Tim Foxon*, Reader in Sustainability and Innovation at Leeds, focusing on innovation systems and processes for a transition to a low-carbon economy;
- *Evan Fraser*, Visiting Fellow and former Senior Lecturer at Leeds, now Associate Professor at Guelph. His research focuses on food security under economic globalisation and climate change;
- *Cameron Hepburn*, Senior Research Fellow at the Grantham Research Institute at LSE, specialising in climate and environmental economics;
- *Ralf Martin*, Visiting Fellow and former Research Fellow at CEP at LSE, now also Assistant Professor in Economics at Imperial College Business School. His research examines how government policies affect business performance.
- *Lindsay Stringer*, Reader in Environment and Development in Leeds and Co-Director of the Sustainability Research Institute, specialising in environmental change and livelihood dynamics.

7. Financial tables

Table 3. ESRC funding to date: budget and expenditure

	Financial Year 2008/09		Financial Year 2009/10		Financial Year 2010/11		Financial Year 2011/12		Financial Year 2012/13	Financial Year 2013/14
	Budget	Actual Expenditure	Budget	Actual Expenditure	Budget	Actual Expenditure	Budget	Actual Expenditure	Budget	Budget
DI Staff	73,554.42	25,508.07	219,927.23	207,461.38	233,246.76	282,026.38	254,621.09	285,967.76	291,216.66	134,080.57
DI Travel & Subsistence	9,841.67	5,427.19	21,221.09	35,105.11	20,733.42	59,545.27	21,299.17	45,858.52	21,831.66	11,165.65
Other DI Costs	77,189.72	26,310.52	114,675.11	51,992.05	116,739.30	29,382.88	119,930.56	75,045.22	122,934.25	62,874.81
Exceptions	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Sub-total	**160,585.81**	**57,245.78**	**355,823.43**	**294,558.54**	**370,719.48**	**370,954.53**	**395,850.82**	**406,871.50**	**435,982.57**	**208,121.03**
The following categories are paid, as per the grant profile, so there is no difference between budget and actual.										
DA Investigators	57,553.13		91,669.14		74,980.08		77,026.00		78,951.68	40,378.42
Other DA Costs	32,136.89		65,692.65		67,282.71		61,033.68		62,559.58	31,995.02
Estates	33,823.79		69,349.30		71,256.43		73,200.76		75,030.80	38,373.38
Indirect Costs	151,352.74		310,320.34		318,854.06		327,554.54		335,743.30	171,710.58
TOTAL	**435,452.36**	**332,112.33**	**892,854.86**	**831,589.97**	**903,092.76**	**903,327.81**	**934,665.80**	**945,686.48**	**988,267.93**	**490,578.43**

Table 4. Additional grants secured by CCCEP

Name of grant	Total value of grant	Start and end date of grant	Funding source	HEI, private, public or third sector	Alignment to core Centre grant (see key)	Name of grant holder linked to Centre
Munich Re 5th Programme of CCCEP	3,000,000.00	Oct 2008 -- Dec 2013	Munich Re	Private	1/2	Simon Dietz, Judith Rees and Leonard Smith
Grantham Research Institute on Climate Change and the Environment	12,000,000.00	Oct 2008 -- Sept 2018	Grantham Foundation for the Protection of the Environment	Third sector	1/2/3	Simon Dietz, Sam Fankhauser, Judith Rees and Nick Stern
GRI Web Officer	81,656.00	May 2009 -- May 2011	HEIF	Internal HEI	1/2/3	Bob Ward
India Workshop: Environmental Sustainability and Climate Change	37,000.00	Nov 2008 -- Nov 2009	ESRC–ICSSR	Public	1	Judith Rees
Alcoa Foundation: Advancing Sustainability Fellowship Programme	1,076,269.29	2010 -- 2015	Alcoa	Private	3	James Van Alstine

Climate for Culture	200,000.00	2009 -- 2014	European Commission	Public	2	Susana Mourato
Project on Environmental Economics	8,700.00	May 2010 -- Feb 2011	OECD	Public	1	Alex Bowen
Postdoctoral Fellowship	200,000.00	Oct 2010 -- Sept 2012	ESRC	Public	1	Antoine Dechezleprêtre
The New Climate Order	41,000.00	March -- Oct 2011	European Climate Foundation	Third sector	2	Michael Jacobs
Senior Communications Officer	54,000.00	January -- July 2011	HEIF	Public	1/2	Bob Ward
Program Enhancing Communications Activities on Climate Change at LSE	417,975.00	Jan 2011 -- Dec 2012	Grantham Foundation for the Protection of the Environment	Private	2	Bob Ward
Intergenerational and Intragenerational Equity in Climate Change Policies	49,000.00	July 2011 -- June 2012	Frisch Centre Oslo	Public	1	Sam Fankhauser
GLOBAL-IQ	140,000.00	Oct 2012 -- Sept 2015	European Commission	Public	1	Simon Dietz
LIMITS	213,000.00	Oct 2012 -- Sept 2015	European Commission	Public	1	Alex Bowen
Green Growth and the New Industrial Revolution	1,264,400.00	Sept 2012 -- Aug 2014	Global Green Growth Institute	Public	1/2	Alex Bowen
ENHANCE	430,000.00	Sept 2012 -- Aug 2015	European Commission	Public	1/2	Swenja Surminski
ENTRACTE	400,000.00	Sept 2012 -- Aug 2015	European Commission	Public	1	Antoine Dechezleprêtre
Dahrendorf Fellowship	287,000.00	Sept 2012 -- Dec 2013	Siftung Mercator	Private	1	Luca Taschini
EQUIP	420,648.00	Jan 2010 -- March 2013	NERC	Public	1/2	Lenny Smith Andy Challinor
Future Energy Decision Making for Cities: Can Complexity Science Rise to the Challenge?	293,149.00	Oct 2009 -- Sept 2012	EPSRC 'Energy Challenges for Complexity Science' programme	Public	1/2	Tim Foxon
Towards a Climate Resilient, Low Carbon Economy	300,000.00	March 2010 -- Feb 2012	Yorkshire Forward Centre for Low Carbon Futures	Public	1	Andy Gouldson
The Impact of the Recession on Greenhouse Gas Emissions	20,000.00	June -- Oct 2009	ESRC and the Scottish Environmental Protection Agency	Public	1	Alex Bowen Andy Gouldson

Evaluating the Impact of Business Support on the Preparedness of Businesses for the Implementation of the UK Climate Change Act	20,000.00	Oct 2009 -- Jan 2010	CO2Sense Yorkshire	Public	1	Andy Gouldson
Multi-Level Governance of Natural Resources	278,000.00	Oct 2006 -- Sept 2010	EU Framework Programme 6 Marie Curie Research Training Network	Public	1/2	Jouni Paavola
How Modern Social Science Research Helps Shape Public Policy, Market Forces and Social Understanding	300,000.00	May 2010 -- April 2013	HEFCE Strategic Development Fund	Public	1/2	Andy Gouldson
Managing Land for Carbon: Relationships between Carbon, Poverty and Ecosystem Services	44,891.00	July 2010 -- Jan 2011	NERC/DFID/ESRC ESPA programme	Public	1	Andy Dougill
Sustainable Agriculture for Global Food Security	250,000.00	April 2011 -- Oct 2014	Private alumni donation	Third sector	1	Andy Dougill
Mini-Stern Review for Leeds City Region	50,000.00	Dec 2010 -- Aug 2011	DECC/Centre for Low Carbon Futures	Public	1	Andy Gouldson
Assessing Institutional and Governance Partnerships for Climate-Compatible Development in sub-Saharan Africa	202,000.00	Feb 2012 -- Jan 2013	Climate Development Knowledge Network (CDKN) Innovation Fund	Public	1	Andy Dougill Lindsay Stringer
Achieving Triple Wins in the Coastal Zone	200,000.00	Oct 2011 – Feb 2013	CDKN	Public	1	Lindsay Stringer
Aviation Climate Change Research Initiative	89,466.00	March 2010 -- March 2011	FAA	Public	1	Piers Forster
Transforming Knowledge for Upland Change	13,279.00	Oct 2010 -- Dec 2012	ESRC	Public	1	Lindsay Stringer
IAGP	710,169.00	Oct 2010 -- Sept 2014	EPSRC	Public	1	Piers Forster
CASCADE	387,684.00	Jan 2012 -- June 2017	EU	Public	1	Andy Dougill
SUNLIBB	143,291.00	Jan 2010 -- Sept 2014	EU	Public	1	Lindsay Stringer
BASE (Building Strategies for Adaptation to Climate Change in Europe)	351,572.00	Nov 2012 -- Oct 2016	EU	Public	1	Jouni Paavola
FESSUD: Financialisation, Economy and Sustainable Development	197,309.69	Dec 2011 -- Nov 2016	EU	Public	1	Andy Gouldson
Climate Smart Cities	105,606.00	June 2012 -- May 2013	CLCF	Public	1	Andy Gouldson
SPECS	69,859.00	Nov 2012 -- Oct	EU	Public	1	Andy Challinor

		2014				
Drought Risks from Climate Change	50,000.00	Feb 2012 -- March 2012	CLCF	Public	1	Piers Forster
EUPORIAS	601,003.00	Nov 12 -- Oct 2016	EU	Public	1/2	Andy Challinor et al.
Realising Transition Pathways: Whole Systems Analysis	305,566.00	May 2012 -- April 2016	EPSRC	Public	1/2	Tim Foxon
Climate Mitigation	50,000.00	Nov 2011 -- Oct 2016	Royal Society	Public	1	Piers Forster
DESIRE	209,548.00	Feb 2007 -- Jan 2012	EU	Public	1	Lindsay Stringer et al.
Land of the MUSCos	415,869.00	Dec 2011 -- Dec 2014	EPSRC	Public	1/2/3	Julia Steinberger
Embedded Carbon Emissions Indicator	99,041.00	Feb 2011 -- Jan 2016	DEFRA	Public	1	John Barrett
Border Levelling	25,000.00	March 2011 -- Dec 2011	CLCF	Public	1	John Barrett
Undermining Infastructure: Avoiding the Scarcity Tip	225,206.00	Oct 2011 -- Sept 2014	EPSRC	Public	1/2/3	Julia Steinberger
Advancing Knowledge Systems to Inform Climate Adaptation Decisions	790,647.00	April 2012 -- March 2016	ERC	Public	1	Suraje Dessai
Organisational Operational Response & Strategic Decision Making for Long Term Flood Preparedness in Urban Areas	158,107.00	Dec 2012 -- Dec 2015	EPSRC	Public	1	Dabo Guan
Delivering and Evaluating Multiple Flood Risk Benefits	290,810.00	Jan 2013 -- Dec 2015	EPSRC	Public	1	Dabo Guan
TOTAL	**27,567,720.98**					

1 = Funding within the broad scope of the ESRC award.
2 = Additional research activities led by the Centre but related to new research fields adjacent to the scope of the ESRC Centre.
3 = Additional research which the Centre has taken on which is beyond the scope of the ESRC award but reflects a strategic priority to provide value added.

