



**PLACE-BASED
CLIMATE ACTION
NETWORK**

UK RESEARCH ON THE SOCIAL SCIENCE OF CLIMATE CHANGE

A SYNTHESIS OF ESRC AND RELATED INVESTMENTS

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ABOUT THIS REPORT

This report was commissioned and funded by the Economic and Social Research Council (ESRC) as part of its support for the Place-Based Climate Action Network (PCAN). PCAN is a collaboration between the London School of Economics and Political Science, Queen's University Belfast, the University of Edinburgh and the University of Leeds. The aim of PCAN is to translate climate policy into action at the local level to bring about transformative change.

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EXECUTIVE SUMMARY

- The Economic and Social Research Council (ESRC) and UK Research and Innovation (UKRI) have a long history of supporting social science research on climate change. Between 2008 and spring 2019, UK research councils have awarded grants to 481 climate change projects with strong social science components worth £438 million overall (including non-social science components).
- Although the social sciences are the purview of ESRC, social science research on climate change is supported by all research councils – typically in a multi-disciplinary setting. ESRC has supported 70 per cent of the projects and is the lead council in 20 per cent of them. The Natural Environment Research Council (NERC) leads on 55 per cent of the projects, while the Engineering and Physical Sciences Research Council (EPSRC) is the leading funder of energy research.
- Research centres and major programmes play an important role in social science research on climate change. The largest ten per cent of projects – including 15 research centres – account for almost two thirds of all funding. Roughly one half of all projects were for £200,000 or less.
- Funding has been allocated to universities across the UK, but with a noticeable concentration in London and the South East. Northern Ireland, Scotland and the North East have received the lowest amount of direct funding.
- The supported research covers a remarkable diversity of topics, methods and geographies. Support is split evenly between projects that focus on the UK and overseas. Most overseas research treats climate change as a global issue, but there is also a strong interest in Africa.
- There is an even split between research on adaptation (concerned with climate change impacts) and mitigation (concerned with emissions reductions). Many adaptation projects are concerned with developing countries, while mitigation projects are often focused on the UK.
- Despite the diversity, it is possible to identify some thematic priorities. These include research on:
 - practices and behaviour in relation to climate change;
 - climate policy and governance;
 - the UK energy transition;
 - floods and droughts in the UK;
 - climate-compatible development in Africa;
 - agriculture and land use;
 - climate change and the natural environment.
- There are research gaps in most of these areas. In addition, there are new topics that have not yet been covered in detail. Notable research gaps include:
 - the political economy of the zero carbon transition;
 - combining environmental and social objectives into a just transition;
 - poverty alleviation in a zero carbon world;
 - the integration of climate and broader environmental research;
 - the social science of carbon capture and negative emissions technology;
 - the role of finance.

**“UK SOCIAL SCIENCE RESEARCH
ON CLIMATE CHANGE COVERS
A REMARKABLE DIVERSITY
OF TOPICS, METHODS AND
GEOGRAPHIES.”**

INTRODUCTION

This report synthesises social science research on climate change that was supported by the Economic and Social Research Council (ESRC) and the other research councils that form part of UK Research and Innovation (UKRI) between 2008 and spring 2019. The report was commissioned by ESRC as part of its support for the Place-Based Climate Action Network (PCAN).

Climate change is a critical environmental and social challenge. It stands apart from other societal problems not just in its urgency and scale, but also in its complexity. It is important therefore that action against climate change is informed by the best available scientific evidence, including evidence from the social sciences.

Research councils have recognised this early on and have supported climate change research for the past 30 years or so. This has helped UK universities to play a leading role in climate change research and contribute substantively to international efforts such as the assessment reports of the Intergovernmental Panel on Climate Change (IPCC).

When reviewing social science research on climate change, the delineations are not always straightforward. Climate change is a deeply interdisciplinary subject and social scientists collaborate closely with researchers in many other disciplines. The same is true for research councils, which often join forces to support climate change programmes. Similarly, climate change is intertwined with many other research interests, such as energy, food and the natural environment.

The scope of the review is therefore kept broad. We are interested in all research projects that have a substantive social science component and where climate change is a significant research objective. Nevertheless, some judgement calls have had to be made as to what constitutes a substantial social science contribution or a significant interest in climate change, particularly in large projects. Most, but not all, of the research was sponsored by ESRC, often in collaboration with other research councils.

Overall there have been 481 research projects and programmes since 2008 that fit this definition. They vary in size from less than £20,000 to over £33 million. Strategic focus is provided by 15 research centres (listed in the Appendix), which receive funding for 5-10 years and sometimes more. The overall funding volume for these projects, including both social science and non-social science components, is £438 million.

We are interested in the research questions that these projects pose, rather than in their findings. The aim is to identify the main topics that have been covered, not to assess the state of knowledge, which is done much more expertly by bodies like the IPCC. We also identify key research gaps that deserve further attention.

The assessment is based on desk research. Key sources include the UKRI Gateway to Research database, project websites and selected research outputs. The timeframe of the project did not allow interviews with project teams, but the text was reviewed by most principal investigators of supported research centres. More detail on the assessment methodology is contained in Box 1.

STRUCTURE OF THIS REPORT

The report is structured in two parts. Part A contains descriptive statistics on the portfolio of climate and social science projects that are supported by the research councils. An initial set of statistics provides information about the nature of the funding – for example, typical funding amounts and the geographical distribution of projects within the UK. This is followed by statistics about the content of supported projects – for example, the split between mitigation and adaptation research, and the relative importance of different types of climate action (behaviour or technology).

Part B contains brief descriptions of seven research themes that are particularly salient and/or have received particular attention from the research councils. The scope of supported research is broader than these seven themes. However, they are reflective of cross-cutting funding priorities over the past decade. The seven themes are:

- Practices and behaviour in relation to climate change
- Climate policy and governance
- The UK energy transition
- Flooding and droughts in the UK
- Climate-compatible development in Africa
- Agriculture and land use
- Climate change and the natural environment.

The main body of the report is complemented by an Appendix which summarises the objectives of the 15 research centres on climate change that have a strong social science focus. A list of all investments is available in a separate spreadsheet.

BOX 1: ASSESSMENT METHOD

This synthesis has been informed by the principles of systematic reviews, but it does not aspire to be a systematic review. We started with a search for relevant research, based on keywords. Selected projects were double-checked manually and classified according to their thematic focus. This allowed the identification of core themes that have received particular attention. These topics were then reviewed in more detail.

Defining the scope

We started with a wide search in the UKRI Gateway to Research*, pulling up all projects classified under any of the headings titled 'climate change', 'environment', 'natural resources, environment, and rural development', 'environmental economics', 'carbon capture and storage' and 'energy efficiency'. Some additional unclassified projects were picked up throughout the search and added to the list. The synthesis is limited to projects that were active between 2008 and spring 2019.

This process yielded over 3,000 potential projects. The projects were then assessed for their relevance to the social sciences, yielding a core group of 481 projects. The focus was on projects that use social science techniques to analyse climate change and related issues. Policy relevance or engagement with research users was neither a necessary nor a sufficient condition for inclusion. Most contemporary research now features such components, as proposals are assessed on their pathway to impact.

Some of the projects contained multiple sub-projects under the same programme, or sub-components going to different research organisations. For the purposes of this report, we have merged these projects under one total funding amount. Where no lead organisation is identified, projects were assigned to the research organisation that received the largest amount of funding.

Classifying projects

Projects were classified according to four criteria:

- **Response categories:** adaptation (projects studying climate change impacts and societal responses to these impacts); mitigation (projects studying ways to reduce greenhouse gas emissions); geoengineering (the manipulation of environmental processes to reduce climate risks) and general climate change (projects that study climate change generically).

- **Types of climate action:** changing practices and behaviour (e.g. attitudes toward air travel); technological change and innovation (e.g. research on electric cars); policy and governance (e.g. research on carbon pricing) and data research.

- **Geographical focus:** UK, Africa, Asia, Europe, Latin America, North America and Oceania. There is also a category 'Global' for research with a worldwide scope or concerning broader categories of countries (e.g. the Global South or donor countries).

- **Sectors:** We use different sector categories for adaptation and mitigation to align with the conventions used in these research areas. For adaptation, the sectoral distinctions were informed by the UK Climate Change Risk Assessment 2017: flooding and coastal damage; agriculture; health/wellbeing/productivity; infrastructure, the natural environment; natural hazards; and water supply. For mitigation, the sector classification was informed by the IPCC: energy; transport; buildings; industry; forest, land use and agriculture; waste; and personal emissions.

Identifying core themes

Descriptive statistics of the project portfolio according to these different classifications allowed us to identify seven main themes that are either particularly salient to the climate change debate and/or have benefitted most prominently from research council support. For each of the seven themes we reviewed in detail the activities of the largest investments (typically research centres) as well as a small number of randomly identified smaller projects that are typical for research under these themes.

*<https://gtr.ukri.org/>

PART A: OVERVIEW

1. The overall level of support

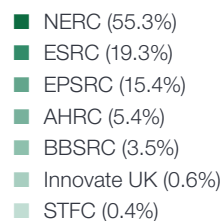
A search through the Gateway to Research database identifies over 3,000 research grants that were active between 2008 and spring 2019 and have climate change as one of their objectives. In 481 of them social science research is a substantive component, and these are the projects of interest in this review (see Box 1). In total, they were awarded £438 million in funding.

FUNDING BY RESEARCH COUNCILS

There is a strong collaboration between the research councils on climate change research, reflecting the interdisciplinary nature of the problem (see Box 2). Indeed, although social science research is primarily the domain of ESRC, it has been the lead council in only about 20 per cent of climate change projects with a strong social science component (Figure 1). For 55 per cent of projects the lead council has been the Natural Environment Research Council (NERC). A third prominent funder is the Engineering and Physical Sciences Research Council (EPSRC), which has led on about 15 per cent of projects. Most EPSRC awards have been for large energy-oriented research centres.

Many projects have been co-funded by several councils, and here ESRC's contribution has been substantial. Seventy per cent of projects have received some ESRC funding. The total amount of ESRC support cannot be ascertained since many projects are supported through joint funding pools and in the case of small projects no inter-council payments are made. We therefore do not show the financial contributions of each research council in Figure 1.

Figure 1: Research support by research council



The chart shows the relative number of projects led by each research council. Research councils often contribute to projects led by other councils. Such participation is not reflected in the figure.

BOX 2:

RESEARCH COUNCILS SUPPORTING SOCIAL SCIENCE RESEARCH ON CLIMATE CHANGE

Six of the seven research councils that now form part of UK Research and Innovation (UKRI), as well as Innovate UK, have supported social science research on climate change explored in this document.

Most of the support has come from three councils:

- Economic and Social Research Council (ESRC)
- Engineering and Physical Sciences Research Council (EPSRC)
- Natural Environment Research Council (NERC)

Four institutions have contributed smaller amounts:

- Arts and Humanities Research Council (AHRC)
- Biotechnology and Biological Sciences Research Council (BBSRC)
- Innovate UK
- Science and Technology Facilities Council (STFC)

ALLOCATION OF FUNDING BY REGION

Although all UK regions benefit from research funding, the allocation is not even across the UK (Figure 2).

There is a noticeable concentration of funding in London and the South East, with both regions receiving research grants worth more than £33 million over the past decade. Yorkshire and the Humber also received substantial amounts of climate change funding, with the University of Leeds as a significant beneficiary. Northern Ireland, Scotland and the North East have received the lowest amount of funding, at less than £8 million each.

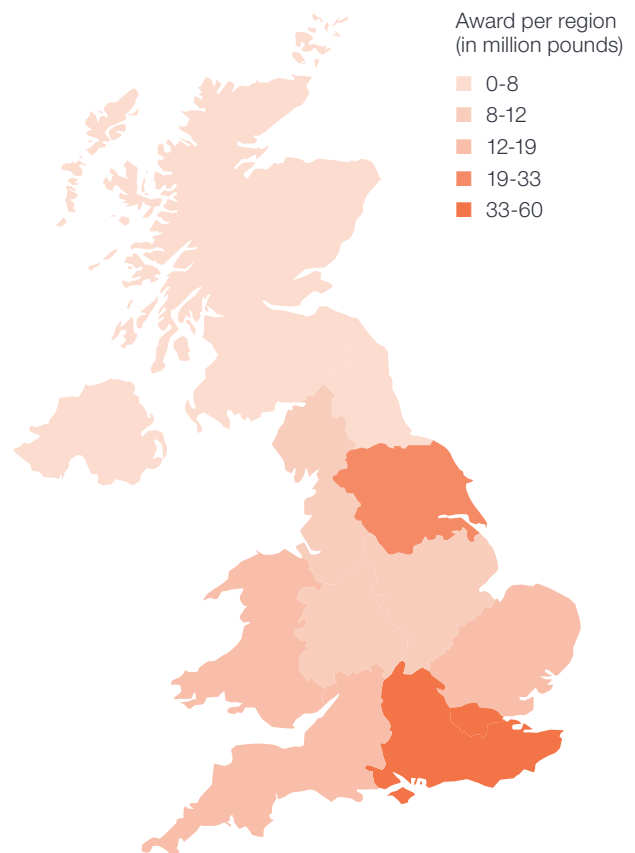
It should be noted, though, that these statistics only refer to the lead institution in each grant. Most large grants are collaborations, which means funding may be more widely spread than the headline numbers suggest.

FUNDING BY SIZE OF THE AWARD

Research support is relatively concentrated, with a small number of large projects securing most funds. The largest ten per cent of projects received almost two thirds of all funds. This includes 15 dedicated research centres on climate change or related topics like energy and sustainable prosperity. These strategic investments are at the core of research council support and have defined the research agenda.

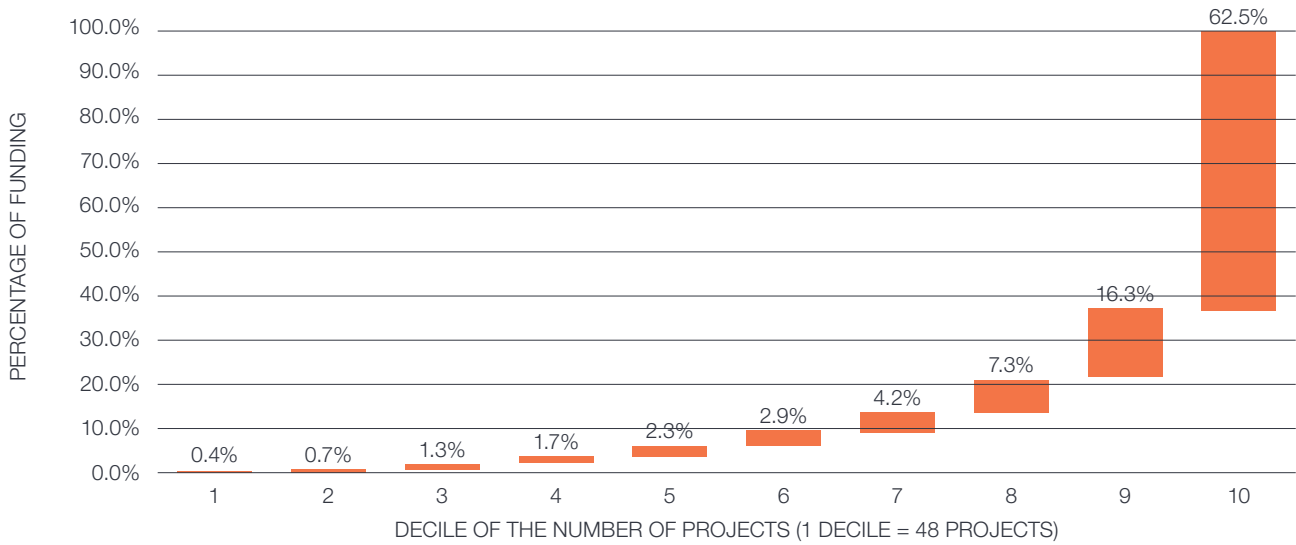
However, there is also diversity. About half the projects are smaller than £200,000. Together they account for less than seven per cent of total funding, but they cover a wide range of topics from climate justice to weather insurance, travel behaviour and trade.

