



UK Research
and Innovation



Joint UKRI & Met Office Science Plan

SPF UK Climate Resilience Programme

18 July 2019

Vision: To enhance the UK's resilience to climate variability and change through frontier interdisciplinary research and innovation on climate risk, adaptation and services, working with stakeholders and end-users to ensure the research is useful and usable.

The programme is jointly led by UKRI and the Met Office and has £18.6m of funding to achieve three main objectives:

1. Characterising and quantifying climate-related risks
2. Managing climate-related risks through adaptation
3. Co-producing climate services

The Challenge

Climate variability and change affect all sectors of society through both human and natural systems. Effective adaptation builds capacity to respond to this variability and change and is one of two broad and increasingly important strategies (along with mitigation) for climate risk management.¹ Even under the most optimistic mitigation scenarios there is an urgent need to **build resilience** and **accelerate adaptation** to climate variability and change.² Informing the extensive range of actions needed to manage climate risks, reduce damage without exacerbating existing inequalities, and realise emerging opportunities, is a **critical scientific and societal challenge**.

It is widely recognised that single disciplinary approaches will not be able to 'solve' this complex challenge and that multi- and inter-disciplinary research efforts that include e.g. the natural sciences, social sciences, engineering, the arts and humanities are needed. It is also recognised that the engagement and involvement of a wider range of stakeholders comprising e.g., of practitioners and policy-makers, is essential in addressing this challenge.

¹ Moss, R. H., et al. (2013). "Hell and High Water: Practice-Relevant Adaptation Science." *Science* 342(6159): 696-698.

² IPCC (2018). Global warming of 1.5°C. An IPCC Special Report on the impacts of global warming of 1.5°C above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change, sustainable development, and efforts to eradicate poverty. V. Masson-Delmotte, P. Zhai, H. O. Pörtner et al.



State-of-the-art and research capability

The UK research base in this area is world leading but fragmented. The Met Office and UKRI-funded climate scientists have been at the forefront of **climate science** and the early development of climate services, exemplified by the recently released UK Climate Projections 2018 (UKCP18) and the development of high-resolution global climate modelling. **Engineering** and **other sciences** have translated climate hazard knowledge into impact and risk metrics, e.g., in infrastructure and urban adaptation, creating a national infrastructure system-of-systems model. **Social science** research has focused on areas such as barriers to adaptation, economic costs and benefits, risk perception, behaviour and communication, and the science-policy interface. The **arts and humanities** have achieved contributions in the philosophy of climate science, the history, heritage, ethics, and culture of climate change, climate adaptation and resilience, and artistic interventions focusing on living with change and loss. The UK was also world leading in bridging scientific research, policy making and adaptation practice through the UK Climate Impacts Programme and Environment Agency.

Research priorities and opportunities

Through the Climate Change Act 2008, the UK introduced climate change adaptation legislation that requires around 100 organisations to report on their climate change risks and adaptation strategies (Adaptation Reporting Power) and requires government to undertake a cyclical Climate Change Risk Assessment (CCRA) and National Adaptation Programme (NAP). The NAP recognises that building the UK's resilience to climate change is an economic, social and environmental challenge that cuts across every sector of society and sets the vision of "*a society which makes timely, far-sighted and well-informed decisions to address the risks and opportunities posed by a changing climate*".

While undertaking the delivery of the CCRA2 evidence report, the Adaptation Sub-Committee (now Adaptation Committee) collated over 200 evidence gaps which were discussed and supplemented at a research needs conference in late 2016. The Adaptation Committee concluded that to make progress in understanding climate risks in future CCRA2s, the following cross-cutting evidence gaps need to be addressed: UK spatial modelling capability; socio-economic scenarios for the UK; decision support frameworks; monitoring; behaviour change and adaptation options. Government departments e.g., Cabinet Office, Public Health England, Department for Transport, have identified additional priorities for climate resilience research which include both quantification of risk and approaches to building resilience. For example, the cross-department evidence gathered by BEIS on behalf of Government highlights the need for more focus on quantifying current risk, and better tools to quantify future risks. As adaptation responses are place- and context specific, research priorities vary between the devolved nations. Furthermore, whilst Government stakeholders are vital to developing an enabling environment, building resilience will ultimately be achieved through changes at the local level – with the impacts of extreme weather and climate taken account of through regulation, standards and organisational or system practice in many cases. A growing



ecosystem of existing and emerging climate service providers is likely to play an important role in building resilience. This programme recognises the importance of climate action alongside other UK development priorities as described in the Sustainable Development Goals.