Part II: Proposal for Phase Two

1. Introduction

The first phase of CCCEP built on four research programmes, reflecting our assessment of where the state of the art in academic research on climate-change economics and policy was in 2008, and the then state of the world in climate policy. The programmes were: (i) developing climate science and economics; (ii) climate-change governance for a new global deal; (iii) adaptation to climate change and human development; and (iv) governments, markets and climate-change mitigation.

In selecting the priority themes where CCCEP can make the strongest academic contribution and have the biggest impact in the next five years, in the last twelve months we have conducted extensive consultations with our members and associates, our Steering Committee and a range of stakeholders. These consultations highlighted:

- the need to address the significant changes in the context for climate action that have taken place in recent years, particularly the implications of the financial crisis and economic downturn, the continuing absence of a comprehensive international agreement on climate change, and recent controversies relating to climate science;
- that we should build on the strengths we have developed in Phase One, whilst also developing more integrated approaches to climate research that combine insights from science, economics and policy and that allow joined-up decision-making on adaptation and mitigation;
- that we should continue to engage with key stakeholders throughout the research process in multiple ways, and be driven by outcomes and impacts;
- that CCCEP should seek to make a distinctive contribution within the context of other international research on climate change that also resonates with ESRC strategic priorities.

Our scientific programme for Phase Two is structured around five integrated or cross-cutting themes.

Our five research themes for Phase Two therefore deliberately cut across the lines drawn in Phase One in order to build synergies between different research topics usually pursued in isolation – especially adaptation and mitigation – and to explore the scope for integrated approaches. The five themes are:

- **Understanding green growth and climate-compatible development:** what could constitute ‘green growth’ or ‘climate-compatible development’ in industrialised and developing countries, and how can we critically evaluate both the scope for and the limits of such concepts?
- **Advancing climate finance and investment:** how can we unlock major flows of finance and investment into both adaptation and mitigation in different contexts, and how can we evaluate the implications of such flows?
- **Evaluating the performance of climate policies:** how can we assess the performance of different forms of climate policy, and how can we understand the scope for policy learning within and between contexts?
- **Managing climate risks and uncertainties and strengthening climate services:** how can we promote new approaches to the assessment, management and communication of climate risks and uncertainties, and how might these inform the provision of improved climate services?

- **Enabling rapid transitions in mitigation and adaptation:** in case of slower than anticipated progress, how can we understand the scope for rapid transitions to dramatically cut emissions and adapt to significant climate change?

To research these themes, we plan to refresh the CCCEP team, including by bringing in expertise from new staff who were not directly involved in Phase One. As well as conducting robust research using innovative methods, we will continue to engage with key stakeholders throughout the research process and to exploit a range of pathways to impact, so that we continue to build on the influence we have exerted in Phase One.

Beyond the planned scientific programme, we also propose to create a **CCCEP Innovation Fund** with the aim of stimulating, developing and disseminating innovative ideas in climate policy from both the academic and practitioner communities. We see this Fund as a vital, responsive-mode device, enabling us to adapt to the ever changing context of our work.

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2. Strategic Context

Our Phase-Two plans respond to the changing context of climate policy.

As stated above, our consultations on the key themes to be addressed by CCCEP Phase Two highlighted the various ways in which the context for climate action has changed in the last five years. Three major trends have been identified:

First, **the financial crisis and the recession** in the UK, the EU and the US have impacted on climate policy in multiple ways. They have reduced and/or slowed the rate of increase in emissions in these countries, but they have also undermined carbon prices and climate-related investment. To an extent they have also restricted the capacity, both economic and political, of governments to adopt or implement ambitious climate policies. In this context, increased emphasis is placed on the links between climate change, competitiveness, employment and economic development. At the same time, increased reliance is being placed on forms of climate governance that draw not only on public but also on private and civic capacities. By contrast, rapid economic growth in many developing countries – such as the BASIC countries – creates new opportunities for climate policy and potentially also for green growth. But understanding the scope for and the limits of green growth and climate-compatible development remains limited.

Second, **the delay in agreeing a comprehensive global climate treaty** has had far-reaching – but again potentially ambiguous – effects. The absence of a global deal with binding targets for major emitters has clearly slowed the pace of action to some extent, whilst again putting into question whether climate policies – particularly those adopted unilaterally – reduce competitiveness. But progress has still been made in a more piecemeal fashion, with various 'building blocks' for a global deal emerging, including on finance to developing countries and on the programme on Reduced Emissions from Deforestation and Forest Degradation (REDD). And below the international level, we have seen some major innovations in climate policy emerge, partly due to the absence of a global deal. Consequently, we now have a wider range of policy options to choose or learn from, and a longer track record of their implementation to evaluate.

Third, **debate about the conduct and results of climate science** has been prominent, at least in places such as the UK and the US. Confidence in climate science has ebbed somewhat, among other things due to mistakes in the Fourth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC), as well as controversy around hacked e-mails from the University of East Anglia's Climate Research Unit. A wider decline in public trust in established power and expertise, linked to the downturn, may also be partly to blame. Many of the implications of these changes have yet to become clear, particularly in areas relating to the assessment, communication and management of climate risks and uncertainties (or in other words what Meteorological Offices are now calling the provision of 'climate services').

Our Phase-Two plans build on the areas of expertise and comparative advantage established in Phase One, but incorporate new research methods and address new, timely topics.

In the first phase of CCCEP we built expertise and an international reputation in several areas, including on:

- Investment decisions, both for mitigation and adaptation, in the face of 'deep' uncertainty;
- The impacts of climate change on food security using 'closed-loop', participatory modelling;
- Robust, firm-level econometric evaluation of climate policies;
- The design and performance of policy instruments to price carbon, especially Emissions Trading Schemes and associated carbon markets.

In Phase Two we aim to build on our existing expertise: all four of the above areas are included in our plans, but we also aim to ask new questions and develop and use new methods. For example, our Phase-Two plans put much stronger emphasis on the implications for competitiveness and trade of climate policy that is applied unevenly across the world. The research programme as a whole also seeks to understand more comprehensively the linkages between responding to climate change and economic growth, and the possibility of green growth and climate-compatible development. New methods include participatory portfolio decision analysis, coupling of models from the non-linear systems community with economic models of investment, and perspectives from economic history into climate-compatible transitions, especially the prospects for rapid transitions.

Our bid continues to place engagement of users and beneficiaries centre-stage.

Our engagement strategy is built on the principle that CCCEP can only maximise the impact of its work through continual, two-way dialogue with research and non-research communities. The resources devoted to engagement with stakeholders need to be prioritised and invested in opening up access and building constructive reciprocal relationships with key decision-makers and other stakeholders. That way CCCEP's intellectual input is available to inform decisions at the right time and in the right form, and it is driven by outcomes rather than outputs.

Our engagement with public policy-makers, business and the voluntary sectors is greatly aided by the leveraged support of the Policy and Communications team at GRI, which contains seven specialist posts ranging from media relations, through website management to responsive-mode policy research and maintaining high-level contacts.

Our bid aims to complement rather than duplicate research by other ESRC investments and that is internationally distinctive.

We plan to continue to collaborate with other major ESRC investments such as the ESRC Climate Change Leadership Fellows, the STEPS (Social, Technological and Environmental Pathways to Sustainability) Centre, the ESRC Research Group on Lifestyles, Values and Environment (RESOLVE), the UK Energy Research Centre (UKERC), and the Sustainable Behaviours Research Group, when opportunities arise. For example, in Phase One we collaborated with Professors Simon Caney and Peter Newell – both ESRC Climate Change Leadership Fellows – respectively on the ethics of carbon trading and the governance of carbon markets. But we also seek to ensure that our research complements other relevant ESRC-funded research. Thus we will not place significant emphasis on, for example, the determinants of individual environmental behaviour, because this is a major focus of RESOLVE and the Sustainable Behaviours Research Group.

We aim to contribute to several of the ESRC's Strategic Challenges.

Our bid will make a core contribution to the ESRC's strategic challenge "Environment, Energy and Resilience", as well as being highly relevant, in its focus on green growth and climate-compatible development, to "Global Economic Performance, Policy and Management". In its focus on measuring low-carbon innovation and on understanding it from a socio-economic systems

perspective, it will also be highly relevant to the ESRC strategic challenge on "New Technology, Innovation and Skills".

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3. Scientific Plan of Phase Two

Table 5. Summary of Phase Two research themes and projects.

<table>
<tr><th rowspan="2">Research theme</th><th colspan="5">Year</th></tr>
<tr><th>1</th><th>2</th><th>3</th><th>4</th><th>5</th></tr>
<tr><td rowspan="2">1. Understanding green growth and climate-compatible development (Gouldson)</td><td colspan="3">1a. Green growth and climate change in Chinese cities (Gouldson and Guan)</td><td colspan="2">1b. Mainstreaming climate-compatible development in Africa (Stringer et al.)</td></tr>
<tr><td colspan="5">1c. Green growth and employment in advanced economies (Bowen)</td></tr>
<tr><td rowspan="3">2. Advancing climate finance and investment (Fankhauser)</td><td colspan="3">2a. Political economics of climate finance (Gennaioli and Fankhauser)</td><td colspan="2"></td></tr>
<tr><td colspan="5">2b. Policy learning in climate finance (Falkner, Gouldson, Sullivan)</td></tr>
<tr><td colspan="5">2c. Evolution of carbon markets (Hepburn and Taschini)</td></tr>
<tr><td rowspan="3">3. Evaluating the performance of climate policies (Fankhauser)</td><td colspan="3">3a. Consumption-based carbon accounting and mitigation policies (Barrett and Gouldson)</td><td colspan="2" rowspan="2"></td></tr>
<tr><td colspan="3">3b. Carbon, competitiveness and trade (Dechezleprêtre et al.)</td></tr>
<tr><td colspan="5">3c. Measuring and evaluating low-carbon innovation (Dechezleprêtre and Martin)</td></tr>
<tr><td rowspan="3">4. Managing climate risks and uncertainties and strengthening climate services (Dietz)</td><td colspan="5">4a. Institutions, climate services and adaptation (Dessai, Ranger et al.)</td></tr>
<tr><td colspan="5">4b. Climate change, nonlinear systems and economic decisions (Stainforth, Dietz et al.)</td></tr>
<tr><td colspan="3">4c. Integrated sustainability science for pro-poor climate policy (Dougill et al.)</td><td colspan="2"></td></tr>
<tr><td rowspan="3">5. Enabling rapid transitions in mitigation and adaptation (Paavola)</td><td colspan="3" rowspan="2"></td><td colspan="2">5a. The economics of rapid transitions (Ranger et al.)</td></tr>
<tr><td colspan="2">5b. Systemic approaches to low-carbon transitions (Foxon et al.)</td></tr>
<tr><td colspan="5">5c. Governing rapid transitions in mitigation and adaptation (Paavola et al.)</td></tr>
</table>

Theme 1. Understanding green growth and climate-compatible development (Leader - Gouldson)

The OECD (2010) has claimed that "the financial and economic crisis has provided the opportunity for policy interventions aimed at encouraging recovery and renewed growth on more environmentally and socially sustainable grounds". While in saying so the OECD evidently has crisis-hit industrialised countries in mind, the green-growth agenda has also extended to emerging markets and least-developed countries. In spite of this surge in political interest, however, the empirical and theoretical foundations for the design of green-growth policies are still weak. This theme will examine claims for green growth and jobs using analytical and empirical approaches within economics, as well as evaluating in an interdisciplinary manner how green growth could be operationalised in important case-study contexts, including the UK labour market, Chinese cities and rural communities in Sub-Saharan Africa.