Figure 2: Funding by region



All funding is assigned to the main grant holder. Particularly large grants are often consortia of several universities. The chart does not reflect how funding may be allocated between consortium partners.

Figure 3: Research funding by grant size

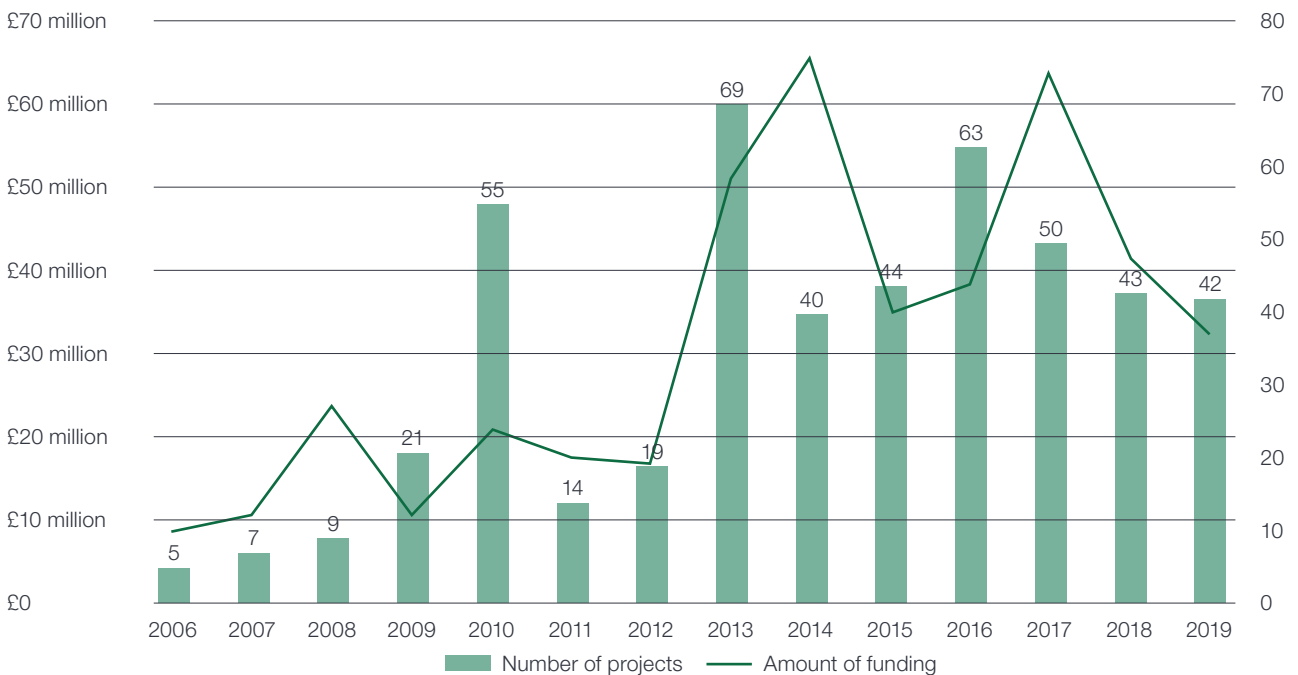


FUNDING OVER TIME

Funding for the social science of climate change has increased over time. While some prominent research centres, such as the Tyndall Centre, the UK Energy Research Centre (UKERC) and the Centre for Climate

Change Economics and Policy (CCCEP) date back a decade or more, there has been a notable increase in climate change support (both in terms of project numbers and grant amounts) since 2013/14 (Figure 4).

Figure 4: Climate change support over time



Pre-2008 awards are for long-term projects that were still active after 2008. The 2019 awards are for projects that started in 2019; the award would typically have been made in 2018.

2. Funding by research content

Social science research on climate change covers many topics and approaches the issue from a variety of angles. It is instructive to review which aspects of the climate change problem have received most attention from the research councils.

RESPONSE CATEGORIES

Projects can be grouped in different ways and we adopt several classifications (see Box 1). First, projects are classified by generic response category, that is, whether they deal with adaptation, mitigation, geoengineering or a combination of these approaches. Second, projects are classified by the type of climate action that is analysed, that is, whether the focus of the research is on policy/governance, technology/innovation, practices/behaviours, or deal with data. Third, we are interested in the geographic focus of the research.

Figure 5 shows the share of project awards and funding under each of these classifications. The research councils have awarded similar amounts of funding to adaptation and mitigation in social science research. However, adaptation projects tend to be smaller and more numerous than mitigation projects, where much of the research effort is concentrated in large research centres. As a result, there are 45 per cent more projects on adaptation than on mitigation.

Climate policy and governance and data-related work are the dominant climate actions, reflecting the importance of public policy in, and the empirical nature of, social science research. They account for about a third of project awards each. However, policy and governance projects are larger, which means they account for over half of all funding. Research on practices and behaviour has received relatively modest funding, but this has started to change in the most recent funding rounds.

In terms of geographic distribution, research support is split evenly between projects that focus on the UK and overseas. Most overseas research treats climate change as a global issue, but there is also a strong research interest in Africa. Other world regions received less attention and projects tend to be smaller. The allocation of non-UK research is influenced heavily by the £1.5 billion Global Challenges Research Fund (GCRF), which is devoted to research in low income countries, such as those in Africa.

RESEARCH FOCUS BY SECTOR

A further classification is provided in Figure 6, which shows the distribution of projects by sector. Agriculture and land use is the most important sector by number of projects, with 85 awards in total. About half of these projects have an adaptation focus, where the main concern is food production and trade. The mitigation projects are mostly interested in agricultural emissions but also forestry and land use change.

Although there are fewer projects, the sector that has received most funding is energy, with awards in excess of £100 million. A substantial amount of this funding has been channelled through a number of high-profile research centres. They deal with energy issues holistically and many also cover energy demand in buildings, industry and transport. Figure 6 therefore under-represents the amount of effort that has been devoted to buildings, industry and transport. Nevertheless, mitigation research is relatively concentrated on a few sectors.

In comparison, adaptation projects are more evenly spread. Water supply, agriculture, and health and wellbeing obtained the highest amount of funding, but there is also a considerable number of (mostly smaller) projects dealing with flooding and coastal protection. There is a relatively low allocation to infrastructure research, although it is a well-identified priority of adaptation policy. There may be additional projects interested in the engineering aspects of the problem, which are not covered here.

“CLIMATE POLICY AND GOVERNANCE AND DATA-RELATED WORK ARE THE DOMINANT CLIMATE ACTIONS, ACCOUNTING FOR A THIRD OF PROJECT AWARDS EACH.”

Figure 5: Classification of projects

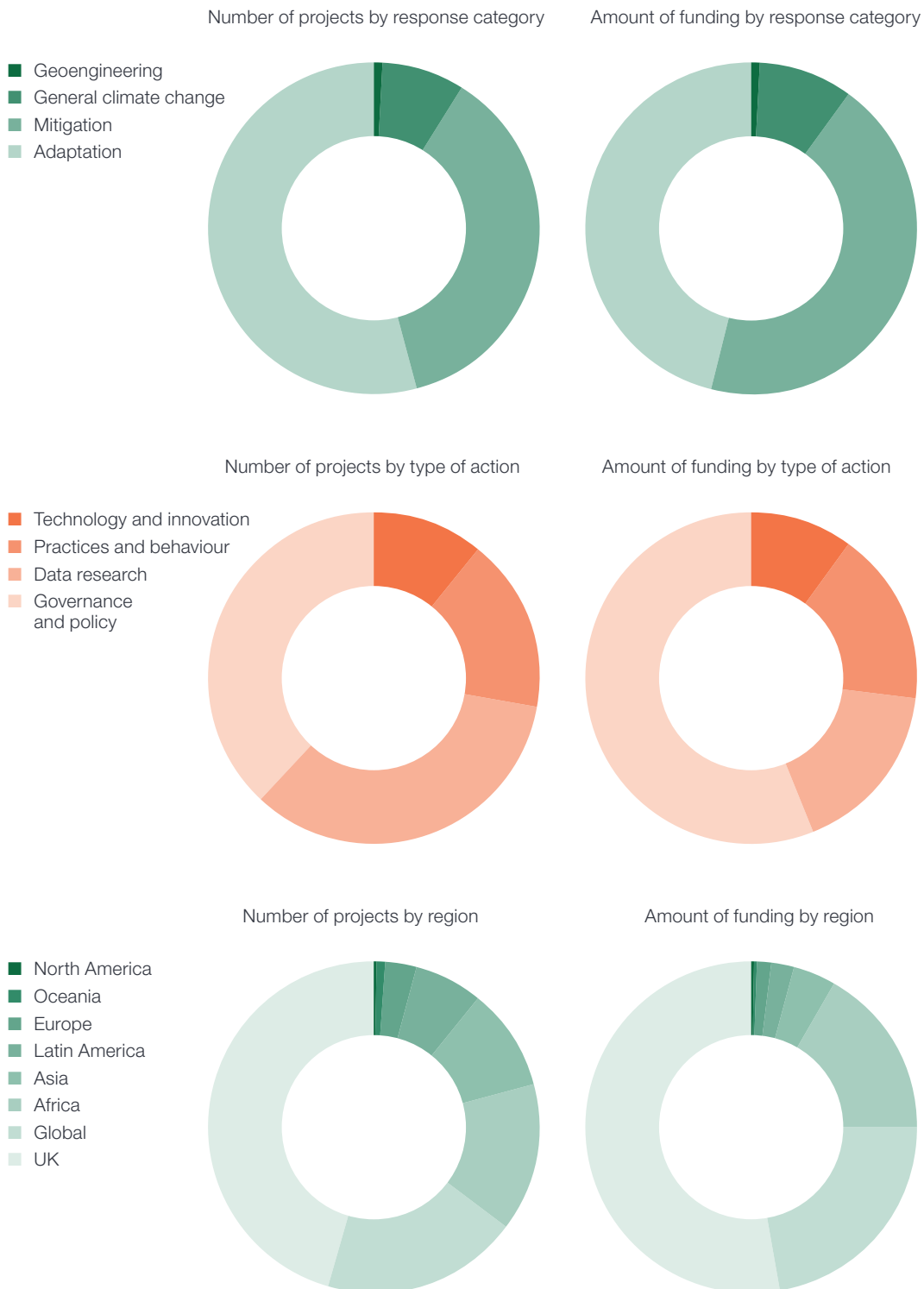
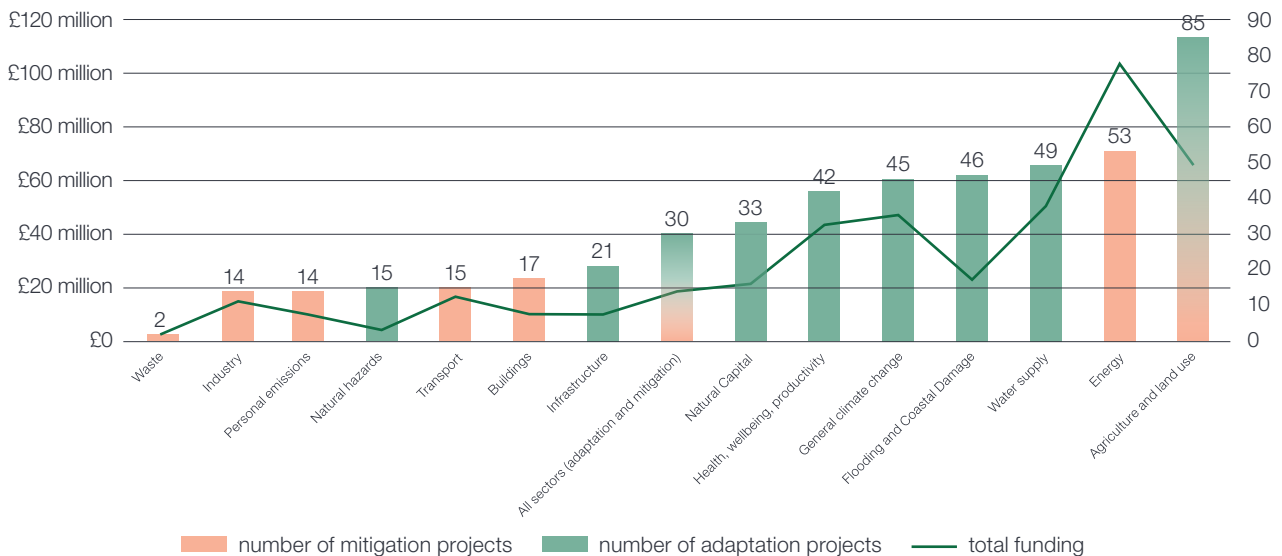


Figure 6: Research focus by sector



Sector categories used in adaptation research are shown in green, and the sectors used in mitigation research are in orange. For sectors that are interested in both adaptation and mitigation, the colours are blended. A number of projects deal with end-use energy demand across mitigation sectors (e.g. transport, buildings, industry). Their activities are allocated to the energy sector.

VARIATIONS BY GEOGRAPHICAL REGION

The overall pattern of funding priorities masks considerable differences in the research focus in different regions (Figure 7). Projects focused on developing countries, particularly in Africa and Oceania, mostly deal with adaptation, reflecting the high climate vulnerability of these regions. Mitigation research features most prominently in the UK, but alongside general research also in the (much smaller) Europe and North America portfolios.

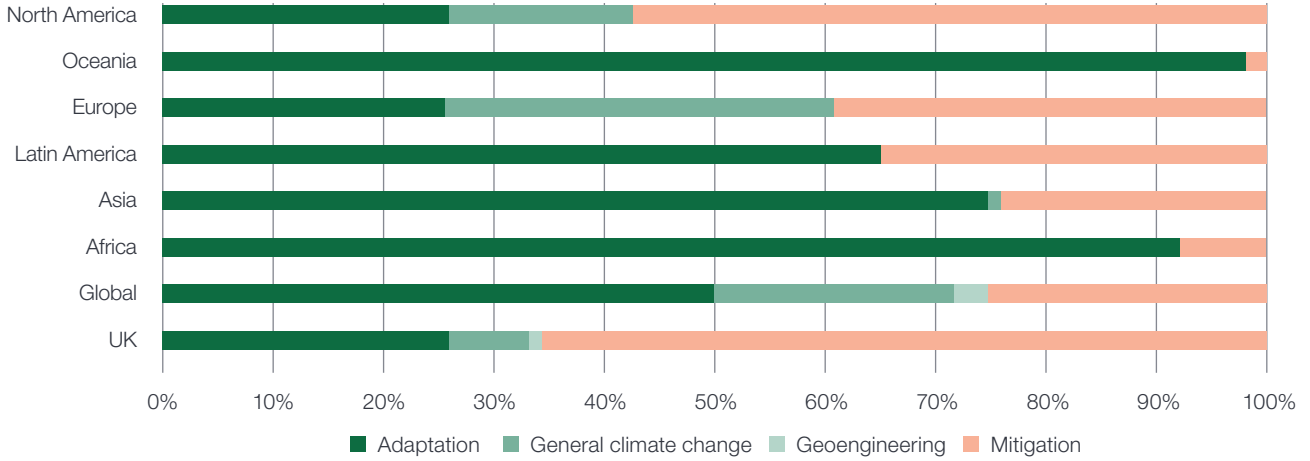
There is a strong concentration of energy research on the UK, with very little work in the other regions. Outside the UK, the most prominent sector is agriculture and land use. Water management is a notable research interest only in Africa, while flooding and coastal damage features in heavily-affected Asia and Oceania.