The Strategic Priorities Fund (SPF) provides an opportunity to improve climate risk assessment and enhance UK resilience by encouraging and funding **high-quality multi- and interdisciplinary research** and innovation using integrative approaches that cross traditional disciplinary boundaries. It provides space for pioneering research, laying the foundation for future capability and aims to **link effectively with Government departments' research priorities and opportunities**. The UK Climate Resilience Programme is an example of SPF's ability to respond with agility to strategic priorities and opportunities, and ensure the UK remains at the cutting edge. This Programme will liaise with other SPF relevant programmes (e.g., Landscape Decisions) to maximise synergies and opportunities.

Consultations undertaken by the programme champions with academic and non-academic stakeholders, Met Office scoping and input from the scientific Steering Committee identified numerous opportunities to significantly improve capabilities and make major progress in filling knowledge gaps that address the challenges of quantifying risk and building resilience. However, within the funds available to the programme, not all gaps and capability needs can be addressed. Balancing the needs with the resource³, we highlight the following major outputs or legacies⁴ that the programme will aim to deliver:

1. A step change in future Climate Change Risk Assessment capability, including, through improved UK spatial modelling of climate-related risks, characterisation of interdependent risks and representation of adaptation strategies in integrated assessment models of impact and adaptation.
2. Enhanced capability and understanding of climate hazard and risk, through consideration of past, present day and future risks to the UK, including understanding robustness of methods, single and multi-hazard events, and producing high-end scenarios for national stress testing. This will enhance the UK's current decision-relevant climate scenarios from other sources such as UKCP18 and CMIP6.
3. Strengthened understanding of how people, organisations and policy scales are adapting and how system scale interactions can act to incentivise adaptive behaviour, remove barriers and avoid maladaptation.

³ Through the following programme principles: High quality, truly, multi and interdisciplinary research; Links to government priorities including CCRA and NAP; User co-production from the outset; Relevant to stakeholder interests; Alignment and coherence between UKRI and Met Office work packages; Potential for legacy and continuation; Realistic ambition given time and resources.

⁴ Some of the items cover top-level gaps from the CCRA2.



4. Consistent set of UK socio-economic scenarios for national, regional and local risk planning and research.
5. UK roadmap for the future development and implementation of climate services addressing the roles of public and private sectors. This provides the UK response to the Global Framework for Climate Services.
6. Grow the community of interacting researchers, practitioners and policy-makers in climate resilience.
7. Synthesis of findings across the programme to provide updated national guidance standards, policy regulations and good practice.

Joint Science Plan

The joint science plan has been informed by consultation with UKRI and Met Office communities and climate resilience stakeholders from public, private and third sectors, consideration of past and on-going programme activities, Government department's research priorities, the evolving UK climate resilience research landscape and the state-of-the-art in relevant disciplines.

The concept of **resilience** is understood differently by different academic communities and practitioners. Here, the programme takes a broad perspective of climate resilience that encompasses capacity to adapt to, anticipate and absorb climate variation and extremes, to enable incremental to transformational change.⁵ **Climate risk**, risk management through **climate adaptation** and the nature of risk in society have been central concepts in climate change literature, research and practice in recent years. Risk of climate-related impacts results from the interaction of climate-related hazards (including hazardous events and trends) with the vulnerability and exposure of human and natural systems.⁶ The emerging field of **climate services** involves working alongside stakeholders to generate and contextualize information and knowledge derived from climate research to support effective decision making, predominantly in adapting to changing risks.

The science plan is divided into three research themes that link to the central objectives of the programme, but with recognition that they overlap:

1. Characterising and quantifying climate-related risks

⁵ Bén , C., Godfrey Wood, R., Newsham, A., Davies, M. (2012). Resilience: new utopia or new tyranny? Reflection about the potentials and limits of the concept of resilience in relation to vulnerability reduction programmes. Brighton: Institute of Development Studies.