1a. Green growth and climate change in Chinese cities (Gouldson and Guan)

While the green-growth debate is becoming more prominent at the international level, understanding how to operationalise green-growth strategies is still lacking at more local levels. This project will seek to add on-the-ground empirical value to our understanding of green growth by evaluating perspectives, experiences and outcomes in Chinese cities. The project will build on high-profile research on the economics of low-carbon cities conducted in the UK as part of Phase One of CCCEP (Gouldson, Kerr et al. 2012; Sullivan, Gouldson et al. 2012), as well as several on-

going, collaborative projects in China, including with the China Centre for International Cooperation on Environment and Development, and the Chinese Academy of Sciences.

Cities are central to the green-growth debate as the locus of economic activity and the driver of energy consumption and carbon emissions. They can be particularly vulnerable to the impacts of climate change too. Over the coming years, growth, urbanisation and their resulting emissions will cement the importance of Chinese cities in particular in the international climate-policy picture. Yet cities across China are already pursuing greener futures by incorporating environmental objectives into their economic strategies. In this project we ask how are they doing so, how much is being achieved and what can be learned? Given the great heterogeneity of Chinese cities, we will select a relatively large sample of 20 or more to study, representing different stages of development. From these, we will select a smaller number (i.e. five) to work with to map the detail of their green-growth strategies and the processes through which the agenda is operationalised. As well as mapping institutional conditions and the levels and forms of influence that can be exerted, the project will evaluate policy-learning processes at multiple scales (national, provincial, city-region and city) and assess the outcomes of green-growth initiatives already underway.

1b. Mainstreaming climate-compatible development in Africa (Stringer, Dougill and Sallu)

Sub-Saharan Africa is acknowledged to be among the most vulnerable regions to climate change (IPCC 2007). While the region is not a major emitter of greenhouse gases, there are many opportunities for cost-effective emissions abatement. Existing work, including in CCCEP Phase One (e.g. Abson, Dougill et al. 2012; Stringer, Dougill et al. 2012; Stringer, Dougill et al. 2012), has identified the potential of 'climate-compatible development' to deliver triple-wins in the region across adaptation, mitigation and development. There is hence a strong interest in how climate-compatible development can be implemented in sub-Saharan Africa, especially via 'mainstreaming' adaptation and mitigation actions.

This research explores how mainstreaming of adaptation and mitigation varies across developing countries in sub-Saharan Africa, to enhance understanding of the factors that determine the responsiveness of different sectors to calls to mainstream and integrate the two sides of the climate-policy coin. The project will generate novel insights into and an important critique of the concept of climate-compatible development. It investigates the factors that promote and restrict mainstreaming at international, national and local levels, taking into account institutional capacities, collaborations and partnerships, and the scientific evidence base for climate change. Extending knowledge in this area is vital in informing the design and implementation of more integrated development planning. The research will develop multi-scale, mixed-method approaches, integrating national and international policy analyses, interviews with policy, donor, programme and NGO staff, and participatory data collection methods with communities involved in climate-compatible development projects.

1c. Green growth and jobs in advanced economies (Bowen)

Many advanced economies are experiencing relatively sluggish and jobless recoveries from the financial crisis, yet are operating in an increasingly carbon-constrained environment. In this context, what is the scope for green growth and jobs? How do emissions relate to employment and economic performance in sectors figuring prominently in the climate-policy debate? What size and direction of labour-market flows will be necessary to bring about green growth under different assumptions about mitigation policies and about the macroeconomic environment? This project will study the joint evolution of carbon emissions, employment and investment as the economy moves through the business cycle, with a primary focus on labour-market consequences in advanced economies. It will do so by combining quantitative econometric and macroeconomic simulation modelling with perspectives from economic history and business history.

The quantitative analysis aims to fill a gap in existing studies. Several studies (including in CCCEP Phase One) have examined the relationship between business cycles and emissions at the aggregate

level (e.g. Fisher and Springborn 2011; Doda 2012; Heutel 2012), but have had little to say about the sectoral composition of emissions and its interaction with employment and investment. Cole et al. (2005) undertook a disaggregated study of UK manufacturing, but used old data and focused on local pollutants. Fankhauser et al. (2008) and Bowen (2012) consider the employment implications of climate policy, but they do not conduct a detailed empirical investigation. Finally, Satchi and Temple (2009) calibrate a computable general equilibrium (CGE) model using a sophisticated search-theoretic approach to employment determination, but do not focus on either emissions-intensive sectors or developed countries. The unit of observation for our analysis is disaggregated sectors in advanced countries, which poses a challenge of finding suitable data. We plan to use real energy expenditures as a proxy for emissions and later to extend to an even higher resolution using, for example, firm-level data from the UK Annual Respondents Database matched with the Quarterly Fuels Enquiry. The analysis can also be used to develop and calibrate a simple CGE model of an archetypal developed-country economy to facilitate analysis of 'green' job creation. Our quantitative analysis will be complemented by a critical review of the economic-history and business-history literature on past energy-system transformations to extract information about their labour-market consequences.

Theme 2: Advancing climate finance and investment (Leader - Fankhauser)

Questions of finance and investment are at the heart of discussions on mitigation and adaptation at all levels and in all contexts. Internationally, recent UNFCCC negotiations have centred on finance, with key debates on the amounts and forms of finance required, and on the institutional frameworks needed to stimulate, allocate and oversee the funds. This theme extends our work on carbon markets as a central tool in raising and spending carbon finance, as well as examining the 'multi-level governance' of climate finance from an interdisciplinary perspective, including human geography, international relations and political economics.

2a. The political economics of climate finance (Fankhauser and Gennaioli)

International commitments on climate finance raise the prospect of substantial new capital flows to developing countries. This is widely, and rightly, seen as a positive development and an important element of the international policy architecture. While there is already a normative debate on how these flows should be originated, governed, managed and monitored, this project will examine whether there is the risk of a '*climate-finance curse*' and under which circumstances it might arise. The analytical starting point is the extensive literature on the resource curse, according to which resource abundance can be detrimental to economic growth and the quality of institutions. Numerous theories seek to explain this phenomenon, emphasizing both economic channels and political-economy factors. We will contribute to this literature both theoretically and empirically.

We will first develop a set of theoretical frameworks on the climate-finance curse on the basis of classical models of the resource curse, and analyse to what extent climate finance is similar to other forms of resource abundance. For example, will carbon trading, like natural resources, tend to crowd out tradable activities (the Dutch Disease hypothesis)? Will climate finance stimulate patronage politics, rent-seeking and corruption activity by politicians? The second part of the project will look more closely at corruption as a specific outcome of the climate-finance curse. Several climate-finance scandals have already been disclosed, such as fraud in the EU ETS, corruption in the renewable energy sector and the suspicion of cheating in reporting under the Clean Development Mechanism (CDM). An important question to ask is: under which conditions can climate policy increase corruption? We will take an empirical approach, trying to establish whether there is a correlation between corruption and the diffusion of projects funded under the CDM or other climate policies, and what affects it. We will also determine the main effects of corruption on the economic efficiency of climate investments, and propose policy solutions to reduce the likelihood of corruption.

2b. Policy learning in climate finance (Falkner, Gouldson and Sullivan)

Climate finance is a relatively new field – with new policy initiatives typically accompanied by new institutional arrangements that often depend on inputs from public, private and sometimes civic actors. There is hence a clear need for an understanding of the scope for and the processes of policy learning. Are some approaches and institutional conditions more viable (politically, economically, institutionally) than others? Do different approaches stimulate different outcomes, and to what extent and under what conditions can policy learning and transfer take place, be it across levels, within or between contexts, or over time? Theories of policy learning emphasise the potential for narrow technical and wider social forms of learning, learning that is formal and evidence-based, and that is informal and discursive. They also emphasise the importance of institutions at multiple levels, including the national and sub-national levels, the significance of path dependencies in policy processes, and the important role that shocks and formative events can play in creating scope for rapid learning.

This project will consider the relevance of different theories of policy learning to the evolving provision of climate finance at two levels. At the global scale, as the international community begins to implement pledges on global climate finance, politically fraught questions about the Green Climate Fund's institutional design, operational policies and governance arrangements need to be resolved. Existing international aid mechanisms (e.g. the Global Environment Facility) provide important lessons on how to design international climate-finance institutions. In parallel, at the national and sub-national levels within the UK, we are witnessing various experiments with different institutional arrangements and business models to finance low-carbon measures, such as the Green Deal and Green Investment Bank. The 'big society' could let a thousand flowers bloom, but how will we learn about the arrangements that work best and can good practice be transferred from setting to setting? This project will investigate the extent to which processes of policy learning and institutional diffusion are at work in this emerging area. We will evaluate the drivers (e.g. functional logics; path dependency; power asymmetries) that shape such learning and diffusion processes. And we will consider the preconditions for, and the barriers to, policy learning in different settings. By considering these issues, we aim to enable accelerated learning in the field of climate finance at the international, national and sub-national levels, as well as offering insights to the CCCEP scientific programme as a whole, and the wider academic community.

2c. Evolution of carbon markets (Fankhauser, Hepburn and Taschini)

While the European and international carbon markets are going through difficult times, there is growing interest in market-based mechanisms in Australia, California, China, Mexico, New Zealand and Korea for example. The rise of these new carbon markets, as well as the on-going problems with existing schemes, requires both theoretical work and policy advice. The design and functioning of carbon markets was a key research topic in CCCEP Phase One, structured around a dedicated Carbon Market Group at LSE. In Phase Two our goal is to analyse the design options facing new carbon-market schemes and ways to strengthen existing schemes within prevailing policy constraints (e.g. ways to tighten supply in the EU ETS). We will document the continuing evolution of carbon trading from a specialist niche market to a widely used policy tool, and analyse the interaction of carbon markets with other climate policies (such as the support of renewable energy) and policy objectives (such as raising revenues).

The project will examine how to design policies in a context where concerns about extreme permit prices and compliance costs have hampered efforts to adopt ETSs. Hybrid policies, in particular price collars (where there is both a price ceiling and floor), have attracted attention as a way to constrain costs and price variability. However, price collars also expand the range of possible emissions outcomes, which calls into question the environmental integrity of such systems. Using stochastic/dynamic economic modelling that allows inter-temporal trading and correlated uncertainties, we will investigate how different hybrid policies affect economic and environmental performance. A second key area of research will investigate strategic permit trading and technology

adoption: a key consideration when choosing a policy is the incentives it provides to invest in or adopt new low-carbon technologies. Most of the current literature relies on calculating the aggregate cost savings achieved by regulated firms that have adopted the new technologies. It neglects the impact of aggregate reductions in the amount of unused allowances available for exchange and the fact that some firms can free-ride on allowance price decreases caused by other firms' abatement. We will analyse the dynamic incentives for technology adoption in a trading system, when it is possible to trade strategically in the market (imperfect competition). What is the optimal compliance strategy of the firm and when is a contingent policy required to restore the dynamic incentives to adopt low-carbon technologies?