There are fewer regional patterns in terms of climate action. In most regions there is substantial work on climate policy/governance and data research. Work on technology and innovation is prominent only in the UK and North America-focused research, while behavioural research features mostly in the small Europe and Oceania portfolio.

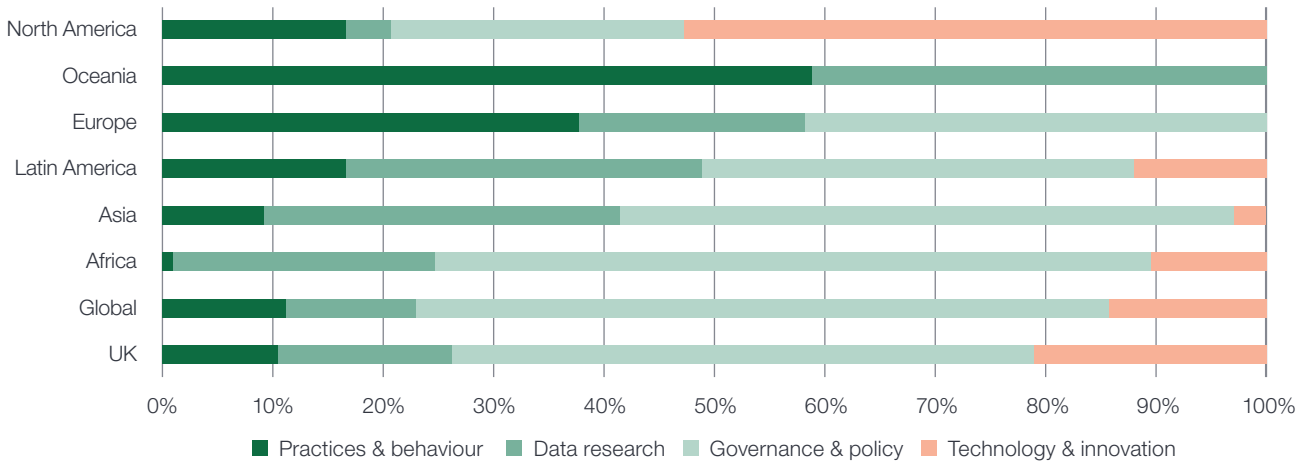
The descriptive statistics provided in Figures 5 to 7 reveal a diversity of research angles, methods and topics. Most projects address several dimensions. Nevertheless, it is possible to identify a handful of research themes that feature particularly prominently in the research portfolio or are of particular interest to the policy debate. They are reviewed in more detail in Part B of this report.

Figure 7: Research focus and geography

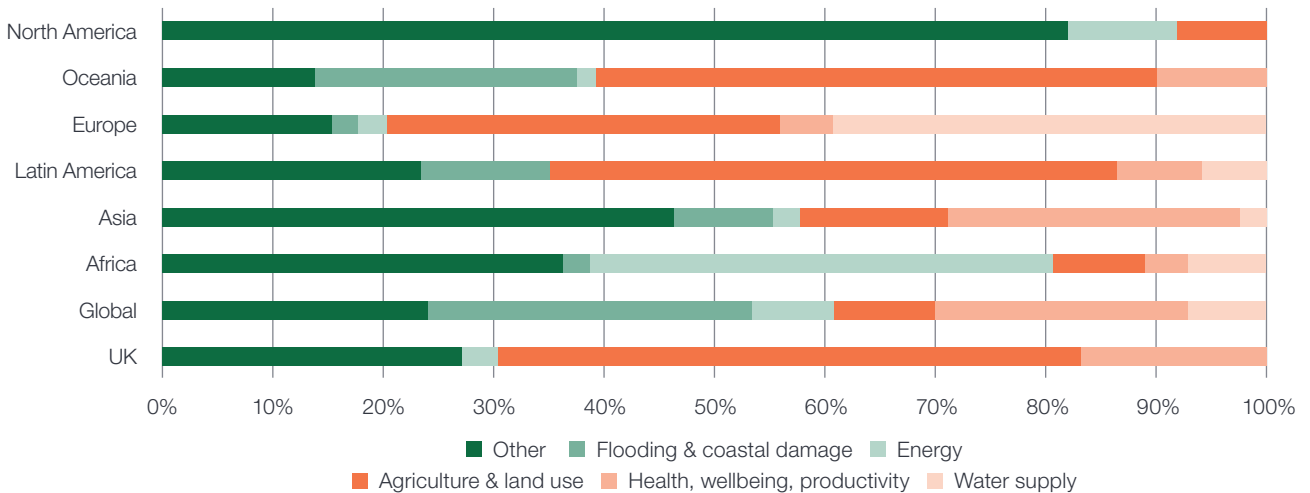
Funding by response category



Funding by type of action



Funding by sector



PART B: PROMINENT RESEARCH TOPICS

3. Practices and behaviour in relation to climate change

Research on practices and behaviour with respect to climate change is an emerging priority that is receiving increased attention from research councils. The term “behaviour” is mostly used by social psychologists, while sociologists refer to “practices”. The theme cuts across the adaptation and mitigation sectors and across geographies. Research councils have so far supported 81 projects in this category and awarded over £41 million in funding (covering both social science and non-social science components).

This strand of research is all about people. Many projects are focused on public perceptions of different policy options or public reactions to different climate events

(such as heatwaves). An important focus is how practices and behaviour in relation to the mitigation of greenhouse gas emissions are shaped. In addition, there are projects that look at people’s attitudes towards climate change, including assessments of climate change risk and resilience perceptions, for example through social media.

Much of the research is based on interviews, survey data and community engagement. However, researchers have also been creative in finding new ways to engage and observe people. The practices and behaviour theme includes: projects on the visualisation of climate change; participatory photography and narrative storytelling for climate change education; creative resilience through community imaginings; and performing conversations of sustainability. These projects investigate how practices that stress imagination and connection inspire community resilience in the face of environmental challenge. They are aimed at developing dialogues, imagery and stories to aid understanding and facilitate deeper engagement with climate issues.

Table 1: Selected projects on practices and behaviour in relation to climate change

Lead institution	Project title	Award (£)
Cardiff University	CAST: Centre for Climate Change and Social Transformations	4,903,412
University of Leeds	SANDPIT: Integrated Assessment of Geoengineering Proposals	1,728,839
University of Manchester	Sustainable Practices Research Group	1,633,510
Open University	Stories of Change: Exploring energy and community in the past, present and future	1,169,421
University of Cambridge	Pathways to understanding the changing climate: time and place in cultural learning about the environment	655,757

ATTITUDES TOWARDS EMISSION REDUCTION TECHNOLOGIES

Attitudes towards emission reduction technologies and low carbon energy form a large part of the research in this theme. Most of the projects in this vein are UK-focused. Typically, these projects are about people's responses to different modes of energy, but there are also large projects about UK attitudes towards geoengineering (see Box 3) and unconventional gas (shale gas and fracking).

There are some projects about energy and community, and some about rural living and energy. These latter projects are focused on the reduction of personal emissions.

PERSONAL EMISSIONS

Another strand of work explores practices and behaviour with respect to personal emissions. Most of the projects do not focus on a particular strand of individual behaviour but look in general at practices that individuals can engage in to reduce their personal emissions, barriers to reducing personal emissions, and how solutions can be better framed to encourage change at the individual level.

Personal emissions reductions have been an interest of several research centres (see also Chapter 5 on Energy). The Centre for Industrial Energy, Materials, and Products (CIE-MAP) established an approach to allocate all the emissions embodied in materials and products to households. This data was then applied by social psychologists to consider the emission reduction potential of changing consumption, such as using products longer and changing purchasing behaviour. The proposed mitigation options were then used to assess public perceptions to low material futures.

Another energy-oriented project, DEMAND, studies personal emissions and energy demand as an outcome of established social practices. DEMAND investigates situations, sites and sectors such as domestic IT use, home heating, office work and business travel, online shopping and care dependence to determine what factors influence energy demand.

There is increasing support for this type of research, with the opening of the Centre for Climate Change and Social Transformations (CAST) in May 2019. CAST is a global research centre that looks into the transformation of individual and collective activity to mitigate climate change. It focuses on people as agents of transformation in consumption, food and diet, travel, heating and cooling.

BOX 3: SANDPIT: INTEGRATED ASSESSMENT OF GEOENGINEERING PROPOSALS (IAGP)

IAGP is an interdisciplinary research project that has brought together a wide range of expertise – from climate modelling to philosophy and engineering to public perceptions – to situate the assessment of geoengineering within wider societal values. IAGP opened in October 2010 and closed in February 2018. It received £1.7 million in funding from EPSRC and NERC.

In addition to researching UK attitudes towards geoengineering, the programme also included the development of a framework for the evaluation of geoengineering proposals, their climate effects, and the challenges of controlling the climate with geoengineering.

IAGP's research on attitudes sought to examine in detail the public acceptability of different geoengineering proposals, including public perceptions and stakeholder perspectives. It tracked the difficulties involved with crafting public support for geoengineering.

The project also looked at the impact of geoengineering solutions on emissions behaviour. On the one hand, the realisation that scientists are considering geoengineering may encourage the public to take the need for mitigation more seriously. On the other, the prospect of geoengineering can create a "moral license" to continue with business as usual.

Another important aspect was climate change communication. The project explored how significant climate events, such as the 2013/14 floods, change the nature of communication about climate change and attitudes to particular solutions. It looked in detail at the effect of framing by natural analogy on public perception, finding that describing geoengineering technology by reference to natural processes makes the public more likely to support geoengineering.

**“RESEARCH ON PRACTICES
AND BEHAVIOUR IS
ALL ABOUT PEOPLE.”**

CLIMATE RESILIENCE AND ADAPTATION

There are more projects on adaptation behaviour than there are on mitigation behaviour. However, they are smaller and received less total funding. The projects on adaptation practices and behaviour are also more geographically diverse. They are overwhelmingly targeted towards the health, wellbeing and productivity sectors. Examples include the wellbeing of workers, including explorations of the climate change–modern slavery nexus in the Columbian construction industry and the exploration of just transition in India and Bangladesh to the wellbeing of young people and their experiences with the food-water-energy nexus in Brazil. A large project was awarded on the wellbeing of pensioners and the assessments of green infrastructure on the health service and the ageing population.

Another significant grouping of projects is focused on farmers in developing countries. Adaptation projects in terms of food production and trade look at practices and behaviour mainly in rural communities and consider how they adapt to, and prepare for climate change (see also Chapter 7 on climate-compatible development in Africa). Projects include insights from Kenyan horticulture and BIO-smart livestock farming in Columbia. Another interesting stream of projects is focused on island communities and resilience to climate change, and on the preservation of cultural heritage and futures.

RESEARCH GAPS

Practices and behaviour in relation to climate change is an emerging research interest of ESRC and of growing policy relevance as the UK moves toward a net zero economy. However, a number of research gaps remain. Many important aspects have only recently gained traction in the research community. Under-explored research questions concern, for example, attitudes toward personal emissions (e.g. eating habits and travel behaviour), the understanding of adaptation behaviour, nudge approaches to encourage behaviour change and the public acceptability of certain technologies. The establishment of the Centre for the Analysis of Social Transitions (CAST) will be an important step toward closing these gaps.

**“THERE ARE MORE PROJECTS
ON ADAPTATION BEHAVIOUR
THAN THERE ARE ON
MITIGATION BEHAVIOUR.”**

4. Climate policy and governance

Most climate change projects with social science components touch on issues of public policy. Almost 40 per cent of projects, representing over half of all funding, engage academically with questions of climate policy and governance. For many other projects, their route to impact involves engagement with public sector decision makers.

Table 2: Selected projects on climate change policy and governance

Lead institution	Project title	Award (£)
Imperial College London / UCL	UK Energy Research Centre	33,609,563
London School of Economics	Centre for Climate Change Economics and Policy	14,500,105
Institute of Development Studies	STEPS: Social, Technological and Environmental Pathways to Sustainability	9,245,460
University of Surrey	Centre for Understanding Sustainable Prosperity	4,843,923
London School of Economics	The Place-based Climate Action Network (PCAN)	2,998,074
University of Leeds	Multi-level governance, REDD+ and synergies between change mitigation and adaptation	249,100

Research centres play an important role in this strand of work. The Centre for Climate Change Economics and Policy (CCCEP) focuses largely on questions of climate policy and governance, broadly defined. Other centres cover particular policy and governance angles,

such as energy policy (e.g. the UK Energy Research Centre), environmental limits to growth (e.g. the Centre for the Understanding of Sustainable Prosperity) and the contribution of natural capital in meeting policy objectives (e.g. Ecosystem Services for Poverty Alleviation).

GOVERNANCE AND REGULATION

Research on climate change governance is concerned with the institutional mechanisms and political processes that help steer social systems toward low carbon and climate resilient outcomes. The research councils have supported governance research at all levels – international, national, sub-national and communities.

Work on the international climate change architecture, and its broader institutional and political context, featured prominently in the first phase of CCCEP, which pre-dates the Paris Agreement. There have been no major projects explicitly on the gestation of the Paris Agreement, although associated projects (leveraged by ESRC investments, but funded by third parties) have studied the national implementation of the Agreement and the credibility of the pledges (Nationally Determined Contributions) that countries made under it.

In comparison, there is a rich set of projects concerned with climate change governance at the sub-national level and particularly in cities. The work aims to inform the design and delivery of urban climate action and its integration into related development strategies.

The research features both UK case studies (e.g. the city of Leeds) and international work for example on Chinese cities and urban Africa. Sub-national climate governance is also the theme of the recently awarded Place-Based Climate Action Network (PCAN), which supports city-level climate commissions in Belfast, Edinburgh and Leeds.

Community-based governance models are a strong feature in projects on climate resilience in developing countries, including research on drought and water scarcity, the food-energy-climate nexus and the governance of ecosystem services. A particular focus is Africa, as discussed further in Chapter 7 on climate-compatible development in Africa.

“MOST CLIMATE CHANGE PROJECTS IN THE SOCIAL SCIENCES TOUCH ON ISSUES OF PUBLIC POLICY.”

GROWTH AND PROSPERITY

There is a long-standing debate in environmental policy about ecological limits to economic growth. The presence and extent of such limits is still debated and research has been supported on both sides of the argument.

In CUSP and the earlier RESOLVE programme, ESRC has sponsored research that is explicitly dedicated to the understanding of prosperity in a world of environmental, social and economic limits. In addition to the moral, societal and individual exploration of a “good life”, CUSP also looks at the practical policy implications of a “post-growth” economy.

As a counterpoint, CCCEP has an extensive work programme on “green growth”, which asserts that environmental protection and economic prosperity are not mutually exclusive. The research explores the empirical and theoretical foundations for clean growth and the design of clean-growth policies, featuring case studies on Chinese cities, the UK labour market and rural communities in Sub-Saharan Africa. Another focus is the empirical exploration of business performance in the low carbon economy and the scope for low carbon trade.

Other projects study specific angles of the clean growth question. The energy-oriented research centres have looked at the interactions between the UK energy system and the economy, including the consequences of different energy pathways for economic growth, employment, prices and trade flows. Natural environment programmes have explored how ecosystem services (of which a stable climate is one) can be factored into policy making (see also Chapter 5 on the UK’s energy transition and Chapter 9 on climate change and the natural environment).

PLANNING AND STRATEGY

Spearheaded by the energy-focused programmes, substantial research effort has gone into devising detailed decarbonisation pathways, which show how countries like the UK, or the world as a whole, could meet policy targets for reducing emissions. Using detailed energy-economy models, these studies explore different energy futures in the face of socio-economic and technological uncertainty.

Other projects are interested in the implications of such decarbonisation pathways for industrial strategy and in the potential to secure industrial opportunities. Several projects looked at innovation systems and the systemic transformation of industrial systems. Another strand of work has studied the carbon footprint of different consumption patterns, that is, carbon emissions embedded in the products we consume (see Box 4).