⁶ IPCC (2014). Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. C. B. Field, V. R. Barros, D. J. Dokken et al. Cambridge, Cambridge University Press.: 1132.



2. Managing climate-related risks through adaptation
3. Co-producing climate services

1. Characterising and quantifying climate-related risks

This theme aims to provide a step change in capability and filling of knowledge gaps to enable robust characterisation and quantification of hazards and risks, including how they are communicated within the research communities and more widely.

Climate-related hazards

Whilst there are many evolving methods for looking at present day hazards their robustness and intercomparability are not well understood. As many stakeholders start their engagement through considering their current risk, the Government has highlighted this as an important research area. A major task is to significantly improve understanding of present day hazards through progress in interpreting and using observational data and a variety of modelling approaches. This task includes detailed evaluation of specific methodologies, such as the UNSEEN⁷ approach or using other long-simulations of the historic period, as well as the development of new techniques.

Alongside consideration of the present day, new work will provide better information on future change for different lead times (from a season ahead to many decades or more) with particular emphasis on extending methods to provide decision-relevant scenarios, including better addressing the most extreme changes and plausible worse-case scenarios. An increasing body of decision and adaptation literature has highlighted both a need for such scenarios (e.g. for sensitivity testing) and a lack of research producing them. The CCRA and adaptation reporting power gap analyses also highlight a need for new understanding of multiple hazards occurring in a short space of time and factors affecting the repeat of hazards.

The research on climate hazards should provide both new quantification of hazard as well as improved understanding of the mechanisms causing the hazards.

Climate-related risks

There is a need for better and more usable translation of hazard information into risks. In many cases there will be a requirement to convert the hazard from climate/weather metrics into more relevant impact metrics, e.g. river flows. It is necessary to combine the hazard with vulnerability and exposure information to produce risk estimates, such as the number of people flooded with and without particular adaptations. The impact and risk metrics will be sector specific and may be location specific. The risks considered should focus on the UK but should also take account of remote climate change on UK exposed sectors (e.g., food, finance,

⁷ Thompson, V., et al. (2017). "High risk of unprecedented UK rainfall in the current climate." *Nature Communications* 8(1): 107.



security, etc.) - transboundary climate risks. Monitoring is expected to play a role and there is scope for research on enhanced monitoring, for instance using novel approaches to earth observation.

In order to characterise future vulnerability and exposure, this programme will develop a consistent set of socio-economic scenarios for the UK, on a spatial scale that is appropriate to risk quantification and resilience building and which include population and technological change. These should be traceable to international scenarios, such as the Shared Socio-economic Pathways used in the latest IPCC assessment.

While progress has been made in assessing climate-related risks in recent years,⁸ several user-driven challenges remain as identified by the Adaptation Committee. Enhancing climate risk and adaptation assessment capability is of national importance. A step change in research capability is needed to improve: UK spatial modelling that is able to link different sectors together (e.g., natural environment, human health and infrastructure) and shows the geographical distribution of risks; the characterisation of interdependencies between sectors and risks; and the representation of adaptation strategies in models and assessments. This programme will lay the foundations for the development of integrated assessment modelling capability in climate change risk assessment for the benefit of future CCRA and NAPs.

Risk perception, tolerance and communication

The inclusion of climate risk into decision-making varies in sophistication between stakeholders, with many examples of users not able to maximise the value of the climate information. There is also substantial evidence that understanding people's perceptions of climate-related risks is essential when developing policy to manage them, e.g. by influencing individual and group behaviour. New research will focus on understanding how climate hazard and risk can be better communicated and more effectively used in a range of decision support frameworks for risk assessment.