Theme 3: Evaluating the performance of climate policies (Leader - Fankhauser)

Experience is now accumulating from the implementation of climate mitigation and adaptation policies and governance arrangements at all levels from the local to global. Evaluation of their performance is thus increasingly possible and should be done to inform the design and refinement of new policy interventions. Our first research theme will involve projects that analyse the performance of key climate policies in a fragmented, multi-speed world and that also innovate methodologically by generating new datasets and measures of low-carbon innovation.

3a. Consumption-based carbon accounting and mitigation policies (Barrett and Gouldson)

Analysis of carbon emissions embodied in the goods and services we consume confirms that, in countries like the UK, emissions have not been decoupled from economic growth, merely outsourced to other countries. While the UK's territorial carbon emissions fell by 27% between 1990 and 2009, consumption-based emissions rose by 13%. This trend is set to continue (Barrett and Scott 2012). While there has been considerable effort to measure and improve the robustness of consumption-based accounts, there has been reluctance to develop policies that build on its insights and a lack of research to that end. However, there has been recent political interest in consumption-based accounting in the UK, which is shifting focus from measurement and reporting towards policy. In response to a review by the Energy and Climate Change Select Committee, the Department of Energy and Climate Change has been asked to outline how consumption-based accounting will be used to report emissions *and to explore further climate-policy options*.

This research project will address a series of inter-related research questions: what are the policy implications of consumption-based accounting? What are the policy options for addressing them? What factors shape the potential for policy learning on this issue and how can research enable such learning? Grounded in theories of policy learning drawn largely from political science, the research will be based on a series of workshops and stakeholder interviews. Results will then be fed back into research on consumption-based accounting to see if there are ways of presenting data and policy options that would best facilitate policy learning. While we will be working primarily in the UK and engaging primarily with national government, international and local dimensions will also be considered where appropriate.

3b. Carbon, competitiveness and trade (Dechezleprêtre and Martin)

A major political debate is taking place in Europe and elsewhere over whether to use carbon-based border tariffs to mitigate the effects of unilateral action on competitiveness and carbon 'leakage'. In a world of free trade, the unilateral adoption of a carbon price by e.g. the EU through its Emissions Trading Scheme (ETS) may generate a pollution-haven effect elsewhere: foreign countries specialise in the production of carbon-intensive products in which they have a newly acquired competitive advantage and which they can subsequently export back to 'virtuous' countries. Multinational companies may also decide to relocate their 'dirty' production activities. Here we seek to contribute to the debate by analysing the effects of existing mitigation policies on the competitiveness and trade performance of companies. The analysis will be mostly based on the EU ETS, since firm-level data on European countries are available and of high quality, and since the EU ETS has been running for sufficiently long to allow meaningful statistical analysis. However,

we will monitor the possibility of analysing other ETSs or carbon-tax schemes subject to the availability of suitable data.

The research will revolve around two main lines of analysis. First, we will analyse how the EU ETS has affected European firms' competitiveness, as measured by their productivity and their ability to compete on international export markets with other firms that have not been affected by the policy. Second, we will analyse the impact of the EU ETS on the importing patterns of regulated companies. We will investigate whether the EU ETS has made regulated companies more dependent on foreign imports. This will allow us to estimate the extent of carbon leakage. An important advantage of the EU ETS is that the policy only affects a share of European companies. This allows us to compare changes in outcomes of firms subject to ETS regulation with those that are not, both before and after the introduction of the scheme (or before and after the beginning of a new trading period), using state-of-the-art econometric techniques such as matching.

3c. Measuring and evaluating low-carbon innovation (Dechezleprêtre and Martin)

Innovation is essential to responding to climate change. However, there are multiple market failures and barriers that hinder innovation and call for public policy responses. A key challenge in evaluating such policies is the measurement of innovation. Researchers have come up with several innovation metrics, but each of them has its problems. Patent counts (Griliches 1990; Jaffe and Trajtenberg 2005) are easily available and provide additional information of interest, such as citations and information about patent owners and inventors. However, not all innovations are patented. Moreover patents are an outcome measure of innovation, so they cannot for instance be used to examine if inventors tried, but did not succeed, in innovating. By contrast, R&D-spending data (Griliches 1984) are a measure of innovation inputs. However, they are not widely available. Moreover, what is formally classified as R&D spending for accounting purposes is likely only a small fraction of actual innovation spending. Dedicated surveys on innovation such as the Community Innovation Survey (CIS) in the EU (Mohnen, Mairesse et al. 2006) provide a detailed picture of the innovation activities of surveyed firms and can reveal information on both innovation inputs and outputs. However, conducting such surveys is expensive, so they can only ever capture a small fraction of innovating firms.

This project explores new ways of measuring low-carbon innovation, by exploiting new datasets emerging from Internet activity, such as Google search data. The challenge is how to aggregate and scale raw events of online activity into a metric that is informative of (clean) innovation activity. In the case of Google search data this would involve finding the right search keyword combinations. Our starting point would be informed by our work from CCCEP Phase One on clean innovation using patent data (Dechezleprêtre and Martin 2010). We will go on to study the relationship between our new measures and the existing innovation metrics mentioned above. Finally, the eventual purpose of the construction of new innovation indicators is to facilitate the evaluation of policies to promote low-carbon innovation. We will do so by for instance examining if our innovation indicators are related to the price of allowances in the EU ETS.

Theme 4: Managing climate risks and uncertainties and strengthening climate services (Leader - Dietz)

New scientific evidence on climate change and slow progress on emissions abatement together indicate the future holds significant climate risk. The core objective of this theme is to research how best to manage climate risk in the context of uncertain and potentially rapid climate change. An essential aspect is, by implication, the production of climate information or what the community of climate scientists is increasingly framing as "climate services" (WMO 2009). This theme extends our work on the evaluation of the predictive ability of climate models using a novel analogy with the theory of chaotic systems. It also builds on Phase-One research that established the conceptual/normative basis of sound adaptation planning, to consider what is the capacity of key actors to adapt in the face or uncertainty and 'tail risks', and what are the implications of this for mainstreaming adaptation?

4a. Institutions, climate services and adaptation (Dessai, Morton, Ranger and Stainforth)

Decision-makers come under intense pressure to demonstrate the economic benefits of strategies to adapt to climate change. Yet the science still cannot provide robust estimates of the probabilities of future climates (Stainforth, Allen et al. 2007). This poses challenges for traditional investment appraisal. Phase One of CCCEP laid normative foundations for investment decision-making under 'deep' uncertainty (e.g. Millner, Dietz et al. 2010; Oreskes, Stainforth et al. 2010; Ranger, Millner et al. 2010). This project will go on to explore 'positive', operational aspects of adaptation in organisations making decisions across portfolios of large, capital-intensive and climate-sensitive assets, such as water companies, local councils, energy suppliers and national governments. In doing so, we integrate two new research dimensions: (i) the co-production of knowledge and (ii) portfolio decision analysis.

First we will draw on a state-of-the-art technique in management science, portfolio decision analysis (Salo, Keisler et al. 2011), to examine how to adapt a multi-component/asset organisation or system under deep uncertainty. This technique has a rigorous decision-analytic core, but unlike many such approaches it stresses deliberation and participation. Hence it can be used for positive analyses, i.e. as a basis on which to examine how organisations and systems currently work. This part of the project is a 'narrow and deep' case study of a particular organisation, based on a process of continuous engagement between scientists, economists, decision-makers and stakeholders, including the use of participatory workshops. Second, by drawing on a broader set of cases from diverse countries and sectors[1], we will develop more generic conclusions about the science and economics of portfolio investment, including on the value of information, and on the impact of spatially correlated uncertainties. Third, we will evaluate the experiences gained of knowledge co-production in adapting to climate change. While the literature implies that co-production of knowledge is beneficial, there is little empirical evidence to support this claim (McNie 2007). We will conduct a cross-national comparison of co-produced climate knowledge for adaptation, identifying four spaces of science-policy interaction where co-production takes place. Can co-production help to overcome the information barriers to adaptation within organisations?

4b. Climate change, nonlinear systems and economic decisions (Stainforth, Dietz and Werndl)

Climate is a complex nonlinear system (Stainforth, Allen et al. 2007), which under climate change is being driven into previously unobserved states. Producing climate information and managing climate risk therefore require a conceptual understanding of the transient behaviour of nonlinear systems under time-dependent forcing, of the implications of nonlinearity for the interpretation of imperfect models, and of the consequences of nonlinearity for economic and policy decisions. This project is an end-to-end study of the implications of nonlinearities in climate change. It builds on the novel, inter-disciplinary collaboration already underway in CCCEP across philosophy, nonlinear systems theory, climate modelling and economics. It will tackle three challenging, highly relevant, yet rarely addressed questions.

First, how can we describe the behaviour of a nonlinear system under varying forcing? Many concepts in nonlinear-systems theory are defined with respect to systems in which, unlike climate change, parameters do not vary over time. Through the study of simple nonlinear systems with time-dependent parameters, analogous to the problem of climate change, we aim to advance the general theory of such systems, but also to better understand the predictive capability of standard climate-modelling approaches. Second, what is the basis for ruling out some models as irrelevant to specific aspects of climate change? In its efforts to provide "climate services", the climate-modelling community tries to exclude or down-weight "bad" models, yet this is a challenging task: all climate models are in some sense "unrealistic", conversely most represent certain aspects of the system in a useful way. We ask, how can a sound physical basis be provided for retaining some

[1] Leveraging on-going and existing projects, such as from CCCEP Phase One, EUFP7 ADAPTIVE, EUPORIAS, BASE, EQUIP, ICAD and ARCC-Water.

models while excluding others? The research will not only inform climate modelling: it will have wider relevance in the philosophy of science. Third, what are the implications of climate nonlinearities for economic decisions? There has recently been a surge of interest in the implications of uncertainty about the climate system for economic analysis (e.g. Weitzman 2009), yet the literature remains limited to smooth, long-run, average changes in climate. In this part of the project, we will undertake the first formal analysis of the implications of climate uncertainties – related to nonlinearity – for economic decisions. We will do this by coupling classical models developed in nonlinear systems theory with models of economic decision-making under climate change (e.g. Lorenz 1963; Lorenz 1984).

4c. Integrated sustainability science for pro-poor climate policy (Dougill, Stringer and Quinn)

The UN-REDD programme, voluntary carbon markets and the strong push for climate-compatible development have together created a demand for integrated assessments of carbon storage potential in forests, which link scientific knowledge and local knowledge in ways that promote sustainable development. This project will assess the use of the evolving field of terrestrial carbon science, its uncertainties, and how it is and can be integrated with local knowledge. This interdisciplinary, multi-stakeholder research will: a) analyse the use of climate science (from regional climate models and carbon-budget studies) in relevant theoretical frames, such as ecosystem service valuation, community-based natural-resource management and climate-compatible development; b) analyse the corresponding use of climate science in Agriculture, Forestry and Land Use (AFOLU) projects in sub-Saharan Africa; and c) identify best practice in the integration of carbon science and community perspectives. The aims are to enable better monitoring of where carbon is stored in soils and forests, to facilitate more inclusive climate policy (nationally and internationally) and to guide development practices in projects harnessing climate finance.