Planning and strategy are also prominent features in the adaptation portfolio. Researchers have explored, for example, how access to climate information and different decision-making heuristics may inform adaptation planning in different institutional and socio-economic contexts. One particular focus of this work was African cities and lands.

Other work put climate resilience in the wider context of climate-compatible development and explored the balance between adaptation, mitigation and development objectives in sectors such as agriculture, forestry, energy and water.

BOX 4: USING PRODUCTION AND CONSUMPTION-BASED CARBON ACCOUNTS TO GUIDE URBAN CLIMATE POLICY

Meeting the commitments made in the Paris Agreement on climate change will require different approaches in different countries.

However, a common feature in many contexts relates to the continued and sometimes increasing significance of the carbon footprints of urban centres. These footprints consider both production or territorial (i.e. Scope 1 and 2) emissions, and consumption or extra-territorial (i.e. Scope 3) emissions.

Although a growing number of cities have adopted targets for their production-based emissions, very few have even started to analyse or address their consumption-based emissions. This presents a potential challenge for urban policy making if consumption emissions rise while production emissions fall, and for climate mitigation more broadly if emissions are effectively migrating to areas without carbon reduction targets or capabilities.

To explore these issues, researchers at CCCEP are analysing and comparing production and consumption-based emissions accounts for urban centres in China, the UK and the US. Results show that per-capita income and population density are strong predictors of consumption-based emissions levels, and consumption-based emissions appear to diminish but not decouple with higher per-capita incomes. In addition, results show that per-capita income is a predictor of net emissions – or the difference between production and consumption-based accounts – suggesting that continuing increases in per capita income levels may drive the “leakage” of urban emissions.

These findings highlight a risk in placing too much faith in city-level climate strategies focused only on production-based emissions and stress the importance of new city-level initiatives that focus on consumption-based emissions, especially in cities that are shifting from producer to consumer city status.

CLIMATE AND ENERGY POLICY

Climate change requires policy intervention on a wide-ranging scale. Carbon policy has therefore been studied in some depth, including research on the design of low carbon policies and their impact on environmental and economic performance. Experience is accumulating from the implementation of climate mitigation policies and governance arrangements worldwide, which makes the empirical evaluation of their performance increasingly possible.

Researchers have looked at energy efficiency policy, innovation policy and incentives for behaviour change. An important focus of CCCEP has been carbon pricing through either taxation or emissions trading schemes. The Centre for Industrial Energy, Materials and Products (CIE-MAP) worked with the UK Government to ensure that changing resource efficiency was recognised as an important policy option for climate change mitigation. It is now included in the Government's Resources and Waste Strategy and its Clean Growth Strategy.

The technology and policy assessment programme of UKERC offers timely evidence on energy policy, including on contentious issues such as energy prices and consumer bills. The impact of carbon policies on industrial competitiveness has been studied by CCCEP.

Research on wider environmental policies was mostly case-study based and covered, for example, concrete instances of pro-poor management of ecosystem services. Particularly closely related to climate change were projects on market mechanisms and associated governance arrangements, to reduce emissions from deforestation and forest degradation and promote sustainable forest management (known as REDD+).

RESEARCH GAPS

Research on climate policy and governance has been relatively broad. However, not all issues are covered in equal depth. Low carbon policies outside the energy sector – for example in transport and industry – have received much less attention than electric power and (at least in a developed country context) agriculture and land use. There has also been relatively little work on technology governance, with the notable exception of a couple of projects on greenhouse gas removal techniques.

Some emerging new themes are too recent to be reflected in funding decisions. They include the need for a just transition, which combines environmental and social objectives, and the role of finance in the zero carbon transition. Sustainable finance solutions are gaining policy attention, including through a new Green Finance Initiative. The political economy of the zero carbon transition and the political/institutional context in which the Paris Agreement is being implemented has also received relatively little attention.

**“CLIMATE CHANGE REQUIRES
POLICY INTERVENTION ON A
WIDE-RANGING SCALE.”**

5. The UK energy transition

Clean energy is essential to addressing climate change, and accordingly energy issues have received substantial research funding. Most of that support has been focused on UK energy. The research councils have supported 41 projects with a substantive social science component worth £97 million devoted to the UK energy transition. Energy research is concentrated in a handful of high-profile research centres, with a much smaller number of independent projects.

Table 3: Research centres on energy in the UK

Lead institution	Project title	Award (£)
Imperial College London / UCL	UK Energy Research Centre	33,609,563
University of Oxford	CREDS: Centre for Research into Energy Demand Solutions	19,435,274
University College London	CEE: RCUK Centre for Energy Epidemiology	5,745,855
Brunel University	CSEF: Centre for Sustainable Energy in Food Chains	5,699,187
University of Warwick	I-STUTE: Interdisciplinary Centre for Storage, Transformation and Upgrading of Thermal Energy	5,213,689
Lancaster University	DEMAND - Dynamics for Energy, Mobility and Demand	3,937,512
University of Sussex	CIED: Centre on Innovation and Energy Demand	3,539,214
University of Leeds	CIEMAP: Centre for Industrial Energy, Materials and Products	3,046,231

UKERC is a long-established research centre that covers the whole energy sector, while the other listed projects focus on end-use energy demand. CREDS is the latest such centre (operating since 2018) and replaces the six original energy demand centres.

The main funder of UK energy projects with a strong social science dimension is EPSRC, which is the lead council on a series of strategic investments into end-use energy demand. However, other research councils, including ESRC, are contributing to all of them. EPSRC has also invested heavily in engineering research, which is not covered in this report.

Research on end-use energy demand combines engineering with socio-economic approaches, studying socio-technical and techno-economic aspects of energy use in industry, transport and the built environment. Research on energy supply is similarly interdisciplinary, combining engineering and social science approaches to study electric power systems, technology innovation and upstream energy supply.

RESIDENTIAL ENERGY USE

Residential energy use has been a particular interest of the energy demand centres, with detailed work on energy-efficient technologies, materials and designs, and the market, regulatory and policy contexts in which they are deployed. Research has looked at innovations in heating, air conditioning and energy storage, including home heating controls and central heating systems, and the way in which these systems are used by consumers (see Box 5).

Other research links data from energy companies with data about buildings and people to show how people use energy and the effectiveness of their energy saving actions. Research on human psychology and energy saving activities analyses actions such as the disposal and purchase of electrical appliances (see also Chapter 3 on practices and behaviour in relation to climate change). There is also work on fuel poverty to determine how energy policies affect certain groups in society.

The impact of innovation on reducing energy demand forms another research focus. Research looks at technologies such as heat pumps and driverless cars, social arrangements such as car sharing and modes of behaviour such as biking. It aims to understand how innovations and new technologies in these sectors affect user behaviour, market trends and the broader political environment. They also analyse business models for introducing technologies to market, and drivers and barriers to the uptake of technologies.

BOX 5: OFFICES AND OFFICE WORK

Energy use in offices was studied as part of the DEMAND Centre's "Situations, Sites and Sectors" theme.

Commercial, industrial and public sector buildings account for around 20 per cent of UK CO₂ emissions. DEMAND's work on non-domestic buildings such as offices shows how understandings of "normal" standards emerge, how competing interpretations of acceptable, marketable and desirable office environments are resolved and where opportunities lie for managing energy demand by negotiating user needs at different points in the building lifecycle.

A study of the design and specification processes associated with building and refurbishing ten commercial office buildings in London provided insights into how escalating expectations and standards of assumed user needs are designed into the fabric and services of buildings, creating rising "designed in" energy demand, in particular because of choices about cooling systems and power loads.

The project included the discussion of changes to office buildings and increasingly flexible and mobile work practices in the future. It discussed the contradiction of the information society promising to dematerialise society, but the modern office becoming a large and rapidly growing consumer of energy and resources.

TRANSPORT AND INDUSTRY

Another strand of energy demand research has focused on energy-intensive industries and the high levels of emissions associated with the production, consumption and transport of materials and products.

One of the research centres, the Centre for Industrial Energy, Materials and Products (CIE-MAP), considered the options to reduce industrial energy demand through further improvements in efficiency while also exploring the role of changing consumption patterns of materials and products. Material and product demand drives industrial emissions. As well as a sector level analysis of UK industry, CIE-MAP has therefore undertaken a detailed assessment of resource productivity strategies from the redesign of products through to the sharing economy.

This research aims to deliver reductions in the use of energy and energy-intensive materials in industries that supply the UK's physical needs. Solutions proposed include how to realise the remaining potential for energy efficiency in UK industry as well as the energy demand reduction from both material substitution and changing and reducing consumption. On a more systemic level, this research involves assessments of the relationship between economic growth and energy consumption.

Research on mobility and the decarbonisation of the transport sector is a key theme of the Centre for Research into Energy Demand Solutions (CREDS), which started operating in spring 2018. However, energy use in transport also featured in the earlier end-use energy demand centres. There has been research on transport system transitions, including a focus on cities, the school commute, road freight, and shifts to rail. Other projects study transport behaviour and the social aspects of vehicle innovation, notably the electric vehicle transition.

ENERGY SUPPLY

While energy demand has gained most prominence, there has been substantial research on energy supply, the UK energy transition, and synergies and trade-offs between its key drivers. These projects look at energy, the economy, and societal preferences. The main strategic centre focused on energy supply, UK Energy Research Centre, has investigated UK energy supply to 2050, the radical changes needed from 2020 onwards and the policy pathways to getting there. A key focus was on secure and sustainable energy and gas supplies and the decarbonisation of the heat sector.

Energy supply projects are heavily focused on governance and policy, regulatory incentives, and policy pathways. One key area of research was directed towards the governance and regulatory infrastructure required to incentivise renewable energy. This includes electricity market reform and design for a sustainable, low carbon electricity sector. Climate science support was sought for robust decision making in wind energy investments and policies. Particular solutions that were looked at include scenarios for the development of smart grids, smart metering, and offshore network design (connecting offshore wind farms and onshore power grids).

The regulatory work was complemented by behavioural research looking at the acceptability and social incidence of renewable energy policies and projects. Research includes surveys on the societal appreciation of the security of energy supply and public values, attitudes and acceptability towards transforming the UK energy system.

WIDER ENERGY RESEARCH

Research on technology and innovation projects cuts across the research centres but was also the focus of some smaller scale projects. There is research into the production of bio-methane, biomass-fed combined heat and power systems, nuclear energy in the UK and priorities for new building, funding and developing its supply chain, including public attitudes towards nuclear energy. Technology and innovation in the renewable energy sector was also looked at.

Complementing research into electricity and renewable energy were a few smaller scale projects on upstream energy supply options, such as fracking and unconventional energy sources, and peoples' attitudes towards (the social licence for) these technologies. They are discussed further in Chapter 3 on practices and behaviour in relation to climate change.

RESEARCH GAPS

The clean energy transition in the UK has been studied so extensively that there are few major research gaps. Energy has received more funding than any other climate change theme, and many of the major projects are still ongoing. The challenge for these projects is to deepen understanding of particular energy challenges (such as energy storage) and to remain responsive to a rapidly evolving policy landscape (e.g. the design of energy markets dominated by renewables). More research may be warranted on the political economy of energy reform, including the public acceptability and distributional impacts of higher energy prices, and on climate resilience. Energy research has almost exclusively been about mitigation, although there are important climate-resilience questions, for example the link between buildings efficiency and thermal comfort during heatwaves.

6. Floods and droughts in the UK

Floods, droughts and water management in the UK is a relatively small aspect of social science research on climate change (see Figure 6, page 12). However, it is an issue of considerable salience and policy relevance in the UK climate debate.

Over the past decade, 29 projects with a substantive social science component have received funding to research the impact of climate change on floods and droughts in the UK. Twenty-three of them were led by NERC. Total funding amounts to about £21 million or just over £700,000 per project on average.

There was a noticeable funding spike in 2014, when 10 projects received funding totalling £16 million. This includes the four largest projects in the floods and droughts portfolio, which were awarded a combined £15 million. It is possible that this was a response to earlier weather events, including the 2011/12 drought and the winter floods of 2013/14.

The projects are typically focused on a single hazard and mostly concerned with the effective management

of weather extremes. A particularly prominent research theme is sound decision making in the face of climate uncertainty and the effective use of climate information. Other projects study the interactions between hydro-meteorological and socio-economic systems, particularly in an urban context.

Research specifically on climate change is complemented by broader, related efforts to understand the social and environmental impacts of current climate variability on the UK, for example under the NERC-led UK Drought and Water Scarcity programme. In addition, there is substantial natural science research, for example on atmospheric science and hydrology, which is not covered in this review. Together, they add up to a much richer programme of flood and drought research on the UK.

Table 4: Selected projects on flooding and water management in the UK

Lead institution	Project title	Award (£)
University of Reading	IMPETUS: Improving Predictions of Drought for User Decision-Making	4,454,364
University of the West of England	Developing a drought narrative resource in a multi-stakeholder decision-making tool for drought risk management	4,248,091
University of Oxford	MaRIUS: Managing the Risks, Impacts and Uncertainties of droughts and water security	3,996,657
British Geological Survey	Analysis of historic drought and water scarcity in the UK: a systems-based study of drivers, impacts and their interaction	2,401,839
University of Liverpool	Adaptation and Resilience of Coastal Energy Supply	1,415,385

DROUGHT AND WATER SCARCITY

Managing weather extremes is a complex social, environmental and engineering challenge. The impact of droughts depends on meteorological, hydrological, geographical and socio-economic factors such as water demand and water abstraction regimes. Climate change substantially adds to this complexity by deepening the uncertainty about the future magnitude and interplay of these factors.

Improvements in decision-making has been a central theme of UK drought and water scarcity research. The largest project, IMPETUS, aimed to improve the forecasting of UK drought on monthly to decadal timescales, including better water demand forecasts, with a view to inform decision-making processes.

Complementary projects studied drought and water scarcity, including its socio-economic drivers, in a historical context. In one project, the social and cultural aspects of droughts were compiled from oral histories, print and media records and – in the case of the 2010-12 drought – social media analysis. Another project used storytelling, memory-work, community archives, visual stories and online forums to document historical knowledge about drought impacts and adaptation in different river catchments.

Another prominent drought project, MaRIUS, conducted research on drought governance, including the role of communities, and explored new drought management options. It studied the impact of drought and water scarcity on terrestrial and aquatic ecosystems, agriculture and farming, the economy and electricity production.

FLOOD RISK ASSESSMENT AND MANAGEMENT

Another central aspect of the UK floods and drought portfolio is research on flood risk management. A key aim of these projects is to improve flood risk assessment tools by taking account of climate change projections and their intrinsic uncertainty. Refinements in fluvial flood risk assessments and flood hazard maps provide an improved evidence base to decision makers in flood policy and flood management functions. Decision makers were engaged in interdisciplinary networks to increase their understanding of flood science.

Other projects introduce an economic angle to flood risk assessment by conducting cost-benefit analyses of either physical protection systems or, in several projects, blue-green solutions, which rely on the natural environment to offer hazard protection (see Box 6). In another project, a hedonic evaluation of house prices was used to identify the benefit of flood protection and sustainable urban drainage systems.

BOX 6: COASTWEB: THE CONTRIBUTION OF NATURAL HABITATS TO THE ALLEVIATION OF COASTAL FLOODING

Starting in 2016 and running for three years, CoastWEB received £1.1 million in funding from NERC, ESRC and AHRC.

The project is led by the Plymouth Marine Laboratory, in collaboration with the University of Oxford and Bangor University. It is developed in partnership with Natural Resources Wales, The Crown Estate and Natural England.

The project's main concern is the connection between the natural environment and human health. Specifically, it seeks to measure the contribution of natural habitats to human health through the alleviation of coastal natural hazards and extreme events. The research team uses natural science and modelling techniques to study Welsh saltmarsh ecosystems and document their contribution to coastal flood protection under different interventions. Changes in the level of ecosystem services are linked back to changes in human health and wellbeing at the local and national level, using qualitative dialogue and quantitative survey techniques.