Suitable communication approaches will need to be developed and tested that allow the communication of risk information across the different research communities involved in this programme, to practical users of the programme output, and to the wider community, focusing e.g., on coastal risks, flooding, water scarcity and overheating. In this programme a particular challenge is to better quantify current and evolving weather and climate risk attitudes in the UK amongst different publics and different sectors. For climate resilience this must take account of the interaction of messages and policies on both mitigation and adaptation. It is also necessary to produce new understanding of how individual risk

⁸ Adger, W. N., et al. (2018). "Advances in risk assessment for climate change adaptation policy." *Phil. Trans. R. Soc. A* 376(2121): 20180106.



perceptions can contribute to a UK tolerance for risk, taking account of how conflicting information and ethical dimensions are treated.

Research in this programme should go beyond previous studies to understand not only trends in risk perception but to provide more information on the drivers of these views for different stakeholders. The practical use of this research will be important in the climate service demonstrators where research findings can be applied in particular impact domains. The research will also inform theme 2.

2. Managing climate-related risks through adaptation

Societal responses to climate risks arise from complex decision-making processes that are shaped by the choices of individuals as well as collective actors, such as firms, civil society, local authorities, national governments and international organizations. Effective management of and adaptation to climate-related risks by organisations, systems and society helps to minimise damage and exploit potential opportunities. This occurs in a social and institutional context where history, culture, values, ethics, institutions and governance are recognised as important determinants of adaptation responses. Most climate-related decisions, operate in complex contexts which require greater attention to process and have become associated with wicked problems.⁹ Academic and practitioner research on governing¹⁰ adaptation has been fragmented and ignored scale interactions.

Governing adaptation

Recognising the multi-faceted, multi-scaler, dynamic and reflexive nature of climate-related decisions needed to strengthen national resilience, this theme builds on existing work and focuses on understanding and tracking adaptation at the organisational and policy scales and the interactions between them:

- *Organisational and sector capacity*: It is critical to improve understanding of how organisations of different cultures, scales and sectors make sense of information about climate-related risks and translate this into meaningful action in their specific context. We also need to understand how this is incentivised or constrained by internal or wider factors; and how to assess capacity to respond and ways to track and enhance it over time. Special focus could be given to organisations invited to report under the Adaptation Reporting Power, organisations critical to the UK

⁹ Wicked problems are not well bounded, are framed differently by various groups and individuals, harbour large scientific to existential uncertainties and have unclear solutions and pathways to those solutions (Rittel and Webber, 1973; Australian Public Service Commission, 2007).

¹⁰ Understood broadly



economy and regulators or standard setters that have influence over other organisation's decisions are of particular importance.

- *Policy, institutions and governance:* The rules, laws and regulations we develop mediate how individuals, organisations, sectors and systems behave in response to risk information. Effective governance is needed to establish credible and fair goals, link up diverse areas of policy, including that relating to mitigation and rapid decarbonisation, to strengthen alignment. Given the uncertainty regarding the level of adaptation needed, this needs to ensure that learning from experience leads to continuous course correction over time. Research needs to examine the appropriateness of existing rules, policies and regulation and how new governance arrangements, including ungoverned adaptation (that is more informal), are developed while ensuring they do not exacerbate existing inequality and the costs of adaptation are met in a socially just way.
- *Scale interactions:* It is critical to improve understanding of scale interactions between policy and organisations through a system perspective. Failure to consider scale interactions can lead to lock-in, to undesirable pathways, unintended consequences and ultimately decreased resilience. Interactions between scales provide an opportunity to reshape the system to become more resilient to emerging climate risks.

Living with uncertainty

The magnitude and rate of climate change means that UK society has to make decisions about which landscapes, buildings, towns and even species we want to keep and which we lose. As humans, we find such decisions difficult, painful, and even stressful. The term 'solastalgia' links memory of loved places with nostalgia and feelings of stress that can act to motivate or demotivate action to respond. Direct experience of climate related change can increase awareness of our vulnerability (of people and places) and lead to increased action and greater resilience. This theme aims to deepen our understanding and explore how these aspects affect our sense of place, identity, decision-making and the potential for new societal-environmental configurations. We have much to learn from the relative vulnerability and resilience of past communities about intentional decision processes and where we need to let go of control and make decisions with considerable ambiguity. At the same time, opportunities could arise in growing new crops, establishment of new species and lives saved (because of fewer cold-related deaths). The themes of accepting loss, living with uncertain or disorderly change and acknowledging new opportunities would benefit from interdisciplinary research led by the arts and humanities community.