Our focus will be on a middle-income country such as South Africa where national policy focuses on a Green Growth Plan and significant scientific investment has been made in climate services, as well as on low-income countries such as Malawi and Swaziland where policy development and investment in climate services are lagging. The mix of theoretical analysis, case studies and analysis across levels builds on CCCEP Phase One, where we looked at the links between climate science, development and local adaptation to climate change in dry-land systems (e.g. Fraser, Termansen et al. 2010; Twyman, Fraser et al. 2011; Simelton, Fraser et al. 2012; Stringer, Dougill et al. 2012).

Theme 5: Enabling rapid transitions in mitigation and adaptation (Programme Leader - Paavola)

Despite two decades of efforts, global carbon emissions continue to increase, and are accelerating rather than decelerating. At best, the 'Durban Platform' will yield a global agreement in 2015 to be in force in 2020. China asserts that its emissions will not peak until around 2030. This slow progress in mitigating climate change now may require more radical mitigation and adaptation later. On one hand, there may be a need for rapid, ambitious decarbonisation at the scale of 5-6% emissions reductions per annum. On the other hand, more severe climate impacts associated with a significantly warmer world may require radical adaptation measures, such as population relocation or large-scale structural adjustment. While existing structures and institutions may well cope with slow, incremental change, it is unclear how they perform under and can facilitate more radical change. This theme uses economic and institutional approaches to examine what a systemic transition to a low-carbon, climate-resilient economy might look like.

5a. The economics of rapid climate transitions (Fankhauser, Hepburn and Ranger)

The scope for rapid transitions towards both decarbonised and climate-resilient economies needs to be better understood, despite not being in any sense 'Plan A'. Transitions like these may require preparation to maximise the probability of delivering results in a way that minimises structural disruption to the global economy and keeps transformative options open (e.g. avoid locking in high-

emissions infrastructure or economic development in hazard zones). This project is an economic and political-economic analysis of rapid climate transitions.

At the macroeconomic level, the research examines analogies with the transition from communism in Eastern Europe, and with the rapid economic transition during war to gain insights into this sort of major structural change. Rapid transitions may have significant economic and financial consequences, which are presently inadequately understood. For example, the major shift from "fossil rents" to "climate rents" in the case of decarbonisation, or the need for large-scale relocation in the case of climate resilience, will create enormous resistance from vested interests. At the microeconomic and technological level, the research will use techniques such as optimal control theory, industrial organisation, regulatory economics and spatial economics to study – both theoretically and by using case examples – issues such as path dependence (e.g. the effect of existing research on future R&D or of existing settlements on location decisions), time inconsistency (e.g. the credibility of managed-retreat policies), rigidities to structural change (e.g. economic restructuring away from fossil fuels), and radically different response equilibria (such as situations where the optimal response "flips" as a function of climate impacts, say, from coastal protection under a modest change to a managed retreat under extreme change).

5b. Systemic approaches to low-carbon transitions (Foxon, Steinberger and Taylor)

The need to accelerate the innovation and deployment of low-carbon technologies and processes is set out in many reports. This suggests the need for a more systemic approach, emphasising potential wider co-benefits to the economy and society and examining the interests and roles of government, market and civil-society actors in achieving them. This project will therefore undertake a systemic, co-evolutionary analysis (Foxon 2012) of low-carbon innovation, combining historical insights, case studies of current best practice, and future implications. The research will involve three linked phases.

The first phase will examine conditions for a new energy-industrial revolution. This will examine the justification for, levels of investment in and roles of actors needed for a new Schumpeterian wave of innovation in low-carbon technologies and processes, drawing on insights from past industrial transformations and taking a co-evolutionary approach that spans changes in technologies, institutions, business strategies and user practices. The second phase will investigate best practice and opportunities in current low-carbon innovation policies. It will examine current examples of successful low-carbon innovation, covering demand-side as well as supply-side technologies, in order to draw out the lessons for appropriate combinations of regulatory drivers and incentives for market experimentation, with a particular focus on interventions that encourage systemic changes. Third, the wider social and economic implications of low-carbon innovation will be explored in relation to trends in energy supply and demand, distributional equity within and between countries, job creation, and human-development benefits (Steinberger, Timmons Roberts et al. 2012). The three areas of research will be brought together into recommendations for policy-makers and identification of areas that would benefit from further research, development, demonstration and deployment (RDD&D).

5c. Governing rapid transitions in mitigation and adaptation (Paavola, Gouldson and van Alstine)

There is increasing awareness of the limited capacity of the state to intervene in the economy. Globalisation and liberalisation have raised the political capital required for state intervention, especially if the intervention impacts on competitiveness. Optimists suggest these limits have led to a shift away from the 'provider' or 'controller' state towards the 'facilitator' or 'enabler' state and even the 'big society'. Rather than regulating directly, the facilitator/enabler state seeks to create conditions that allow actors to govern themselves. This governance turn is reflected in the extensive use of market- and information-based instruments, as well as self-regulation, which disperse authority and responsibility to multiple actors and levels.

This project asks whether these new governance arrangements have the capacity to deliver deeper transitions towards a low-carbon, climate-resilient economy and society. Do they depend on a degree of self-interest or civic-mindedness that cannot last forever? Will early experiments lead to learning that continually delays the point at which the limits of their influence are encountered? The project will adopt a comparative case-study approach of governance initiatives on both mitigation and adaptation, successful and unsuccessful. Mitigation cases might include voluntary carbon regulation initiatives and carbon targets. Adaptation cases can include climate-change partnerships and voluntary measures to overcome water scarcity or to build resilience to extreme weather events. In each case we will adopt an inter-disciplinary approach, which admits insights from political science and other social sciences to map stakeholder perspectives on, and expectations of, the actual and potential efficacy of these arrangements over time. Our eventual aim is to develop a framework for the successful application of new governance arrangements, which approximates Jänicke and Weidner's influential analysis of success factors in environmental policy.

CCCEP Innovation Fund

Beyond our programmed research, we aim to stimulate, develop and communicate innovative ideas on climate policy and decision-making through a small CCCEP Innovation Fund. The fund will be used for two annual competitions.

The first will seek short descriptions of innovative ideas for climate policy from the research community, with two winners being invited to spend time in CCCEP each year to develop their ideas into a Policy Brief. Each winner would be supported by a small stipend to cover travel and living costs.

The second would be for practitioners from the public, private or voluntary sectors to propose innovative ideas on climate policy/decision-making, with two winners each year working with CCCEP staff to organise workshops to develop their ideas, again leading to a Policy Brief. Each winner would receive one month of research support from a CCCEP PhD student to develop their idea (this would play an important role in capacity building for our PhD students), and each workshop would be funded by CCCEP. As well as promoting dissemination of the full policy briefs from the winners, CCCEP will publish a selection of other ideas on its web-site with the aim of expanding the range of policy options under discussion.

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4. Engagement of users and beneficiaries

Objectives and overall strategy

In Phase One, CCCEP successfully established itself as a leading research centre on climate-change economics and policy, not only in terms of the academic community's quest for new knowledge, but also in promoting better decision-making about climate change beyond academia in the public, private and voluntary sectors. In Phase Two, CCCEP has an ambitious strategy to consolidate and expand the influence of its ideas among the research community, while also increasing its engagement with decision-makers in the UK and abroad.

Our engagement strategy for Phase Two has been framed by discussions with a wide range of external users and beneficiaries of our research, including with the non-academic members of our Steering Committee and with a wider network of stakeholders. The strategy is guided by six key principles:

- That ***continual two-way dialogue*** with research and non-research communities ensures relevance, establishes channels of communication and develops pathways to impact throughout the life of the research.
- That we should recognise resource constraints and ***target key audiences*** in order to maximise the prospects for impact. These audiences will often be in core policy and

decision-making communities, but they can also lie amongst wider networks of engaged stakeholders (e.g. NGOs), where influence can be exerted less directly and at times the context for decision-making can be changed.

- That in order to prioritise and target our resources, we should seek the right balance between ***extensive and intensive engagements***. As we have shown previously, we have engaged with a wide range of organisations in Phase One, but within those organisations we have also engaged with key departments or individuals intensively over time. Building these relationships over time is often a key pathway to impact.
- That we should ***combine formal and informal engagements***, as experience shows this is often the most effective way of exerting influence. Our formal communication of research results through, for example, policy briefs and workshops will continue, but we will also support the building of direct contacts with decision-makers – for example by encouraging CCCEP members to sit on advisory bodies and/or engage in secondments and joint working.
- That we should be adaptable and responsive, continually looking for ***timely and appropriate*** ways of communicating in the right ways with the right people. Again experience shows that value can be added and impacts secured by continually searching for periods of resonance between particular research findings and the most pressing political or economic issues of the moment.
- That we should be driven by a ***focus on outcomes and impacts*** as well as more traditional research outputs – whilst peer-reviewed academic outputs are a *sine qua non* to secure our academic credibility and endorse the robustness of our research, comparable metrics of stakeholder engagement can often be seen as a means to an end rather than as an end in itself. We seek to avoid this trap.

Engaging the academic research community

In Phase One, CCCEP established itself among the communities of researchers specialising in climate change. This will continue to be a mainstay of our academic engagement activities in Phase Two, since much climate research takes place and is communicated in specialist 'field' institutions. Examples of these institutions range from the IPCC, on which CCCEP has several representatives in different capacities from chapter authorship to peer-review, through academic associations such as the American and European Associations of Environmental and Resource Economists and the International and European Societies for Ecological Economics, to flexible consortia and networks of researchers with a shared interest in different dimensions of climate-change economics and policy.

However, the climate field is not the limit of our ambitions for Phase Two. Rather, we have the twin aims of building the profile of climate change in key disciplinary communities, and of strengthening links between these disciplinary communities and inter-disciplinary climate research. So, for example, CCCEP researchers have begun to present their work at disciplinary conferences such as those of the Royal Economic Society and the American and European Economic Associations, and to publish their work in general-interest disciplinary journals. We aim to bolster our presence at such conferences and in such journals, as we see that disciplinary communities could make a much bigger contribution to the climate debate than they currently do. Other means to help to frame high-level debate in the sciences and social sciences include through the British Academy (the Chair of CCCEP, Nicholas Stern, will be President of the British Academy from July 2013) and the Royal Geographical Society (current Director of CCCEP and member of the Grantham Research Institute, Judith Rees, will be the new President of the Royal Geographical Society). As many CCCEP members will combine participation in such disciplinary communities with contributions to inter-disciplinary debates, we see an important role for us in ensuring the two are connected.

Engaging policy-makers

In Phase One, CCCEP engaged extensively with public policy-makers in the UK, in selected other countries and in international climate-policy institutions. In Phase Two, we aim to consolidate this policy engagement, but also to broaden it, particularly to a wider set of countries that are major emitters of greenhouse gases and/or are 'hotspots' of vulnerability to climate change (see e.g. Fraser, Simelton et al. 2012).

We have already established very strong channels of communication with UK policy-makers, both nationally and locally, through a process of continual engagement that informs the scope of our work and allows opportunities for research findings to be fed into decision-making in an appropriate and timely way. Such interactions will be continued in Phase Two.