The contribution of saltmarshes to coastal protection are documented in a Wales-wide map and communicated using an interactive artistic approach. In this way, the project will inform the management of saltmarsh ecosystems and provide insights into broader health and wellbeing.

**“MANAGING WEATHER
EXTREMES IS A COMPLEX
SOCIAL, ENVIRONMENTAL AND
ENGINEERING CHALLENGE.”**

CLIMATE-PROOFING INFRASTRUCTURE

Preparing Britain's infrastructure for climate change has been identified as an important policy priority. Given their long lifetime, infrastructure investments lock in vulnerability profiles for decades into the future. In recognition of this, researchers have studied the upgrade or replacement of flood defence infrastructure and coastal defence systems. In an urban context, a particular area of interest has been sustainable urban drainage systems (SUDS). The flooding of urban infrastructure has been the focus of studies aimed at examining the risks to estuary port systems and their respective supply chains.

Another project researched the challenges facing the UK nuclear energy sector and coastal energy supply under climate change. Integrated computer models of the North-West coast of England were used to predict long-term changes to different types of coastlines (for example, estuaries, soft rock and hard rock cliffs, gravel beaches, sandy beaches and dunes) and the impact of these changes for flooding, erosion, sedimentation, water quality and habitats. The aim is to create a decision-support tool for drawing up coastal management plans and defining adaptation strategies for coastal energy infrastructure.

RESEARCH GAPS

Floods and droughts have been identified as major climate risks in the statutory Climate Change Risk Assessments (CCRA), which the government is mandated to produce every five years. Despite their salience, the amount of social science research in this area is relatively small, although there is a larger body of work dealing with climate variability (as opposed to change) and the natural science (as opposed to social science) aspects of the problem. Flooding in particular has not been studied in much detail, even though there are important social science aspects to flood risk management under climate change, including the design of risk reduction policies, the interplay between physical and behavioural responses, the role of finance and insurance, and the business and human welfare impact of flooding. A new UK climate resilience programme under the Strategic Priorities Fund should help to close some of the research gaps.

**“PREPARING BRITAIN'S
INFRASTRUCTURE FOR CLIMATE
CHANGE HAS BEEN IDENTIFIED AS
AN IMPORTANT POLICY PRIORITY.”**

7. Climate-compatible development in Africa

After the UK, research on Africa has received the next greatest level of funding from projects explored in this report. A third of funding for overseas (non-UK) research is devoted to Africa, or £72 million in total. The prominence of Africa research reflects in large measure the availability of additional funding through the Global Challenges Research Fund (GCRF).

The GCRF is part of official UK development assistance and as such reflects the geographic priorities of UK aid, which is heavily focused on Africa. There is an expectation that GCRF projects emphasise engagement and policy impact. These non-research components therefore feature prominently in Africa research.

While there are some large (often GCRF-funded) programmes, Africa funding has been spread across many smaller projects. Most projects are NERC-led, with contributions from ESRC and other research councils.

Table 5: Selected projects on climate-compatible development in Africa

Lead institution	Project title	Award (£)
Lancaster University	RECIRCULATE: Driving eco-innovation in Africa: capacity-building for a safe circular water economy	5,926,058
International Institute for Environment and Development	GCRF: Social and Environmental Trade-offs in African Agriculture	5,630,400
University of Southampton	GCRF: Building Research Capacity for sustainable water and food security in drylands of Sub-Saharan Africa	5,418,342
University of Cape Town	FRACTAL: Future Resilience for African Cities and Lands	3,777,839
London School of Economics and Political Science	UMFULA: Uncertainty Reduction in Models for Understanding Development Applications	3,619,040
King's College London	Urban Africa Risk Knowledge	3,329,185

Africa makes up less than 5 per cent of global greenhouse emissions but is the continent most vulnerable to the effects of climate change. This is reflected in the research focus of the Africa portfolio. The majority of projects deal with climate vulnerability and the need for climate-resilient development. The dominant topics are water supply and food production, which received funding worth £29 million and £22 million respectively.

“AFRICA MAKES UP LESS THAN 5 PER CENT OF GLOBAL GREENHOUSE EMISSIONS BUT IS THE CONTINENT MOST VULNERABLE TO THE EFFECTS OF CLIMATE CHANGE.”

MEASURING AND REDUCING CLIMATE VULNERABILITY

A large group of projects seek to document, measure and understand the climate risks faced by countries and communities in Africa. Projects include analyses of regional climate systems and climate change risk assessments. Specific examples include the attribution of impacts of external climate drivers on natural hazards in Africa, national scale impact-based forecasting of flood risk, and the use of earth observation data to enhance disaster risk forecasting.

There are projects on building resilience and inclusion through social learning around climate risk, and on how forecasting can be used to improve climate resilience. Projects have looked at ways to use climate information to reduce model uncertainty in ways that acknowledge local data and capacity constraints. Another project studied the epistemology, methodology, and policy space for integrated disaster risk management. Researchers also explored consensus forecasts, which integrate indigenous knowledge with scientific weather and climate information as a way to strengthen resilience to climate change.

WATER MANAGEMENT

Water management is a central interest of climate change research on Africa. Research on weather extremes and water management has explored the effects of flooding and drought on economies and households in Africa. It includes insights into patterns of resilience among young people in communities affected by drought and the emotional response of pastoralists in Ethiopia. The impact of El Niño has been studied for small and medium enterprises in Kenya and Zambia, households in Tanzania and rural water insecurity in Ethiopia. One project features creative experiments for building drought resilience, and another looks into water governance and adaptation to change in African river basins. Other projects support rainfall climatology and time series analysis to aid adaptation in East Africa. Other projects include hydro-climate science for policy decisions, research into hydro-economies and water security and hydro-citizenship.

Several projects explore groundwater security and resilience in groundwater supply, with the aim of improving groundwater management. Projects investigate current failures in order to achieve future success in rural groundwater supply and identify critical thresholds for groundwater recharge. Understanding of climate variability into planning of groundwater supplies, optimising road development for groundwater recharge and retention and adaptive management of groundwater resources for small scale irrigation are all important aspects of this research.

There is a strong connection between weather extremes (floods and droughts), agriculture and livelihoods, which is explored in several projects. Because of their heavy reliance on agriculture, African economies are disproportionately affected by climate variability and change. Relevant projects include research on food systems resilience, food security, trade-offs in agricultural policy and preparedness for agro-climate extremes. These projects are discussed in further detail in Chapter 6 on climate, food and agriculture, but Box 7 provides a good example. There is also a thriving research agenda on the food-water-energy nexus that does not have a climate change focus, which is beyond the scope of this review.

Also worth highlighting are Africa projects on coastal and marine ecosystems. Socio-ecological resilience to coral reef degradation in islands of the Western Indian ocean, global learning opportunities for regional Indian Ocean adaptation, whole decision network analysis for coastal ecosystems and sustainable oceans, livelihoods and food security all form part of this theme.

DEVELOPMENT POLICY AND INNOVATION

Many projects in the Africa portfolio offer policy prescriptions for achieving climate compatible development and improving climate resilience. Among projects with an adaptation focus this includes research on the future resilience for cities and lands, marine coastal management to sustain coastal communities, and the identification of resilient governance systems by modelling climate, ecosystem services and livelihoods. A science-to-policy project provides a knowledge exchange platform for climate-informed health policy in east and west Africa.

Projects interested in climate-compatible development more broadly are exploring how adaptation, mitigation and development policies can be balanced and mainstreamed. They are interested in cases where pursuing adaptation, mitigation and development together can lead to multiple benefits. Related projects look at trends in urbanisation, the value of urban green infrastructure, and wise investments in natural and built water infrastructure.

There are a small number of innovation projects. They include research on eco-innovations and an African circular economy, the optimal packing of insurance and credit for smallholder farmers, the scaling out of data for weather index insurance, and U-Alert – a project that sends signals between mobile phones as an alternative means to measure rainfall intensity and duration.

BOX 7: GCRF-AFRICAP: AGRICULTURAL AND FOOD SYSTEM RESILIENCE

GCRF-AFRICAP combines knowledge about agriculture, climate, ecology, soils, water, post-harvest losses, land use, nutrition and health, rural livelihoods with policy and institutional analysis.

The mission of this pan-African network is to build resilient food systems across Africa through the assessment and creation of food, agriculture and natural resource policies that are both evidence-based and developed in partnership with non-state actors. The project is the biggest investment in both the climate compatible development and food production and trade categories, receiving a total of £8 million in funding between October 2017 to December 2021. The project is funded under UKRI GCRF's Growing Research Capability call.

GCRF-AFRICAP addresses research and capacity growth under three broad themes. The first is trade-offs between agricultural and food systems productivity and climate resilience. Food systems must be resilient to extreme weather from climate change while minimising impacts on the environment and maximising their contributions to livelihoods, food and nutrition. The second theme is agricultural pathways to productivity as the economic and food-security demands on agriculture change over the next decades with climate change. The third theme is policy development that enables sustainable, productive and climate-resilient pathways to be realised in an inclusive way, maximising agriculture's contribution to the achievement of the Sustainable Development Goals.

Work is focused in four countries in Sub-Saharan Africa with varied farming systems that are all affected by climate change: Malawi, South Africa, Tanzania and Zambia. The aim is to disseminate the lessons learned from the case study countries across Africa to contribute to capacity building and an evidence-based agricultural transformation.

RESEARCH GAPS

While climate change in Africa has received a fair amount of social science funding, there are important research gaps. Perhaps the most obvious gap is the paucity of research on zero carbon poverty alleviation. The synergies or trade-offs between development needs and greenhouse gas mitigation – and their implications for development aid and climate finance – are not yet fully understood.

In terms of climate actions, most Africa research is concerned with policy prescriptions for development aid and the observation of climate change behaviour by individuals or in communities. Only one in ten Africa projects is concerned with technology and innovation. This is despite the fact that adaptation innovations (e.g. in agriculture and water management) and the dissemination of technology are a key part of climate-compatible development in Africa. Innovative financing mechanisms, including insurance, have received little mention aside from two insurance projects. The Africa climate change story is also mainly told in terms of the negative effects of climate risks, rather than the search for sustainable development solutions.

8. Agriculture and land use

Research on agriculture and land use covers mitigation and adaptation projects across all geographies. There are 85 projects with a substantive social science component in this category, receiving a total of £65 million. Funding is provided evenly by NERC, ESRC and BBSRC, with NERC leading the largest number of projects.

As is the case with the overall portfolio, adaptation research received more attention, with 44 agricultural adaptation projects worth £39 million. The 42 mitigation projects, which also cover land use change and forestry, received £26 million in funding. There is a considerable focus on Africa, particularly in large projects, and to a

lesser extent the UK. The 17 Africa projects received £26 million in funding, 90 per cent of which is dedicated to adaptation. UK projects received funding worth £19 million, split evenly between adaptation and mitigation. A small number of projects cover both adaptation and mitigation.

Table 6: Selected projects on food and agriculture

Lead institution	Project title	Award (£)
NERC Centre for Ecology and Hydrology	Sustainable Land Use	3,673,130
University of York	IKnowFood: Integrating Knowledge for Food Systems Resilience	2,740,111
University of East Anglia	SEER: Social and Environmental Economic Research into Multi-objective Land Use Decision Making	2,733,444
University of East Anglia	FAB GGR: Feasibility of Afforestation and Biomass energy with carbon capture storage for Greenhouse Gas Removal	1,913,512
University of Leeds	PIGSustain: Predicting the impacts of intensification and future changes on UK Pig Industry Resilience	1,681,384
University of Edinburgh	RUGS: Resilience of the UK Food System to Global Shocks	834,965
Aberystwyth University	Structure, connectivity and resilience of an exploited ecosystem: towards sustainable ecosystem-based fisheries management	818,201

CLIMATE VULNERABILITY AND ADAPTATION

A sizeable number of projects in this theme are focused on impact assessment, seeking to document the negative effect of climate variability and change, often in the form of extreme weather events, on agricultural output and food security. These projects are mainly descriptive, as opposed to providing normative solutions. They are about food systems resilience and preparedness for agro-climatic extremes, food security, and the future of food (see Box 8). Many are forward looking, offering disaster forecasting, predictions of preparedness and estimates of crop yields under climate change.

Most adaptation projects are concerned with Africa. They are interested in disaster decision-making, food systems management and policy options for achieving sustainable food systems, often documenting locally developed solutions. The research explores the socio-economic context in which African farmers participating in different value chains struggle with different environmental pressures.

Another set of projects concerns horticulture and fishing. They study the deployment of technology to achieve the sustainable management of marine ecosystems and oceans, and research on the resilience of land-based agriculture and crops such as coffee. There is also research into food security and on delivering nutrition in the future. Other work studies responses such as the optimal packaging of insurance for smallholder farms and the delivery of pollination services.

UK adaptation projects include research on the resilience of pollination services, the rural economy, the pig industry and the wine sector. Other projects investigate the role of livestock in resilience, tipping points in lowland agricultural landscapes, policies and practices for environmental change, and climate information for improved adaptation decision-making.

There are fewer projects in other geographies, but they follow a similar theme. There is research on food insecurity in Asia and Latin America, sustainable livestock production, and BIO smart livestock farming in Latin America.

BOX 8: INTEGRATING KNOWLEDGE FOR FOOD SYSTEMS RESILIENCE (IKNOWFOOD)

IKnowFood is a collaborative, multidisciplinary project, which opened in October 2016 and is due to close in October 2020. It has received £1.9 million in funding from BBSRC, ESRC and NERC.

The project is aimed at understanding the obstacles to food systems resilience that spans many research responses: practices and behaviour; technology and innovation; and governance and policy.

The project is split into four research themes in different areas of the food system: on farm; in the supply chain; the consumer end; and entire network research.

On farm research aims to identify social and technological on-farm innovations to improve environmental sustainability and productivity, with climate change as one important factor. The project also surveys farmers to explore whether these new technologies would support their livelihoods.

Supply chain research is aimed at promoting resilient supply chains, identifying environmental and political risks and vulnerabilities of the UK food system, and promoting resilient supply chains in the British food system given environmental and regulatory constraints.

Consumer research is aimed at influencing food choice for health and resilience. It seeks to understand consumer choice related to food in a system where it is difficult for consumers to know about the choices they're making. The project will create shopping apps to help consumers understand the climate and sustainability impacts of their food choices.

The network is aimed at integrating knowledge for a more resilient food system, bringing farmers, industry and consumers together.

MITIGATION

Forty per cent of mitigation projects in the food and agriculture theme focus on the UK. These are normative projects that work on building solutions to agricultural emissions, with a strong focus on innovation. Projects are focused on sustainable energy use in food chains, innovative practices for sustainable and ecological grazing systems, and new technologies to achieve low carbon agro-energy. Other projects include research into forest and crop management and energy-crop distribution.

Projects outside of the UK are interested in both forestry and agriculture. There is research on deforestation-payment schemes in Africa and Latin America, including the Amazon, forest degradation management in Colombia, and European beech forest conservation. Projects in Africa and Asia are focused on the benefits of mangroves and community engagement to halt forest degradation and biodiversity loss.

On agriculture, there are projects on sustainable agriculture intensification in Brazil, rice cultivation in Asia, and the sustainable management of the Costa Rica dairy sector. There are policy projects to develop detailed plans to mitigate greenhouse gases from agriculture and an understanding of socio-economic implications of such policies. There is a project on south-south technology transfers that aims to bring innovative technologies to low- and middle-income countries.

Global projects are focused mainly on large-scale land-based mitigation, including greenhouse gas removal in the land sector, afforestation and biomass energy for greenhouse gas removal, the monitoring of smallholder farms, and management of forest biodiversity.