3. Co-producing climate services

A climate service aids the effective use of climate information by individuals, businesses, Government and other organizations. A climate service requires appropriate and usually repeated engagement to co-produce a timely output that is usable and useful. Such outputs are often used to aid decision-making, raise awareness or for horizon scanning. There may be many climate service providers in the space between generation of underpinning climate science and final end users. In the SPF UKCR programme we recognise that future risk assessment and resilience building in the UK is likely to involve climate services. Some of these may be provided by publicly funded research, others may be in the private sector. This programme has a unique opportunity to stimulate the growth of the UK climate service sector to build resilience.

Climate service research

Being an emerging field, there is a need to examine issues such as the delivery model for climate services that best fits the UK. This includes considering the mix of public and private provision and funding, economic benefits resulting from climate services, consideration of the wide range of existing climate service providers and boundary organisations, and the development and regulation of the emerging climate service market. This theme will perform research into the governance models and measures of quality of climate services in the UK, including ethical considerations. Whilst there is a Global Framework for Climate Services and an EU climate services roadmap, there is not yet a roadmap for services in the UK. We lack a clear understanding of how a UK approach fits into the context of the European Roadmap for Climate Services, including the Copernicus Climate Change Service, and this theme will aim to provide some clarity. Whilst some of the research can draw on experience from climate services outside of the programme, a major additional resource for the research in this theme will be climate service prototype or demonstration projects, which will involve different providers and users and will act as learning labs for testing approaches and trying to develop good practice examples. The prototypes/demonstrators will involve real users and data, with particular risk assessment or adaptation needs. Typically, they will be carried out at particular locations but lessons on how to upscale to a national level will be considered. Assessment of the value of climate services will also be within the scope of this theme.

Climate service applications

Climate services provide timely, tailored information and knowledge to decision makers (generally in the form of tools, products, websites, or bulletins) to improve their capacity to manage climate-related risk. This theme will develop and pilot climate services to build resilience. It will do this within co-produced climate services demonstration projects. This will involve working with a range of domain expertise in the wider research and user communities to deliver ways of managing climate risks, including through resilience building and adaptation. Sector coverage could include urban and infrastructure, transport, energy, food,



water, health, finance and coastal and marine infrastructure. Potential applications will be selected based on a real need, an opportunity to learn about applying new approaches from across the programme, and taking account of potential users with different levels of sophistication and technical expertise. Appropriate attention needs to be given to place-based assessments given their importance in adaptation. The learning from these projects will contribute to the awareness within the programme of alternative adaptation options in different contexts, which will be collected together so that it can be applied on a national scale, for instance through improved guidance and standards.

Programme implementation

The science plan will be delivered through four main activities: frontier research, building research capability, developing and testing climate services, and coordination and networking activities. An important aspiration of the programme is to grow the community of interacting researchers, practitioners and policy-makers in climate resilience. This underpins all activities, but will be particularly important in climate services, networking activities and an embedded researcher scheme.

This programme has two implementing agencies, UKRI and Met Office, who procure research in different ways. UKRI generally uses open calls (but there are other mechanisms) while the Met Office uses either open calls or single tenders. Where a single tender is not justified (either for the Met Office or another organisation), the activity/project will be put out to tender (an open, competitive call/ITT) and a contract issued. The mixture of open and directed calls is an opportunity for the programme to address the diversity of research needs, but it is vital the calls are linked in order to exploit synergies and avoid duplication. The Met Office Science Plan for this programme is updated annually to enable flexibility in later years. From the total UKRI allocation of £10m, £3.6m has been allocated to 19 projects of 12 months duration to address research gaps and bring together the UK climate resilience community. The Met Office has committed to a spending of around £2.7m to the end of FY19/20 from a total budget of £7.7m for the full period of the programme. The first Met Office projects focused on theme 1, plus some additional scoping of the needs for climate services, with work beginning in November 2018. This past and on-going activity has been considered in the development of the joint science plan.

The outputs from this joint science plan pave the way for practical measures to improve UK climate resilience. The tools, knowledge and capability developed here will be applicable in future programmes and initiatives.