In national government, CCCEP is engaged at various levels, from ministers through to civil-service directorates and divisions, in the departments for Energy and Climate Change, Environment, Food and Rural Affairs, Business, Innovation and Skills, International Development, as well as the Cabinet Office, the Treasury and the Prime Minister's Office.

In addition to direct contact with government, CCCEP will continue to inform UK national policy-making through written and oral evidence to parliamentary committees (particularly the House of Commons Select Committee on Energy and Climate Change and its Environmental Audit Committee), input to the statutory Committee on Climate Change (of which Sam Fankhauser is a member and GRI Senior Visiting Fellow David Kennedy is Chief Executive), partnership activities with the All Party Parliamentary Climate Change Group, briefings for MPs and peers (such as Bassi, Bowen et al. 2012), and collaborations with bodies such as the Met Office and the Environment Agency.

At the local level in the UK, we already have strong links with numerous local authorities and with the networks of actors involved in low-carbon cities. Relationships will be developed with policy-makers in other major cities in the UK and internationally, who require information and advice about low-carbon targets or financing, and delivering the transition to a low-carbon economy. These contacts will be established and maintained by a part-time Communications Officer, based at CCCEP Leeds, who will also assist with creating a network of local decision-makers in selected international (particularly Chinese) cities interested in low-carbon growth, following work in our scientific programme described above.

As the EU is collectively one of the world's largest emitters of carbon, and as UK climate policy is set within a framework of EU policies such as targets and the ETS, CCCEP will increase its activities to engage decision-makers in Brussels (particularly in the Commission Directorate-Generals for Climate Action and for Energy). Key areas of focus will include the future development of the ETS and the delivery of emissions targets for 2020 and beyond.

But, in recognition of the importance of climate policy-making beyond the EU, we will increase our efforts to engage policy-makers in selected major-emitting countries outside Europe's borders. One practical point of entry is in countries within this set that are introducing, planning or considering ETSs and carbon markets, including Australia, China and South Korea. We have already had input into the design of Australia's new ETS. Another is in leveraging the high-level links of CCCEP members in China and India. Contacts will also be increased with national and local policy-makers on climate-compatible development in sub-Saharan Africa, which is a vulnerability hotspot facing significant adaptation challenges.

CCCEP will also continue to support the negotiations towards an international agreement on climate change, particularly through Nicholas Stern's high-level engagement with the annual summits of the UNFCCC and the G20, but also through a range of other engagement activities, including on the UNFCCC Subsidiary Bodies.

We will further be able to take advantage of long-standing, high-level relationships with major international organisations, particularly the multilateral development banks, including the World Bank, the Asian Development Bank and the European Bank for Reconstruction and Development. Major projects on green growth will also be conducted in partnership with the Organisation for Economic Cooperation and Development and the Global Green Growth Institute, the latter of which has just invested $2 million of leveraged funds in a research partnership with GRI.

Engaging business and the voluntary sector

CCCEP's engagement with business has and will continue to focus on those sectors particularly closely connected with our scientific programme.

One of these is financial services. In Phase One, CCCEP undertook a major partnership with the reinsurance company Munich Re to explore the economics of climate change for the insurance industry. While insurance is not a primary focus of our scientific programme in Phase Two, it will continue to figure frequently, since it is a key tool to manage climate risk. Therefore the (re)insurance sector, including (re)insurance companies and the catastrophe modelling firms that provide them with forecasts of climate-related claims and losses, is a key stakeholder Another important connection with financial services comes in the shape of our research on carbon markets: financial-services providers like investment banks are a key player in carbon markets. Finally, our work on green growth and low-carbon innovation is leading to an increasingly deep engagement with institutional investors, i.e. pension and sovereign-wealth funds, who individually and collectively have a tremendous capacity to facilitate the investment necessary to decarbonise economies.

Our work on the links between mitigation policies and economic performance is likely to be of strong interest to carbon-intensive sectors such as power and heavy manufacturing that tend to bear the brunt of regulation. Our work on adaptation will be especially useful to sectors facing the challenge of investing in long-lived assets under climate change, notably energy and water supply. Indeed, our scientific programme on adaptation is designed around a sustained and close dialogue with example companies in these sectors and our work on climate services has direct relevance to organisations such as the Met Office.

As well as engaging with decision-makers in the public and private sectors, we will also continue to engage with a range of voluntary-sector organisations. Although these are less direct forms of influence than directly engaging with the public or private sectors, they have the potential to amplify our influence. In Phase One, we have worked with NGOs in various ways. For example, we have worked closely with Friends of the Earth and the Energy Savings Trust on the economics of low-carbon cities and with organisations such as Business in the Community to access the information they hold on private sector expectations on the transition to a low-carbon economy. We have also worked with the Carbon Disclosure Programme to explore the links between carbon and competitiveness and between carbon management and carbon performance.

By working with NGOs in these ways, we can sometimes gain access to information to create new research possibilities, and sometimes better enable them to exert influence on policy-making in government or on decision-making in the private sector. We can also work with them to help change the context for decision-making. One example of collaboration that combines all three of these impacts is our work on the limited value of voluntary carbon reporting; the work helped NGOs to make the case for mandatory reporting by UK-listed companies. Such mandatory reporting can be expected to increase the profile of carbon management and performance in mainstream corporate governance processes within the UK. In Phase Two, we will actively explore the potential for similar engagements (not least through our Steering Committee, where we hope to have continued inputs from WWF UK).

5. 'Pathways to impact' in Phase Two

This section explains how we plan to deliver our engagement strategy with the target audiences outlined above.

Pathways for engaging the research community

Consistent with our overall strategy, engagement with the research community starts when the research itself does, and makes significant use of informal but influential contact. Our researchers will be encouraged and facilitated to communicate with the very best in their respective areas right from outset. In many cases, such contact needs little support beyond the identification of researchers and research networks, and mentoring where appropriate. But we will also provide more structured support in various ways.

We will host a programme of events, including Centre-level conferences, more specialist workshops, and regular public lectures and research seminars at both LSE and Leeds. We will continue to participate in major academic conferences worldwide, specialist workshops and to give seminars at other research institutions. We have set aside significant funding to do so.

We will also support short academic visits to and from CCCEP. In recent years, CCCEP has hosted researchers from all over the world for visits ranging from a few hours to several weeks, while CCCEP researchers themselves have visited universities as far away as e.g. the United States and Japan.

At a higher level, continual dialogue is facilitated through CCCEP's representation on the steering committees and editorial boards of major academic organisations and journals respectively.

As the research process reaches its conclusion, we will maximise the possibilities for publishing our work. Subject to journal policies, we aim to publish all of our latest research in our own peer-reviewed, open-access working paper series (now containing one hundred titles). Our strategy is then to publish papers in prestigious and high-impact academic journals, though it may also be appropriate to contribute chapters to edited volumes and to author monographs, where possible/appropriate to be published by the leading university presses.

Pathways for engaging policy-makers, business and the voluntary sector

Our engagement with public policy-makers, business and the voluntary sector is led by a dedicated Policy and Communications Team. This team is part-funded by ESRC, but enjoys substantial leverage, mainly from GRI, but also from an in-kind contribution by Leeds. The GRI contribution alone is worth c. £300,000 per year. Indicative of our emphasis on engagement, the team is exceptionally large for a university research centre, with:

- a full-time Policy and Communications Director, Bob Ward;
- a full-time Policy Communications Manager leading our engagement with public policy-makers and with businesses with a policy interest;
- a full-time Public Communications Manager leading our engagement with the voluntary sector and civil society;
- a planned part-time post for a Communications Officer (Leeds);
- three full-time Policy Analysts specialising in responsive-mode research with a policy angle;
- a full-time Web Officer maintaining the CCCEP website;
- a planned post for a full-time Media Officer.

Drawing on these resources, and applying the guiding principles set out above, CCCEP Phase Two will:

- Encourage ***continual two-way dialogue*** with research and non-research communities throughout the life of each project, by working with theme and project leaders to identify

key target audiences and develop engagement and communications plans that draw, where appropriate, on the Steering Committee and on existing networks and relationships.

- On ***extensive engagements*** with wider audiences, a key pathway to impact is our website. As well as the standard features one would expect to see in a research centre's website, including descriptions of staff and research projects, lists of outputs etc., www.cccep.ac.uk has a distinctive identity based on a professional design and already includes more advanced features such as bespoke commentary/content and social media including Twitter. In Phase Two, we will further develop the website, especially expanding bespoke content, with the aim to eventually attract in excess of 5,000 unique visitors per month. Other extensive engagements include our media work and wider public communications. We already have plans in train, funded by GRI, to appoint a dedicated Media Relations Officer to help increase coverage in the broadcast, print and on-line media both in the UK and internationally. Furthermore, following detailed market research on where we can have most impact on public debate and consciousness, our Public Communications Manager will also provide tailored online content for the wider public, as well as more focused and detailed content for undergraduate students at UK higher education institutions, a demographic ideally placed to change in a productive way the context for decision-making on climate change.
- On ***intensive engagements***, we will continue to engage frequently with key decision-makers in a wide range of organisations, including international organisations like the UNFCCC, World Bank and OECD, UK central-government departments such as DECC, selected local governments, businesses and NGOs. While these engagements are often individual-specific, a key aspect of our engagement activities is that we maintain a strategic overview, primarily through our Policy Communications Manager.
- On ***formal engagements,*** we will continue to communicate with decision-makers and other stakeholders through dissemination of policy briefs and papers and responses to official inquiries etc. CCCEP already has a successful range of policy briefs, professionally typeset and printed on subjects and issues of fundamental interest to a broad range of decision-makers. It also has a series of policy papers, produced in-house, for the rapid dissemination of information relating to immediate issues, or targeted at a narrower range of audiences.
- On ***informal engagements,*** building on the extensive network of contacts that have been developed during Phase One, we will continue to engage in consultations and to provide advice and support to key decision-makers. These relationships will be reinforced in Phase Two through, for instance, support for CCCEP members with advisory roles, the continuation of Visiting Fellowships for individuals from outside academia, and the hosting of regular informal meetings for staff and external contacts in key research areas.
- To provide ***timely and appropriate*** forms of communication, CCCEP researchers will be encouraged to work with the responsive-mode Policy Analysis team to produce policy briefs, policy papers and targeted background research that might support presentations or simply representations at informal meetings.
- To facilitate ***learning on engagement and communications***, we will share best practice and benchmark activities and performance against other ESRC research centres and related centres, and we will continue to engage on the issue of evaluation through the activities of Living With Environmental Change (LWEC) on this topic.

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6. Relationship with the ESRC's Strategic Plan for 2009-2014

Premises of ESRC's Strategic Plan

ESRC's Strategic Plan for 2009-2014 is premised on the need to respond to the challenges of:

> "mapping the causes and consequences of change in this complex and dynamic world…identifying tools to manage risk, finding remedies for ills and preparing society for further change in future." (p1)

Climate change fits squarely into this picture, since it will be one of the foremost sources of – and of course consequences of – economic and social change in the future. Moreover managing climate change is all about managing risk in a broad sense, as our scientific programme makes clear.

The Strategic Plan is also premised on "the social scientist's value [being] increasingly realised in interdisciplinary work" (p1). Our bid for Phase Two is highly interdisciplinary, bringing together elements of the physical and natural sciences with economics and a wide range of social sciences. Moreover it takes us into new disciplinary territory including economic and business history.