“MOST ADAPTATION PROJECTS IN AGRICULTURE ARE CONCERNED WITH AFRICA.”

TRADE-OFFS BETWEEN ADAPTATION AND MITIGATION

Food and agriculture research recognises the connection between adaptation and mitigation. While resources need to be put into dealing with the effects of climate change on agricultural production, there has to be equal recognition of the impact that agriculture itself has on climate outcomes, through the removal of land cover and the emission of greenhouse gases. Many projects recognise this dichotomy and simultaneously explore the adaptation and mitigation sides of agricultural production. These are mainly governance and policy projects that seek to address all important aspects of agriculture and climate change.

Projects in this vein include research on multi-objective land use decision making and the social and environmental trade-offs in African agriculture, covering the risks and trade-offs within and between socio-economic and environmental dimensions of different agricultural development pathways. One UK project studies advanced technologies for efficient crop management and precision agriculture, which have both adaptation and mitigation effects.

Projects on the future of food systems are equally multi-dimensional. There is growing awareness of the need to increase food systems' resilience to environmental stresses while reducing negative outcomes of food systems' activities (from producing to consuming food) for the environment, health and other socioeconomic parameters.

Deforestation projects seek to understand the extent to which policy processes related to forest mitigation and adaptation should be integrated. The aim is to deliver effective emissions reductions and development-compatible outcomes, but also to create a market mechanism for forest mitigation.

RESEARCH GAPS

Compared to other emission sources, the scope and costs for greenhouse gas abatement in agriculture is much less understood. This includes gaps in the socio-economic exploration of suitable policy interventions and incentives for behaviour change (see also Chapter 3 on practices and behaviour in relation to climate change). Globally, the prevalence of unsustainable farming practices in many parts of the world also deserves further scrutiny, particularly from a political economy angle.

As the world moves to net zero emissions, the importance of forests and land use change will become even more apparent, both as a major cause of emissions and as a source of negative emissions through carbon sequestration.

The vulnerability of national and global food systems to climate change is relatively well understood, although there are research gaps related to the behavioural response of farming communities in the face of climate change. There is also room for further integrated research that considers the mitigation, adaptation, food security, animal welfare and nature conservation aspects of food production in a holistic manner.

Funding is currently concentrated in Africa, the UK and on global projects. Given the levels of deforestation in East Asia and Latin America, and the unsustainable farming practices in both regions, they might warrant a greater level of funding.

9. Climate change and the natural environment

There are 33 social-science projects that study the link between climate change and nature, with total funding worth £22 million. Practically all of these projects are NERC-led, with small contributions from ESRC and other research councils. Just under half of the funding goes towards UK focused projects, with the rest spread fairly evenly across Asia, Africa and other world regions. These projects are typically smaller than those in other themes. There are three projects in excess of £2 million, but the remaining investments have an average size of around £300,000.

Research on the natural environment has much wider scope than what can be covered in this review. The projects reviewed here are concerned specifically with the interplay between climate change risks and the health of the natural environment, and the consequent impacts upon human wellbeing, including distributional issues such as poverty.

Climate change is a threat multiplier, increasing the already considerable stress that human activity puts on the natural environment. Accordingly, the analytical starting point is usually not climate change, but the natural environment and the ecosystem services it provides. Climate change is often only a secondary concern. However, the projects recognise that a healthy natural environment is central to climate change adaptation and that climate regulation is a crucial ecosystem service.

“CLIMATE CHANGE IS A THREAT MULTIPLIER, INCREASING THE ALREADY CONSIDERABLE STRESS HUMAN ACTIVITY PUTS ON THE NATURAL ENVIRONMENT.”

Table 7: Selected projects on climate change and the natural environment

Lead institution	Project title	Award (£)
University of Exeter	South West Partnership for Environment and Economic Prosperity (SWEEP)	4,118,113
Lancaster University	SPACES: Sustainable poverty alleviation from coastal ecosystem services: Investigating elasticities, feedbacks, and trade-offs	1,928,731
University of York	Integrating ecological and cultural histories to inform sustainable and equitable future for the Colombian Paramos	1,137,577
University of East Anglia	Interdisciplinary Network for Valuing Biodiversity, Ecosystem Services and Natural Resource Use	628,123
Bath Spa University	Resilient People need Resilient Ecosystems in Smart Cities (RESPIRES)	358,758

ECOSYSTEM SERVICES AND TIPPING POINTS

A key aim of projects in this theme is to deepen our understanding of climate change and ecosystem processes, and how climate change affects management policies in at-risk locations. They assess biodiversity and ecosystem services in a wide range of areas that are at risk from climate change, including managed ecosystems (agricultural land) and natural habitats (e.g. rivers).

Several projects seek to “value nature” by providing economic estimates for climate-driven changes in ecosystem services and natural resource use. The aim is to assess the value of nature in a warming world. The Valuing Nature Programme assesses the impacts of climate change delivery on multiple ecosystem services, and another project considers mangrove valuation.

Another group of projects is centred on climate change-related tipping points. If ecosystems are exposed to multiple threats, they may be pushed toward tipping points. These can be societal or climatological. Projects in this category investigate how climate change is pushing ocean ecosystems, land ecosystems and peatlands to potential tipping points.

INTERACTIONS WITH BUSINESS AND POLICY

Once natural capital has been valued, economic and policy instruments can be devised to manage and protect what has been valued. The next grouping of projects covers policy interventions and business interactions that reduce the multiple stresses on the natural environment.

Research in this vein puts natural capital at the heart of decision-making. It explores natural resource management in the face of climate change, and the development of frameworks for helping natural resource management groups reduce their risk and vulnerability to, and prepare for, climate change. The largest of these projects, SWEEP, is currently working with nearly 150 businesses and policy groups.

Policy projects include addressing climate adaptation policy lock-ins, the role of protected areas in climate change adaptation strategies, and the modelling of climate, ecosystem services and livelihoods to identify resilient governance systems (see Box 9). Projects range from resilient ecosystems in smart cities to sustainable tropical landscapes under climate change.

Some projects look at policy in specific UK countries and regions. For example, one project is devoted to building an evidence base for the implementation of the Welsh Climate Change Strategy, and another to exploring the local implementation of DEFRA's 25-year Environment Plan, which covers England. There is also a project concerned with building UK resilience to risks to natural capital under the Climate Change Risk Assessment.

There are some place-specific projects such as the mapping of ecosystem services for agricultural improvement and human health in Sub-Saharan Africa and reviewing dryland African experiences and opportunities with ecosystems. Technologies are assessed for supporting environmental assessment and decision-making in the Ganges basin.

BOX 9: UNDERSTANDING CLIMATE ADAPTATION POLICY LOCK-INS: A 3 X 3 APPROACH

This European collaboration project aims to understand climate adaptation policy “lock-ins” related to the natural environment. The project began in April 2019 and is set to run until March 2022. It is a relatively small project receiving slightly under £500,000 in funding from ESRC.

Lock-ins are a potential explanation for inaction or selective action in climate adaptation policy. They are frozen situations, in which mutually reinforcing constraints result in path dependencies such that climate change is not taken into account. Several types of lock-ins are studied in the project, including technological, institutional, and behavioural lock-ins.

The project focuses on the Netherlands, the UK and Germany. Comparative research will be done about policies pertaining to nature conservation and biodiversity policies. Research also includes the water and health care sectors. The core questions are: whether the policies pertaining to these sectors in the three countries show signs of lock-ins or not; why that is the case; and ultimately whether and how lock-ins can be overcome or prevented altogether.

In principle all three of these sectors are well equipped to deal with climate adaptation. However, each is subject to lock-in. For example, lock-ins can describe why ecosystem-based approaches to climate adaptation have a difficult time gaining purchase in the Dutch context. Dutch water management has invested billions of dollars in dikes and dams, maintained and upheld by waterboards, a system geared towards a particular way of providing water security. This particular method is locked-in, leaving little room for alternative, ecosystem-based approaches.

POVERTY ALLEVIATION

A major topic under the climate change and nature theme is the link between climate change, ecosystem services, and poverty alleviation. The projects cover multiple response actions, including research, governance and technology. They are centred in the low- and middle-income regions of the world: Africa, Asia, and Latin America.

Ecosystem Services for Poverty Alleviation (ESPA) has been a flagship initiative for the former Living with Environmental Change programme (LWEC; now Research and Innovation for our Dynamic Environment, RIDE), a funding network that cuts across the research councils. ESPA addressed different pressures on natural resources, ecosystem services, economic growth and social progress. A key ESPA theme was the impact of climate variability and change on the water cycle, ecosystem services, and livelihoods. Climate change impacts the ability of poor people to access ecosystem benefits, creating new vulnerabilities and constraints. Researchers have explored socio-environmental feedbacks, opportunities and trade-offs and investigated climate change as a driver of each of these.

The climate-nature-poverty nexus has been studied in a diversity of ecological and socio-economic contexts. One project analysed the multiple stresses facing mountainous Western China, the Qinghai-Tibetan plateau. Mountainous ranges that host diverse ecosystems are under threat from deforestation, climate change, and the melting of glaciers. Another project investigated ecosystem services, health and livelihoods in populous deltas, which are exceptionally susceptible to climate risks. Other projects study land use change in Yunnan, China, and sustainable and equitable futures for the Colombian paramos.

RESEARCH GAPS

The socio-economic evaluation of ecosystem services and the management of natural capital are active areas of social science research. Much has yet to be learned. An important challenge from a climate change perspective is the closer integration of climate change and biodiversity research. Work on nature conservation rightly recognises climate change as a threat multiplier that cannot be ignored. However, climate change is often used as a factor that increases the necessity of the research, rather than as a core theme in and of itself. From a policy point of view, the “climate crisis” and the “natural environment crisis” have not yet been brought together.

CONCLUSIONS

Social science research on climate change is rightly a priority for UK research councils. This report reviews the scope and analytical focus of funding that has been provided since 2008. Our interest is in the research objectives and questions that were posed, rather than in specific research findings. The aim is to identify topics that have been covered adequately and research gaps that remain.

THE IMPORTANCE OF SOCIAL SCIENCE RESEARCH ON CLIMATE CHANGE

The fight against climate change is at a critical stage. A growing number of countries are making commitments to drastically reduce their greenhouse gas emissions. Ultimately, emissions must reach “net zero”, that is, a level where emissions are balanced by the removal of greenhouse gases from the atmosphere. Key zero carbon technologies are increasingly available and rapidly falling in cost. Grassroots movements are pushing for accelerated action. Yet progress is slow and climate risks are growing.

A solid evidence base is essential to navigate the scale and complexity of the climate change problem. This includes a better understanding of the social science of climate change. Ultimately it will be societal processes that drive much of the required change, so it is important to understand them better. These processes include low carbon investments, technology and business innovation, different governance arrangements at multiple levels, more enlightened public policy, and changes in individual behaviours.

THE RESEARCH FOCUS OF EXISTING PROJECTS

ESRC and the other research councils have a respectable track record of supporting social science research on climate change. Between 2008 and spring 2019 they have supported 481 climate change projects worth £438 million.

Climate change research with strong social science elements is supported by all research councils. ESRC is the lead council in only 20 per cent of projects, but it has supported 70 per cent of relevant projects. Fifty-five per cent of projects were led by NERC, while EPSRC is the leading funder of energy research.

Research on adaptation and mitigation have received similar amounts of funding, with each accounting for about 45 per cent of the portfolio. The remainder is generic climate research. This is consistent with the objectives of global climate finance, which also aims for an equal split between adaptation and mitigation support. However, adaptation support is spread over a larger number of projects, with mitigation research concentrated in large research centres.

The research covers a remarkable diversity of topics, methods and geographies. This report highlights seven topics that especially stand out: practices and behaviour; climate policy and governance; the UK energy transition; floods and droughts in the UK; climate-compatible development in Africa; agriculture and land use; and climate change and the natural environment.

NOTABLE RESEARCH GAPS

Without claiming to be comprehensive, the report gives a flavour of the research conducted under these seven themes. For each theme, the report also identifies research gaps and potential areas for further research. Many of the recommendations are about deepening existing efforts on issues such as the role of finance in the zero carbon transition, the zero carbon challenge of low income countries and the integration of climate change and broader environmental research.

On some important topics research is ramping up. Understanding practices and behaviour, for example in relation to issues like air travel and eating meat, is gaining more attention, with a new research centre specifically dedicated to the topic. Recent funding rounds on climate resilience in the UK should help to fill another important research gap.

In addition, there are new topics that ESRC has not yet covered in detail. In part this is because they have gained salience only recently. As national commitments under the Paris Agreement are ratcheted up, and countries like the UK adopt net zero emissions targets, the social science of negative emissions technologies, such as bioenergy with carbon capture and storage (BECCS), is becoming more important. This could include more research on public attitudes toward these technologies, how they can be incentivised and how they should be regulated.

The political economy of climate change policy and how to build and maintain consensus also needs to be better understood. An important aspect of this is the need for a just transition that adequately protects those adversely affected by the zero carbon transition, such as workers in high carbon industries. The surge in support for climate action and the widespread declaration of climate emergencies demands the focus of social scientists, but is too recent to have gained any analytical attention.

Understanding the social science of climate change in all its dimensions is essential to advance action on climate change and ensure that decision making is evidence-based. The continued support of research councils is essential in achieving this goal.

PROJECT LIST

For a full list of social science projects on climate change included in this review, go to: <https://pcancities.org>

APPENDIX: SUMMARY FICHES ON RESEARCH CENTRES

The portfolio of climate change investments includes several large, strategic initiatives. Some of them have the character of programmes (for example, the programme on Ecosystem Services for Poverty Alleviation, ESPA). Others are networks that emphasise engagement with research users (for example, the Place-Based Climate Action Network, PCAN). However, most strategic initiatives take the form of research centres, where a diverse research programme can be pursued over five to ten years and sometimes longer. In total there are 15 research centres that conduct substantial research on the social science of climate change or related topics. They are introduced in this Appendix.

CAST: CENTRE FOR CLIMATE CHANGE AND SOCIAL TRANSFORMATIONS

CAST started operating in May 2019 with the objective of putting people at the centre of the transformations needed to tackle climate change. The Centre was awarded a grant of £4,903,412 from ESRC and will run until April 2024. CAST is led by the University of Cardiff and also includes researchers from the University of Manchester, the University of East Anglia and the University of York. Engagement activities are conducted in partnership with the charity Climate Outreach.

CAST places people at the heart of the changes required. It studies people as agents of transformation in four areas of daily life that impact directly on climate change but have proven resistant to change: (1) consumption of goods and physical products; (2) food and diet; (3) travel; and (4) heating and cooling. The Centre works across multiple scales (individual, community, organisational, national, and global) to identify and experiment with the necessary transformations to achieve a sustainable, low carbon society.

An important feature of CAST is its strong practical focus and its ambition to bringing about social change at all levels of society. Researchers at CAST will establish a citizen's assembly and a youth panel to ensure public concerns are a central part of the Centre's work. Further, they will work closely with business, policy-makers and third sector organisations to co-design and trial practical interventions that arise from their research. These include using behaviour change techniques that are designed to break people's habits, such as encouraging more active travel, as well as organisational change interventions with businesses to engage employees with carbon reduction, and policy-level interventions such as policy design workshops.



RESEARCH FOCUS

The activities of CAST are structured into four main themes:

Visioning: This theme seeks to understand possible and preferred visions of future low-carbon societies. Using a series of innovative and complementary approaches, it will re-imagine the ways in which societies can be configured.

Researchers will examine the underlying processes behind shifts in discourses of climate change and radical decarbonisation. Positioning the UK in a global context, the theme also provides comparisons across countries, focusing on two rapidly developing countries (China, Brazil) and a country with ambitious policies on consumption, diet, mobility and comfort (Sweden).