ESRC's strategic challenges

The Strategic Plan identifies seven areas of strategic challenge for economic and social research and our bid contributes to several of them. The seven challenges are:

- Global Economic Performance, Policy and Management
- Health and Wellbeing
- Understanding Individual Behaviour
- New Technology, Innovation and Skills
- Environment, Energy and Resilience
- Security, Conflict and Justice
- Social Diversity and Population Dynamics

"Global Economic Performance, Policy and Management" is a strategic challenge set against the backdrop of the financial crisis and economic downturn. ESRC seeks to improve our understanding of macro-economic performance and policies to increase it, including the role of infrastructures like energy. Our research theme on **Green growth and climate-compatible development** feeds directly into these topics, as does our work on **competitiveness, trade and innovation**.

"New Technology, Innovation and Skills" is a strategic challenge that recognises how much contemporary economies rely on innovation. It also recognises that innovation takes place in a linked socio-technical system. Our projects on **Measuring and evaluating low-carbon innovation** and **Systemic approaches to low-carbon transitions** offer complementary contributions to this challenge by respectively improving our ability to measure innovation, not just in low-carbon technologies, and by improving our understanding of innovation as a co-evolutionary process inextricably linked with economic and social change.

However, it is on the strategic challenge "Environment, Energy and Resilience" that our bid has perhaps the most obvious connection. This challenge is explicitly orientated towards the **transition to a low-carbon and climate-resilient economy**, which all of our research is focused on. Furthermore, it identifies, as key aspects of the challenge, **managing environmental change under uncertainty, financing sustainability, public-private partnerships, and the effects on the environment of business cycles** (p16), all of which are included in our project topics.

Secondary contributions include the implications of our work for the energy-security agenda, which is covered by the "Security, Conflict and Justice" challenge, and for social resilience to climate change, which is covered both by the "Health and Wellbeing" and "Security, Conflict and Justice" challenges.

ESRC's aim to maximise impact

The focus in the ESRC's Strategic Plan on maximising the economic and societal impact of research should also be stressed, in particular the principle that "active two-way dialogue and collaboration between social scientists and potential users throughout the research process and beyond is crucial" (p23). We hope that our bid shows both a commitment to this principle and the practical means to achieve it.

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7. Organisational structure and management

Please cross-refer to *Direction and Management* for more detail on our current organisational and managerial arrangements, most of which are planned to continue in Phase Two.

Institutional setting

In Phase Two, CCCEP's institutional setting will remain largely the same. At LSE, it will continue to be embedded within GRI, while at Leeds it will be embedded within SRI. Both institutes can provide a substantial baseline of leveraged support throughout Phase Two, including on related research, for access to administrative support and to the GRI's large and growing Policy and Communications team. In addition, both institutes have ambitious plans to expand their leveraged support in the coming years.

As well as leveraged support from other research councils and funders, both LSE and Leeds can demonstrate their continuing commitment to CCCEP. In Phase Two, LSE will make an in-kind cash contribution of £643,315 (i.e. not including its contribution to the Full Economic Cost of the Centre), while Leeds will make a corresponding contribution of £315,701. These contributions will continue to pay for CCCEP's Manager and they will further pay for: 10% FTE of the buy-out of Andrew Gouldson and Jouni Paavola respectively, 25% FTE towards a Communications Officer, two postdoctoral research posts of 2.5 years' duration and three PhD studentships.

Centre Management

We plan to retain the management structure CCCEP relied on in Phase One, comprising a Management Group, Steering Committee, administration team, and programme and project management. The only substantive planned changes are to staffing.

Management Group

The Management Group will continue to be chaired by *Professor Lord Nicholas Stern of Brentford*. In Phase Two, the Centre Directors will be *Dr Simon Dietz* at LSE and *Professor Andrew Gouldson* at Leeds. Their deputies will be *Professor Sam Fankhauser* at LSE and *Professor Jouni Paavola* at Leeds. Dietz has been Deputy Director and Acting Director of CCCEP in Phase One, while Gouldson has been Director throughout. Paavola has similarly been Deputy Director throughout Phase One, while Fankhauser has served as Acting Deputy Director. Dietz and Fankhauser co-direct GRI, while Paavola directs SRI. Also part of the Management Group will again be *Bob Ward*, Policy and Communications Director at GRI, and the CCCEP Centre Manager, a role that will continue to be performed by *Virginia Pavey*. Therefore there is a great deal of continuity in Centre direction between Phases One and Two. The main difference is that *Professor Judith Rees* is stepping down from her role as Director at LSE. However, because she will continue to hold a position in GRI as Phase Two commences, she is on hand to perform an advisory function.

Steering Committee

The Management Group will continue to be advised by a Steering Committee, again including representation from academia, policy, business and the voluntary sector. We plan to refresh membership of the Committee in Phase Two, though we expect to re-invite a few of the most engaged members from Phase One. We also intend to reduce the size of the Committee in Phase

Two: our experience from Phase One is that a Committee with too many members (in our case currently 19) can suffer from problems of collective action, such that few members feel compelled to make a substantial contribution. At the same time, we plan to consult our existing Committee members on how we as a Centre can better engage with it.

Administration

The Centre's administrative support will be as in Phase One.

Theme and project management, and project researchers

The broad structure of theme and project management used in Phase One will continue, whereby theme leaders are drawn from the Management Group, with project leaders and researchers drawn from a wider group. The project research team includes many of our leading contributors in Phase One, but naturally there is also significant turnover to reflect our changing focus and new staff that have joined the two institutes and universities since Phase One began. Here is a summary of our research team for Phase Two (not including post-doctoral appointments to be made and PhD studentships to be awarded):

- *John Barrett*, Professor of Sustainability Research at Leeds. His research interests include sustainable consumption and production modelling, carbon accounting and exploring the transition to a low-carbon pathway. He is a lead author for Working Group III of the IPCC's 5th Assessment Report.
- *Alex Bowen*, Principal Research Fellow at LSE. He leads GRI's research programme on 'Green Growth', with research interests in the macroeconomic aspects of climate change and the design of mitigation policies.
- *Antoine Dechezleprêtre*, Research Fellow at LSE. His research interests include the innovation and international diffusion of low-carbon technologies.
- *Suraje Dessai*, Professor of Climate Change Adaptation at Leeds.
- *Simon Dietz*, Acting Co-Director of CCCEP, Co-Director of GRI and Senior Lecturer in Environmental Policy at LSE. His research focuses on climate and environmental economics, especially decision-making under uncertainty and questions of equity/social justice. He is a member of the editorial board of the *Journal of Environmental Economics and Management*.
- *Andy Dougill*, Head of the School of Earth and Environment at Leeds, and Professor of Environmental Sustainability. His work is known for the innovative methodologies developed to combine science and local participation to ensure locally-relevant research outputs in both dry-land Africa and the UK uplands.
- *Sam Fankhauser*, Acting Deputy Director of CCCEP, Co-Director of GRI and Professorial Research Fellow at LSE. The main focus of his work is the economics of climate change, in particular carbon markets and the economics of adaptation. He is the Chief Economist of Globe International, a member of the UK Committee on Climate Change, including its Adaptation Sub-Committee, and a member of the editorial board of *Global Environmental Change*.
- *Robert Falkner*, Reader in International Relations at LSE, specialising in international environmental politics and governance. He is an associate of Chatham House and serves on the editorial committee of the *European Journal of International Relations (EJIR)*, as well as the editorial boards of *Global Environmental Politics* and *Global Policy*.
- *Tim Foxon*, Reader in Sustainability and Innovation at Leeds, focusing on innovation systems and processes for a transition to a low-carbon economy. He has recently held a Research Councils UK Academic Fellowship.
- *Caterina Gennaioli*, Post-Doctoral Researcher at LSE. Her interests lie in the evaluation of public policy, combining political-economy theory and micro-econometric techniques. She holds a PhD from Bocconi University in Milan.

- *Andrew Gouldson*, Director of CCCEP and Professor of Sustainability Research at Leeds. He is an inter-disciplinary environmental social scientist who has worked on the relationship between environment and economic development for over 20 years. As well as CCCEP, Andrew is a key member of the Centre for Low Carbon Futures and the Centre for Integrated Energy Research. He is also Editor of *Environmental Policy and Governance* and a member of the expert advisory panel on social sciences for DEFRA and DECC.
- *Dabo Guan*, Senior Lecturer in Environmental Economics and Governance at Leeds. He specialises in environmental modelling, including applications to climate change and water. He is a lead author for Working Group III of the IPCC's 5th Assessment Report.
- *Cameron Hepburn*, Senior Research Fellow at GRI, specialising in climate and environmental economics. He is also a Senior Visiting Fellow at Oxford and an Associate Editor of the *Oxford Review of Economic Policy*.
- *Ralf Martin*, Assistant Professor in Economics at Imperial College London and Visiting Fellow at CEP, LSE. In his research he examines how government policies, especially on climate change, affect business performance.
- *Alec Morton*, Senior Lecturer in Management Science at LSE. He is an expert in the application of decision analysis to help organisations deal with contested values and significant uncertainties. He currently serves on the editorial board of *Decision Analysis* and has edited a key volume on *Portfolio Decision Analysis* (Springer, 2011).
- *Jouni Paavola*, Deputy Director of CCCEP, Director of SRI and Professor of Environmental Social Science at Leeds. His research examines environmental governance institutions and their social justice dimensions, focusing on climate change and biodiversity. He is a member of the Scientific Committee of the European Environmental Agency and the editorial boards of *Ecological Economics*, *Environmental Policy and Governance*, *Environmental Science and Policy*, and *Environmental Values*.
- *Claire Quinn*, Lecturer in Natural Resources Management at Leeds. She is an ecological social scientist with over 10 years' experience working on interdisciplinary projects in Africa and the UK, looking at the links between ecological and socio-economic processes in the management and conservation of natural resources.
- *Nicola Ranger*, Senior Research Fellow at LSE. Nicola leads GRI's research programme on 'Adaptation and Development', and also has research interests in climate modelling of global emissions paths.
- *Susannah Sallu*, Lecturer in Environment and Development, and Deputy Director of the Centre for Global Development, at Leeds. Her research is interdisciplinary, using theories from both the natural and social sciences to understand the complexity and politics of social-ecological systems, particularly in Africa.
- *David Stainforth*, Senior Research Fellow at LSE. A physicist by training, his research interests lie in climate modelling and the interpretation of model results. David co-founded and was chief scientist of the *climateprediction.net* project, the world's largest climate modelling experiment.
- *Julia Steinberger*, Lecturer in Ecological Economics at Leeds. Her research examines the connections between resource use (energy and materials, greenhouse gas emissions) and societal performance (economic and human wellbeing).
- *Lindsay Stringer*, Co-Director of SRI at Leeds and Reader in Environment and Development. Lindsay's research is interdisciplinary and uses theories and methods from both the natural and social sciences to understand environmental change and livelihood dynamics. She is an Associate Editor of *Food Security*.
- *Rory Sullivan*, Senior Research Fellow at Leeds. He is an expert on the financial/investment implications of climate change, having spent seven years working on the issue in one of the UK's largest asset management companies, as well as serving as consultant to international bodies such as EBRD, OECD, the World Economic Forum, UNEP and UNDP.

- *Luca Taschini*, Research Fellow at LSE. His work focuses on the theory of market-based mechanisms, energy economics, and technology change. He is a member of the CESifo Energy and Climate Economics Research Group in Munich and a visiting scholar at the Research Center for Sustainability Science at the Ritsumeikan University in Japan.
- *Peter Taylor*, Professor in Sustainable Energy Systems at Leeds. His research combines science, technology, economics and policy to analyse the transition to low-carbon energy systems. Prior to joining Leeds Peter was Head of the Energy Technology Policy Division at the International Energy Agency (IEA) in Paris.
- *James Van Alstine*, Lecturer in Environmental Policy at Leeds. His research focuses on environmental policy and governance, the social and environmental risks of industrial development, the politics of low-carbon transitions and the governance of resource extraction in the Global North and South.
- *Charlotte Werndl*, Lecturer in Philosophy, Logic and Scientific Method at LSE. Her research interests lie in the philosophy of science, physics, biology and mathematics, as well as in logic. Her recent paper, "What Are the New Implications of Chaos for Unpredictability?", won the Cushing Memorial Prize in 2011.

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8. Key Performance Indicator targets

We propose that our Key Performance Indicator (KPI) targets for Phase Two be comparable to Phase One. While, on the one hand, CCCEP is up and running and therefore we do not have to factor into our targets allowance for as long a start-up period, we face, on the other hand, a real-terms budget cut in Phase Two. Unless otherwise stated, Table 6 presents our KPI targets for the core research programme (i.e. not including research partly or wholly supported by leveraged funding).

Table 6. Selected KPI targets for Phase Two (note: ESRC categories).

KPI	Target
Literature	
Conference papers	125
Books	5
Journal articles and chapters in books	225
Working and policy papers	125
Capacity building	
PhD students (core-funded/leveraged)	6/40
Post-doctoral fellows (core-funded/leveraged)	12/30
Financials	
Funding from host institutions	£1 million
External funding	£15 million
Percentage of external funding/core ESRC funding	~ 300%
Knowledge facilitation	
Membership of expert committees	30
Keynote addresses	25
Public lectures/seminars organised	75
International collaborative research projects participated in	30
Policy briefs	10
Communications	
Media coverage – newspapers	25,000
Internet visits (unique visitors)	75,000

9. Work plan

Scientific programme

Our scientific programme for Phase Two is built around the tried-and-tested format of broad themes that nest specific projects. In particular, it comprises five parallel research themes, each containing three research projects. The research projects themselves take one of two forms. The first is a shorter project of two and a half years' duration, resourced with buy-out of established research staff and/or through the appointment of a Post-Doctoral Research Officer. Because these projects rest on established expertise and, in most cases, build on existing programmes of work, we are confident they can be completed in the allotted time. Some are scheduled to start at the beginning of Phase Two, either because they will generate knowledge foundational to work elsewhere in the Centre (as is the case with e.g. project 3b on *Carbon, competitiveness and trade*), or because they respond to user needs that are particularly strong in the next two to three years (e.g. project 3a on *Consumption-based carbon accounting and mitigation policies*, which primarily responds to a 'policy window' in the UK). Other projects are scheduled to start halfway through Phase Two.

The second form is a longer, five-year project. All of our projects designed around PhD Studentships take this form, due to the length of time required to complete a PhD. Nevertheless, significant buy-out time of established research staff is also to be committed to these longer projects, ensuring the students and projects benefit from meaningful engagement of senior researchers. In addition, our projects on *Measuring and evaluating low-carbon innovation* and *Institutions, climate services and adaptation* are also envisaged as five-year projects, due to their sequential nature. The structure and scheduling of our scientific programme are set out in Table 7, although we fully anticipate that deviations from the plan may turn out to be appropriate.

Stakeholder engagement

CCCEP's stakeholder engagement activities will run throughout Phase Two, alongside the scientific programme. This aspect of our work needs to be highly flexible in order to ensure it exploits the best opportunities for impact.

Management

The management of the Centre will be guided by a Steering Committee, which will meet annually to discuss our overall research and engagement strategy, as well as the 'Troika' meeting between the Centre's Directors and ESRC, which takes place twice a year and serves to keep the Centre abreast of the latest developments from ESRC and *vice versa*. Our Management Group will meet at least once a quarter, while project teams will meet much more regularly, in person or virtually.

Events

In Phase Two we plan to hold three flagship conferences. At the beginning of year one, we will hold a conference to launch Phase Two at the same time as taking stock of achievements from Phase One. As well as keynote presentations from CCCEP staff, the conference will include contributions from high-profile researchers and users of research outside CCCEP. At the beginning of year three, we will hold an 'Advances' conference. This will review key developments, promote the findings from the first wave of Phase-Two projects, and invite discussion on future directions, both within programmed projects and in terms of how other resources such as our Innovation Fund or leveraged funds might be deployed. Finally, we will hold an 'Impacts' conference at the end of year five, publicising the outcomes of the Centre's output over the full five-year period, especially the second wave of projects, as well as putting them in the context of wider research. These Centre conferences will also serve as a locus for internal coordination: we will hold a Researchers' Away Day in the margins of each, where our various research teams will learn more about each other's work.

In addition to our flagship conferences, we will also hold a wide range of tailored events. Both CCCEP LSE and CCCEP Leeds will continue to hold regular public lectures and research seminars, while we have budgeted for a range of expert workshops built around our high-level engagement activities (five) and built around each project (fifteen). We aim to retain flexibility as to when these workshops will be held, in order to maximise their impact and usefulness.

Plans for funding beyond Phase Two

As Phase Two passes the midway point, we will increasingly be confronted with the question of how to fund CCCEP beyond the end of Phase Two. We are relatively well placed to respond to this challenge, because CCCEP is firmly embedded within research institutes at LSE (the Grantham Research Institute on Climate Change and the Environment) and Leeds (SRI) that are sustained by leveraged funding and that possess infrastructure for obtaining new funds.

Funding research at the scale of CCCEP requires strategic thinking and a coordinated approach, so we will commence the process of re-funding the Centre by holding discussions with our Steering Committee, amongst the Management Group, with project leaders and with key external stakeholders. These discussions should reveal funding targets (such as ESRC for a Third Phase but also other UK research councils, trusts, foundations and businesses) as well as research/engagement priorities. We will then match priorities to funding targets. We envisage that this process needs to possess ‘variable geometry’ – i.e. it may be optimal to target different funding sources for different pieces of research/engagement – but on the other hand economies of scale strongly point towards obtaining large grants.

Table 7. Work plan for scientific programme.

	1	2	3	4	5
1. Understanding green growth and climate compatible development	**1a. Growth and climate change in Chinese cities**			**1b. Mainstreaming climate-compatible development in Africa**	
	1c. Green growth and employment in advanced economies				
	1a. Selection of Chinese case-study cities	1a. Undertake case studies: i.e. map green-growth strategies & institutional context	1a. Prepare final outputs	1b. Prepare community & policy interviews; conduct policy analysis	1b. Conduct community & policy interviews	1b. Synthesise results & prepare final outputs
	1c. PhD student undertakes research training	1c. Commence first paper on search-theoretic modelling of green jobs	1c. Complete paper one; move to second paper on empirical analysis of green jobs using labour-market data		1c. Complete paper two; move to third paper on economic/business history of impact of energy revolutions on jobs	1c. Complete third paper
2. Advancing climate finance and investment	**2a. Political economics of climate finance**				
	2b. Policy learning in climate finance **2c. Evolution of carbon markets**				
	2a. Develop set of theoretical frameworks/models on climate finance curse	2a. Econometric analysis of corruption in CDM/other climate policies	2a. Prepare final outputs		
	2b. PhD student on international climate finance undertakes research training; reviews lit. & plans data collection 2c. PhD student undertakes research training; analysis of design challenges in new carbon markets	2b. Commence interviews with actors in international climate finance 2c. Commence first paper, e.g. on design options for hybrid cap-and-trade schemes	2b. Continue interviews; scope & commence interviews/workshops at national level 2c. Complete paper one; move to second paper on e.g. strategic permit trading		2b. Complete international interviews, analyse & synthesise; continue & complete interviews/workshops at national level; conduct quantitative analysis 2c. Complete paper two; move to third paper on e.g. technology adoption	2b Complete all analysis; prepare final outputs 2c. Complete third paper
3.Evaluating the performance of climate policy and governance	**3a. Consumption-based carbon accounting and mitigation policies** **3b. Carbon, competitiveness and trade**				
	3c. Measuring and evaluating low-carbon innovation				
	3a. Lit. review of policy-learning theories; commence UK interviews & workshops 3b. Data collection on emissions, firm performance	3a. Complete interviews & workshops; feed results back into research on consumption-based carbon accounting 3b. Complete combined	3a. Prepare final outputs; scope work outside UK (incl. new		

	& trade; begin to combine	dataset; perform econometric analysis	funding) 3b. Prepare final outputs		
	3c. Begin construction of web-based innovation metrics	3c. Compare new metrics with existing measures	3c. Report on new metrics; begin research on policy evaluation with new metrics	3c. Continue policy evaluation; explore possibilities for even newer metrics	3c. Complete policy evaluation; continue work on newer metrics; prepare final outputs
4. Managing climate risk and uncertainties and strength-ening climate services	**4a. Institutions, climate services and adaptation** **4b. Climate change, non-linear systems and economic decisions**				
	4c. Integrated sustainability science for pro-poor climate policy				
	4a. Select case study; prepare portfolio decision analysis; review similar work on other projects 4b. PhD student undertakes research training; construct non-linear model for analysis	4a. Hold participatory workshops; begin analysing results; compare with parallel projects 4b. Commence first 'paper' on philosophical aspects of modelling non-linear system	4a. Prepare outputs from case study; synthesis with results from other projects 4b. Complete paper one; move to second paper on model selection	4a. Begin analysis of knowledge co-production: i.e. construct & conduct cross-national case comparison 4b. Complete paper on model selection; move to third paper on investment	4a. Complete analysis of knowledge co-production; prepare final outputs 4b. Complete third paper.
	4c. Desk-based comparison of theoretical framings; case-study selection	4c. Carry out case studies in South Africa & two low-income countries in Sub-Saharan Africa	4c. Identify best-practice principles; prepare final outputs		
5. Enabling rapid transitions in mitigation and adaptation			**5a. The economics of rapid transitions** **5b. Systemic approaches to low-carbon transitions**		
	5c. Governing rapid transitions in mitigation and adaptation				
			5a/b. Begin review of transition analogies 5a. Scope micro modelling 5b. Scope case studies	5a/b. Complete review of transition analogies 5a. Prepare outputs; construct & run micro-economic models 5b. Undertake case studies of low-carbon innovation	5a. Complete micro-economic modelling & prepare outputs 5b. Complete case studies & prepare final outputs
	5c. PhD student undertakes research training; commence scoping of case studies & conceptual approach	5c. Complete conceptual approach & scoping of case studies; commence case studies	5c. Continue case studies	5c. Complete case studies; compare results with emerging findings from projects 5a/b	5c. Complete analysis and prepare final outputs