Learning: This theme asks how and why social transformations have occurred. Complementing the present and future oriented work of the Visioning theme, this theme explores the history of and opportunities for transformational change through past and emergent examples. The theme will problematise and theorise the notion of transformation, drawing on multiple meanings, experiences and strands of literature to identify different forms, rates, and processes of change. It will identify the most significant drivers, patterns and outcomes of change as well as the conditions under which different degrees of transformation occur.

Trialling: This theme asks how social transformations can be accelerated. It will identify ambitious yet practical approaches that can bring about change in contemporary settings. They will be trialled at multiple scales, applying a "learning by doing" methodology. Two projects will work directly with individuals and households, negotiating opportunities for behaviour change in the contexts of family, community and place. Work with industry partners will co-design and monitor changes to workplace policies and practice. At the city level, CAST will work with the Greater Manchester Combined Authority and Cardiff City Council. At the devolved administration level, CAST will work with the Welsh Government to co-design policies that help Wales meet its emission reduction targets.

Engaging: This theme asks how transformation can be embedded within society. Projects in this theme will integrate and build on lessons from the Centre's work on visioning, learning and trialling transformations to maximise the impact and legacy of CAST. The theme recognises the multiple levels and levers for transformation, including individual, community, organisational and governmental. It acknowledges the value-basis and temporal dimensions of transformation and the critical role of engagement.

CCCEP: CENTRE FOR CLIMATE CHANGE ECONOMICS AND POLICY

CCCEP is an interdisciplinary centre whose activities span from policy design to climate governance, business investment and economic development. There is a strong disciplinary focus on environmental economics and geography, but the Centre also hosts scholars from statistics, government, economic history, law and international relations.

The Centre is hosted jointly by the University of Leeds and the London School of Economics and Political Science. It was launched by ESRC in 2008 and renewed for a second phase in 2013. CCCEP was awarded ESRC transition funding in 2018. This third phase of the Centre will extend to 2023 at reduced levels of funding. Over these three phases CCCEP has been awarded £14,500,105 from ESRC.

CCCEP's mission is to advance public and private action on climate change through rigorous, innovative research. The Centre has extensively contributed to the understanding of climate change and the responses of economies and societies to climate change.

RESEARCH FOCUS

In its first phase, CCCEP research focused on developing climate science and economics; climate change governance for a new global deal; adaptation to climate change and human development; and markets for climate change mitigation. During this phase, ESRC funding was complemented by a parallel programme sponsored by Munich Re, which sought to evaluate the economics of climate risks and opportunities in the insurance sector.

Research in the second phase paid particular attention to understanding green growth and climate-compatible development, advancing climate finance and investment, evaluating the performance of climate policies, managing climate risks and uncertainties, strengthening climate services, and enabling rapid transitions in mitigation and adaptation.

In its third phase the Centre is focusing on seven integrated research themes and the consolidation of its research impact. The seven themes are: (1) low carbon; climate-resilient cities; (2) sustainable infrastructure finance; (3) low carbon industrial strategies in challenging contexts; (4) integrating climate and development policies for climate-compatible development; (5) competitiveness in the low carbon economy; (6) incentives for behavioural change; and (7) climate information for adaptation.

CECAN: CENTRE FOR THE EVALUATION OF COMPLEXITY ACROSS THE NEXUS

CECAN was established in March 2016 with the aim to transform the practice of policy evaluation. It has received funding of £3,127,094 from ESRC and is hosted by the University of Surrey.

CECAN develops, tests and promotes innovative policy evaluation approaches and methods across the nexus of food, energy, water and the environment. It does so through a series of "real-life" case study projects. The team comprises of social scientists, policy makers, policy analysts and experts who all share a common goal to improve policy evaluations for the better.

RESEARCH FOCUS

Designing policies that can respond to the problems facing society is challenging. Not only are policies difficult to design, but it can also be difficult to know whether a policy has worked. Evaluating whether changes have been caused by a specific policy or for other reasons can be hard. CECAN delivers a programme of evaluation methods workshops, training courses in evaluation tools and specialist seminars delivered by international experts, to encourage knowledge sharing and capacity building amongst those working in UK policy making.

CECAN works with government departments, academics and evaluation experts on policy connecting energy, food, water and environment. CECAN is refining existing methods and developing new ones that can be used in policy evaluation.

CEE: RCUK CENTRE FOR ENERGY EPIDEMIOLOGY

CEE was the UK's first research centre dedicated to energy epidemiology: the systematic study of the distributions of energy use and their causes in populations. The Centre opened in May 2013 and closed in October 2018. It was funded through a £5,745,855 grant from EPSRC and its partners. It was one of six centres created to research end-use energy demand. The work of the Centre is being continued with research council funding via the Centre for Research into Energy Demand Solutions (CREDS).

CEE introduces energy epidemiology as a new research method to improve understanding of energy demand. Energy epidemiology provides empirical evidence and an environment that allows interdisciplinary research to address relationships between people, systems, environment and energy demand. CEE's population-level model emphasizes how epidemiological approaches use theory, insights, understanding, aetiology and findings to encourage the detection of population-level patterns related to energy demand.

RESEARCH FOCUS

CEE's research aims to support end-use energy reduction in three areas – domestic buildings, non-domestic buildings, and transport.

Domestic buildings: Research into domestic buildings involves domestic heat pump electricity consumption, condensing boilers, the health impacts of energy efficiency and temperature in indoor environments, and the real impacts of retrofits on energy demand. CEE has investigated the determinants of residential energy consumption, finding that building factors are the largest contributors to energy use, rather than socio-demographic or attitudinal factors. The Centre conducted a longitudinal UK energy survey to understand energy demand in national building stock and has recently conducted a workshop on the energy performance of the building stock in the UK, Brazil, and Latin America.

Non-domestic buildings: Non-domestic building research includes an assessment of the energy performance of the UK's commercial and public sector buildings (e.g. schools, offices, prisons) and the people who own and work in them. Projects have included the creation of 3D models of the non-domestic building stock for use in energy analysis, and Simstock. The latter is a new approach to building stock modelling, generating stocks made of individual building models to interpret existing communities or predict stock-level impacts of interventions. CEE has also compared the energy and density of high- and low-rise buildings.

Transport: Transport projects include analyses of vehicles, travel by land, air or sea and individuals that use them. This includes electric vehicle purchase behaviour and mode-choice behaviour in developing countries – ways of promoting bike and car sharing schemes by examining past, present and future mobility opportunities. CEE's work has quantified the global shipping system's energy demand from 2007-2015 and identified its drivers, finding that expectations of global demand growth are outstripping the rate of energy efficiency improvements. CEE uses advanced data collection methods such as smartphone-based travel surveys, open application programming interfaces ('APIs') and big data analysis of mobility patterns and their energy implications to aid its research programme.

CIE-MAP: CENTRE FOR INDUSTRIAL ENERGY, MATERIALS AND PRODUCTS

CIE-MAP is one of six end-use energy demand centres sponsored by EPSRC, ESRC and other research councils. Working closely with government and industry, the Centre ran from August 2015 to November 2018, although it is still actively producing research. CIE-MAP received £3,046,231 in funding from EPSRC and its partners. The participating universities are Bath, Cardiff, Leeds and Nottingham Trent.

CIE-MAP conducts research to identify opportunities that deliver reductions in industrial energy use. Energy is required at each stage of manufacturing, from raw material extraction through to final distribution and disposal. Therefore, as well as

a sector level analysis of UK industry, CIE-MAP has undertaken a detailed assessment of resource productivity strategies from the redesign of products through to the sharing economy. Many of these strategies could have significant consequences for the general public and the UK economy. With this in mind, CIE-MAP has conducted research on the willingness of the public to engage in resource efficiency measures.

CIE-MAP engaged extensively with UK Government departments. This involved engagement with BEIS (Business, Energy and Industrial Strategy) and DEFRA (Environment, Food and Rural Affairs) including updating their Energy and Emissions Projection model, providing analysis for the Industrial Roadmaps and Action Plans, and developing new indicators on resource and energy productivity. CIE-MAP researchers have informed the Minister for Energy and Clean Growth and directly shaped the UK Government's strategy for increasing energy and resource productivity, feeding into both the Industrial Strategy and the Waste and Resources Strategy.

RESEARCH FOCUS

CIE-MAP had four main work packages:

System analysis of materials and products: This work package provided a detailed map of materials and products to satisfy UK demand considering interactions of energy and monetary flows. The Centre investigated the scope for reducing demand for energy and energy-intensive materials in UK industries, taking into account rebound effects, deployment rates, governance and behaviour, and evaluating the impact of these reductions on future UK energy supply and wider environmental systems.

Understanding consumption: This work package assessed the potential for changes in consumption to contribute to reducing demand for energy and materials and identified the business practices and policy solutions that would best realise this potential.

Materials and products in the construction sector: The work package involved a detailed appraisal of the construction sectors considering the use of alternative materials, the co-benefits of lightweight and longer-lasting design in construction and the role of clients in driving eco-design. The work programme also considered business models such as asset sharing, enhanced repair and upgrade services, novel approaches to product take-back, new forms of contract, second-hand component or material sales, material leasing, restoration and refurbishment for a range of sectors.

Delivery: This work package identified how government policy, industry and social mechanisms can bring about reductions in demand for energy and energy-intensive materials in the UK. This involved examining the potential threats, opportunities, and likely developments related to all opportunities for reducing energy demand in the UK. A full economic assessment was also undertaken using a macro-econometric model to assess the effects on wages, economic growth and trade.

CIED: CENTRE ON INNOVATION AND ENERGY DEMAND

CIED is concerned with technologies and modes of activity that have the potential to transform the way that we use energy. It is one of six centres created to research end-use energy demand, receiving funding of £3,539,214 from EPSRC, ESRC and its partners between June 2013 to February 2019. The centre is a collaboration between the Science Policy Research Unit at the University of Sussex, the University of Manchester and the University of Oxford.

CIED is about analysing innovations. It uses a socio-technical approach to look at the impact of new technologies (e.g. heat pumps, driverless cars), social arrangements (e.g. car sharing) and modes of behaviour (e.g. cycling) on reducing energy demand. It aims to unpack the human software to go alongside the technical hardware.

The Centre seeks to understand how different types of low energy innovations emerge and diffuse in various end-use sectors (including transport, buildings and manufacturing); to identify how more rapid diffusion can be achieved; to quantify the corresponding impacts on energy demand and carbon emissions; and to provide practical recommendations for UK energy and climate policy.

CIED adopts an interdisciplinary approach, drawing upon ideas from economics, innovation studies and human geography and combining case studies, surveys, econometric analysis and modelling. Individual projects investigate a range of incremental and radical innovations in the industrial, buildings and transport sectors, with the aim of identifying common themes and drawing context-specific lessons.

The Centre also collaborates with stakeholders to develop practical ideas and recommendations, as well as providing interdisciplinary training, capacity building, networking and international collaboration in the area of innovation and energy demand.



RESEARCH FOCUS

CIED's research is focused on the following core areas:

Accelerating innovation: The 'best' and 'cheapest' technologies are not always the ones that succeed in achieving widespread take up. CIED's research explores the spread of new innovations and how this process is shaped by market forces, government policy, social interactions and how cultural norms are vital for achieving climate change goals.

Urban transport: Transport is responsible for almost a quarter of the UK's greenhouse gas emissions and emissions from this sector are growing. CIED investigates the impact of innovations in transport, the implications for other policy questions and how these innovations could be supported.

Housing and buildings: CIED researches innovations that could help to deliver more energy efficient buildings, including whole house retrofits, zero carbon new-build homes and smart meters. They provide insights into the policy instruments, business models, finance mechanisms and intermediary activities necessary to deliver energy demand reduction in buildings.

Energy productivity: CIED investigates the links between economic activity and energy use, how improvements in energy efficiency deliver reductions in energy demand, the impact of de-industrialisation on energy use and how investment in carbon-intensive sectors of the economy might be redirected to low carbon activities.

Industry: High levels of emissions are associated with the production, consumption and transport of goods. CIED's research investigates the impacts that new technologies might bring to energy use in these sectors and ways in which carbon emissions can be reduced.

Energy justice: It is important that the transition to a new energy system is managed fairly and that everyone, especially the most vulnerable, have a say in what it will look like. CIED's research investigates the impact that new innovations might have on different people so that the principles of equity, fairness, and equality are adhered to. CIED's energy justice research investigated the impact that new innovations might have on different groups within society, including who stands to lose out and how this might be redressed.

CREDS: CENTRE FOR RESEARCH INTO ENERGY DEMAND SOLUTIONS

CREDS is a new Centre established in 2018 with a vision to make the UK a leader in understanding the changes in energy demand needed for the transition to a secure and affordable, low carbon energy system. The Centre received £19,435,274 to form a consortium of 13 universities. It is funded by EPSRC and ESRC.

CREDS' vision is to push energy demand research in the right direction. Due to the scale of the challenge, research needs to focus on the challenges of demand side change going "further, faster and flexibly". Studies of incremental efficiency improvement and minor behavioural changes are insufficient; attention to transformative change is needed. This changing context for energy implies new research questions in the areas of technology, business models, social change and governance, and in their interaction.



RESEARCH FOCUS

CREDS' work looks at three energy-use sectors and three cross-cutting issues within this context.

Buildings and energy: The first of the energy-use sectors researched by CREDS focuses on the production of affordable, comfortable and healthy built environments by 2030, whilst also reducing energy use and carbon emissions.

Materials and products: Research in this energy-use sector investigates the opportunities available for reducing energy demand in UK industry, including through changing the demand for the materials and products it produces. It brings together new and novel approaches with a joint programme between government and industry.

Transport and mobility: The final energy-use sector that CREDS focuses on is transport. This work aims to reduce energy use in the sector. CREDS is developing state-of-the-art models for the understanding of mobility and transport energy demand. The work focuses on passenger transport on land.

Digital society: CREDS' digital society work is cross-cutting. It is focused on researching the effects that information and communication technologies have on energy consumption and carbon emissions. It covers work on user practices, business models and wider economic change.

Flexibility: Flexibility involves the timing of energy demand, which will be increasingly important as the use of variable sources of energy increases. It includes the capacity to use energy in different locations at different times of day or year; to switch fuels; or to smooth or create peaks in demand. CREDS' flexibility research aims to understand how energy demand is bound up with what people do and to assess intervention to increase flexibility, drawing on technical, economic and institutional analysis.

Policy and governance: CREDS' policy and governance work focuses on researching policies that are in place, and those that are still needed for further reducing energy demand; the governance of energy demand at different scales; and how to better integrate energy demand and energy supply policies.

OTHER PROJECTS

CREDS also works on specific challenges. The first of these relates to the decarbonisation of heat, one of the most difficult sectors to decarbonise, according to a whole energy systems approach. CREDS will review the existing proposals, analyse and further develop two existing whole energy system models, and evaluate potential social, regulatory and governance implications of these findings. CREDS will fund two additional challenges to be announced later in 2019.

CSEF: CENTRE FOR SUSTAINABLE ENERGY USE IN FOOD CHAINS

CSEF was opened in April 2013 and closed in June 2019. During this period, it received a total of £5,699,187 in funding from EPSRC and ESRC. The Centre brought together multidisciplinary research groups from the Universities of Brunel, Manchester and Birmingham and key stakeholders to develop innovative approaches and technologies to effect substantial end-use energy demand reductions.

CSEF was one of six centres created to research end-use energy demand. The Centre researched innovative technologies and approaches that were to have significant impacts and contribute to long-term greenhouse gas emissions reduction targets, and that would have demonstrable impacts in the short term, while taking into consideration socio-economic and behavioural aspects.

RESEARCH FOCUS

CSEF provided a platform for research into energy, resource use and the sustainability of the food chain. The Centre's work was concentrated in several cross-cutting themes that address the main sectors of the food chain. These included four horizontal and three vertical work programmes, and each involved research into specific manufacturing processes.

Horizontal work programmes: The four horizontal programmes researched innovations in food production, distribution, retail and consumption. The food production work programme included innovative projects such as: the development of sustainable baking systems; energy reductions in chocolate; and reductions in instant coffee manufacturing and process cleaning. It also included reviews of energy consumption in UK dairy and meat chains and of rice cultivated in Spain. Distribution involved food chain modelling and optimisation, the effect of storage conditions on the shelf life of food, and on innovations in packaging.

The retail work programme investigated the energy efficiency performance of frozen food retail stores and the novel use of phase change materials in refrigerated display cabinets for energy conservation. The only consumption project looked at energy saving in domestic cooking in developing economies.

Vertical work programmes: The three vertical work programmes concerned: (i) energy and resource flows including waste and sustainability issues in the food-water-energy nexus; (ii) interaction and integration with the UK energy supply system, including the environmental impacts of electricity from biogas produced by anaerobic digestion; and (iii) socio-economic aspects/human behaviour.

CUSP: CENTRE FOR THE UNDERSTANDING OF SUSTAINABLE PROSPERITY

CUSP started its operations in 2016. It has received £4,843,923 in funding from the ESRC. Building on 30 years of multi-disciplinary research on sustainability and decades of policy experience, the Centre is a partnership with University of Surrey, Anglia Ruskin University, Keele University, Goldsmiths College London, University of Leeds, University of Glasgow, Middlesex University, York University (Canada), University of Canterbury (Christchurch, NZ) and the Aldersgate Group.

The research is exploring the economic, ecological, social and governance dimensions of sustainable prosperity, questioning the feasibility (and desirability) of exponential growth on a finite planet. Trying to develop a new vision of inclusive and lasting prosperity, CUSP is working to disentangle prevailing language around progress, wellbeing and economic thriving. The work is driven by one core research question: what can prosperity possibly mean in a world of environmental, social and economic limits? CUSP is paying particular attention to the pragmatic steps that need to be taken by enterprise, government and civil society in order to achieve it.

RESEARCH FOCUS

The research programme is organised around five key themes: meanings and moral framings; arts and culture; politics and institutions; social and psychological understandings; and system dynamics. Each theme is explored in a holistic approach that involves the economic, social, political and philosophical dimensions of the challenge. The themes are drawn together through collaboration and cross-cutting projects, such as "An Economy That Works", "Investing in the Future", and its engagement as secretariat for the All Party Parliamentary Group on Limits to Growth.

The research explores the philosophical assumptions that underpin visions of prosperity, seeking to identify which pivotal institutions and political questions need to be addressed if "sustainable prosperity" is to be achieved in practice, rather than just valued as an idea. The role of art and culture is understood as a component of prosperity that facilitates participation in society and contributes to a creative and fulfilling quality of life; CUSP develops the conceptual framework for this approach and explores the complex interaction between cultural prosperity, place, the quality (and availability) of employment, leisure, and the rights to self-expression.

CUSP examines the contested and situated nature of people's visions of the 'good life' and the role of materialism in delivering (and hindering) prosperity, exploring how different understandings of social justice and fairness enter narratives of the good life. Developing compelling qualitative narratives of sustainable prosperity and robust economic models to deliver them, CUSP is also exploring quantitative implications through system dynamics modelling, including economic, social, and environmental implications.

DEMAND: DYNAMICS FOR ENERGY, MOBILITY AND DEMAND

The DEMAND Centre operated between 2013 and June 2019. It was one of six centres created to research end-use energy demand, receiving £3,937,512 of funding from EPSRC, ESRC and other research councils. The DEMAND Centre was based at Lancaster, with partners at the universities of Aberdeen, Birkbeck, Birmingham, Leeds, Manchester, Reading, Sheffield, Southampton, Sussex and UCL.

The DEMAND Centre took a distinctive approach to end-use energy demand, recognising that energy is not used for its own sake but as part of accomplishing social practices at home, at work and in moving around.

Research was based on a series of core propositions: that energy demand is an outcome of social practices, that such practices are shaped by institutions and infrastructures and that these arrangements reproduce historically and culturally specific interpretations of need and entitlement.

RESEARCH FOCUS

The DEMAND Centre had five key research themes, as follows.

Understanding demand: The Centre developed new ways of analysing what energy is made for, how demand is made, the normality and need of energy demand, and energy efficiency.

Influencing demand: DEMAND analysed policies for steering demand, invisible energy policies, adaptation to social practices and established a commission on travel demand. The Centre also developed knowledge of how end-use and related infrastructures might be adapted and managed to reduce demand.

How demand varies – peaks, trends and rhythms: It is important to know when energy is used in the home, at work and on the move. This theme focused on temporal and spatial variation, time pressures and peak demand, institutional rhythms and flexibility.

Situations, sites, sectors: This theme included a specific focus on Domestic IT use, home heating, offices and office work, business travel, online shopping, car dependence, older people and mobile lives, local smart grids, and cooking and cooling in Asia.

Energy, justice and poverty: This theme integrated and synthesised research across the above themes, exploring practical implications for managing major transitions in demand and applying justice concepts to fuel and transport poverty.

I-STUTE: INTERDISCIPLINARY CENTRE FOR STORAGE, TRANSFORMATION AND UPGRADING OF THERMAL ENERGY

I-STUTE opened in April 2013, with funding of £5.3 million from EPSRC and ESRC. The Centre develops technologies aimed at reducing energy consumption and delivering cost-effective heating and cooling. It was one of six centres created to research end-use energy demand.

Heating and cooling are major sources of energy use in the UK and elsewhere. I-STUTE finds that efforts to reduce demand through behavioural change, optimised industrial processes, improved insulation and reduced levels of infiltration in buildings are insufficient, alone, to meet the UK's 2050 emissions-reduction target. A dramatic increase in the energy efficiency of heating and cooling processes through new and innovative technology will be required.

RESEARCH FOCUS

I-STUTE has three delivery temperature work packages, which are aimed at providing exemplar solutions applicable to multiple sectors. The focus is on high volume markets that offer large emissions-reduction potential. The three work packages are: freezing, cooling and air conditioning (-40 C to +25 °C); space heating (+ 25 C to + 80° C); and low-temperature process heating (up to 200°C). Each delivery temperature work package covers technology, policy and commercial factors, and social factors, as follows.

Technology: In 2050, energy use for all but medium and high temperature industrial processes will need to be achieved through a heat pump system. Present electric heat pump systems perform below their potential, but 50 per cent improvements in efficiency are achievable, as are higher delivery temperatures more compatible with hot water services. In the long term, 65 per cent emissions savings are possible from heat driven heat pumps compared to fossil fuel boilers. In cooling, new technologies can make even greater relative carbon emissions savings and there are opportunities to develop integrated bivalent heating and cooling heat pumps in some end-user applications. I-STUTE seeks to drive developments in each of these areas.

Policy and commercial: With the aid of industrial partners, I-STUTE research covers effective policy tools, changes in industry structure and new, commercially viable business models that will encourage sustainable industries that can deploy new approaches to heating and cooling across a wide range of markets.

Social: To ensure maximum adoption and impact, the Centre aims to understand end-use behaviour across varied groups of consumers and markets, to ensure that solutions are fit for purpose and meet consumer needs. The Centre also researches the required capabilities for successful commercialisation and market growth, e.g. workforce skills for implementation and maintenance, IT capabilities for effective management of integrated solutions and the development of supply chains to serve major new markets.

RESOLVE: RESEARCH GROUP ON LIFESTYLES VALUES AND ENVIRONMENT

The RESOLVE programme was operational between May 2006 and November 2011. It received funding of £2,760,838 from ESRC.

Many of the research themes that were covered by RESOLVE have since been taken up by the Centre for the Understanding of Sustainable Prosperity (CUSP). Both initiatives are led by the University of Surrey and they share the same principal investigator.

RESOLVE was a pioneering centre that linked social science understandings of lifestyles and values directly with the emerging demands of sustainability. A central aim was to understand the challenges that the UK's statutory greenhouse gas reduction targets pose for people's lives and lifestyles.

RESEARCH FOCUS

During the course of the grant, RESOLVE carried out a number of research and policy initiatives dealing with questions of lifestyles and sustainability.

The group worked closely with policy makers and participated actively in the politics of change. This includes contributing research to the behavioural sciences ("nudge") unit established by the Cabinet Office in 2009.

RESOLVE's interdisciplinary research programme was arranged around three interwoven strands of primary research:

- Lifestyle mapping, including research on the minimum amount of household carbon required for a "decent" life in the UK;
- The social psychology of energy-related behaviours, including research on the relevance and strengths of various barriers for energy behaviour changes among end-consumers and households and ways to overcome these barriers;
- The sociology of lifestyles, including case studies on the music industry, meat consumption, the role of churches in influencing consumer behaviour and the issues facing children.

The three research topics were complemented by two cross-cutting themes on lifestyle scenarios and governance and policy.

STEPS: THE SOCIAL, TECHNOLOGICAL AND ENVIRONMENTAL PATHWAYS TO SUSTAINABILITY CENTRE

STEPS began its activities in 2006 and has received total funding from ESRC of £9,245,460 to date. The Centre is a collaboration between the Institute of Development Studies (IDS), the Science Policy Research Unit (SPRU) and the School of Global Studies at the University of Surrey.

The work of STEPS is undertaken as part of a Global Consortium with hubs in Africa, China, Europe, Latin America, North America, and South Asia. Research projects across countries help the Centre to engage with local problems, and to link them to wider concerns.

STEPS explores the involvement of poor and marginalised people in diagnosing problems and identifying solutions in each of these themes. This involves challenging power and assumptions, and exploring different values, perspectives and possible futures. In this way, STEPS unites development studies with science and technology studies to contribute to just and democratic pathways to sustainability in the face of the climate crisis.

To do this, STEPS uses participatory methodologies, drawing from diverse fields including anthropology, medicine, development studies and science and technology studies. The "transdisciplinary" approach used not only includes different academic disciplines, but also knowledge beyond academia, from local partners, ranging from activists to policy makers.

RESEARCH FOCUS

For the period 2018 and 2021, STEPS is in its transition phase and is focusing on four pillars (one per year): transformations, uncertainty, nature and methods.

Transformations research took place in 2018. It focused on making sustainability transformations emancipatory and caring, rather than repressive and controlling. Uncertainty research is taking place in 2019. Uncertainties make future planning difficult. STEPS aims to understand what kinds of uncertainties there are, why they matter for sustainability, and the ideas, approaches and methods that help us respond to them. Nature and methods research will take place in 2020 and 2021 respectively.

Within each of these pillars, research is focused into seven themes. These are: climate change and energy, food and agriculture, governance and policy, health and disease, pastoralism, research methods, resource politics, technology and innovation, understanding sustainability, urbanisation, and water.

THE TYNDALL CENTRE

The Tyndall Centre was founded to conduct cutting edge, interdisciplinary research, and provide a conduit between scientists and policymakers. The Centre brings together expertise from across the scientific, engineering, social science and economic communities. From this perspective, the Centre researches, assesses and communicates the options to mitigate, the necessities to adapt, and the need to integrate climate change into the global, UK and local context of sustainable development.

Research council funding for Tyndall mostly pre-dates the review period covered in this report. From 2000 to 2010 the Tyndall Centre was co-funded to a total of £19m by NERC, EPSRC, and ESRC. The Centre is now primarily funded by research grants and host universities. The proposal for the recently funded Centre for Climate Change and Social Transformation (CAST) was initiated by Tyndall partners at Cardiff, UEA and Manchester. CAST broadens the collaboration with core partners at The University of York and charity Climate Outreach, along with international partners at the Universities of Gothenburg, Paraíba, Peking and Utrecht.

RESEARCH FOCUS

The Tyndall Centre currently has four main research areas.

Accelerating social transitions: This research area analyses individuals' ways of life, and their relationships with technologies and infrastructures. Collectively, the research contributes towards a zero carbon future. The Centre undertakes surveys to examine public perceptions of new technologies and uses historical case studies to understand drivers and barriers to social change. It analyses how plausible storylines of low carbon transitions will affect people's daily lives. This research highlights the importance of people as consumers, energy users, and shapers of shared values and culture.

Overcoming poverty with climate actions: This research area recognises that climate change will most harshly affect the world's most vulnerable people. The research builds understanding about how climate-related actions interact with the multiple dimensions of poverty and inequality within and between nations. Political economy approaches are used to understand how decisions are made to create knowledge on political barriers to the success of climate actions.

Building up resilience: This research aims at mitigating, and responding to, the negative impacts of climate change. It explores how to build climate resilient pathways that reduce vulnerabilities to climate change, and that are consistent with mitigation pathways. It considers synergies and conflicts between these pathways and the Sustainable Development Goals (SDGs) to highlight the opportunities for actions that have multiple benefits.

Reaching zero emissions: This research area focuses on developing the decarbonisation pathways for different sectors and the potential for actively removing greenhouse gases from the atmosphere, including biomass energy with carbon capture and storage (BECCS) and other negative emission technologies. The Centre explores near- and long-term energy and emissions futures for industry, transport and negative emission technologies. Key questions in this area are focused on four sub-themes: circular economy, industry, transport, and negative emission technologies, in addition to cross-cutting questions related to the SDGs.

UKERC: UNITED KINGDOM ENERGY RESEARCH CENTRE

UKERC is the flagship centre of the UK Research and Innovation (UKRI) Energy Programme. The Centre carries out world-class research into sustainable future energy systems and energy system change. The Centre takes an independent, whole-systems approach, drawing on technical and non-technical disciplines including engineering, social sciences and natural sciences.

The Centre is funded by EPSRC, ESRC and NERC. The first phase of the Centre ran from 2004 to 2009. In March 2009, £18.5 million was allocated to support phase 2, which ran from 2009 to 2014. UKERC phase 3 ran from 2014 to 2019, with a total budget of £18m. UKERC is currently starting its fourth phase, which has been running since May 2019, and is set to finish in April 2024. For this fourth phase, the Centre lead has moved from Imperial College London to University College London.

UKERC has two main roles: first, to be a leading centre of research on transitions to sustainable, net zero energy systems; and second, to support the UK energy research community through engagement activities, capacity building and facilitating international collaborations.

RESEARCH FOCUS

The first two phases of UKERC focused on understanding what a decarbonised UK energy system will look like in 2050 and how the transition towards this system could be achieved. Phase 2 had five themes: energy demand; energy supply; energy systems; energy and environment; and technology and policy assessment.

Phase 3 had six interdisciplinary themes, plus a research challenge programme that was funded separately by NERC: Addressing the Value of Energy and Nature Together (ADVENT). The phase 3 themes were: future pathways for the UK energy system; the implications of these pathways for resources and vectors; the implications for energy systems at local, national and international scales; the interactions between the energy system and the wider economy; the implications for decision making by individuals and organisations; and the review and synthesis of evidence on contentious energy topics.

Research in UKERC's fourth phase will focus on new challenges and opportunities for implementing the energy transition, and will be concerned with the following key questions:

- How will global, national and local developments influence the shape and pace of the UK's transition towards a low carbon energy system?
- What are the potential economic, political, social and environmental costs and benefits of energy system change, and how can they be distributed equitably?
- Which actors could take the lead in implementing the next stage of the UK's energy transition, and what are the implications for policy and governance?

UKERC phase 4 will comprise 7 research themes and four national capabilities. The themes will focus on the implications of global energy trends; local and regional energy systems; energy, environment and landscape; energy and mobility; energy infrastructure transitions, decarbonised heat pathways; and decarbonising industry. The capabilities, which will also support researchers and other stakeholders outside UKERC, include systematic evidence reviews, an energy modelling hub, a new Public Engagement Observatory and the UKERC Energy Data Centre.



PLACE-BASED CLIMATE ACTION NETWORK

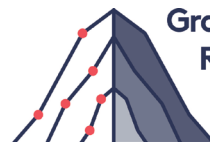
Place-Based Climate Action Network (PCAN)

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