



## Afterword

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### Abstract

- Investing in ‘gluing’ roles, as was performed by the UKCR Champions, is essential for building community and delivering impact, as is a strong online and social media presence and a programme of community building events.

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- Resilience research should be ‘user’ or ‘challenge’ led and needs to invest in ways of working that facilitate innovative and transdisciplinary approaches. Key research gaps remain including in understanding compound, transboundary, cascading and systemic risks; place-based vulnerability assessments that combine risk information with other socioeconomic and behavioural factors; and scaling-up climate services.
- Future adaptation research programmes should prioritise further developing the research-practice community to adequately address the complex challenge of building resilience.

**Keywords** community building · delivering impact · transdisciplinary research · research gaps

Between 2019 and 2023, we championed the Strategic Priorities Fund (SPF) UK Climate Resilience Programme (UKCR), including the production of this volume. This gave us a unique perspective on the research, practice and policy of climate resilience in the UK. Here, we reflect on this experience and present some key messages. In Sect. 1, we reflect on ways of working and community building. In Sect. 2, we summarise the programme’s achievements in producing novel evidence for climate resilience. In Sect. 3, we reflect on lessons learned about interdisciplinary and transdisciplinary approaches to climate resilience research. In Sect. 4, we focus on what remains to be done to address ongoing research questions, and also how to design and deliver fit for purpose research to enhance resilience building.

## 1 WAYS OF WORKING AND COMMUNITY BUILDING

The UKCR Programme and Science Plan recognised the importance of stakeholders and end users in the development of useful and usable climate resilience research. One of the programme’s aims was to grow the community of interacting researchers, practitioners and policymakers in climate resilience. As a result, the funded work of UKCR included a wide spectrum of approaches to co-development and co-production (see Chapter 3).

The role of the Champions, supported by the wider Champion team and the Met Office science coordinator, has been critical in building and maintaining this community. Many aspects of all these roles have been about building relationships with, and making connections between, funded projects and with target groups and initiatives. The importance of investing in people to play such ‘gluing’ roles should not be underestimated; this investment has acted to maximise the value and impact of interdisciplinary and transdisciplinary research programmes, and mirrors messages emerging from UKCR projects about the need to build trusting relationships at every level. This is essential if we are to adequately address the complex issue of building climate resilience. As the programme comes to an end, the Champion team’s role has increasingly focused on the synthesis and tailoring of key messages for specific audiences, in order to maximise the impact of the programme for ongoing policy and practice and to ensure its longer term legacy.

Community building started well with a programme-wide workshop in November 2019 held in Leeds, which convened the first tranche of funded projects from both the Met Office and UK Research and Innovation (UKRI). Here, participants identified cross-cutting themes for the programme. Only a few months later, the ‘work from home’ requirement of the COVID-19 pandemic limited the extent to which the UKCR community could interact ‘in person’. Activities to enhance connections across and beyond the funded work of the programme had to be rapidly rethought and moved online. For example:

- **Fortnightly webinars** were established, whereby academic research teams could share initial findings. The format of the webinars then allowed for a response from a non-academic partner or beneficiary who could give their perspective on the usefulness and relevance of the research, followed by a Q&A session.<sup>1</sup>
- **Quarterly virtual forums** were arranged, to share project updates and relevant news, and discuss specific topics.
- **A mid-term, two-day online conference** was organised with the Climate Change Committee and National Centre for Atmospheric Science, to examine if the UK is on track to adapt to climate

<sup>1</sup> [https://www.youtube.com/playlist?list=PLgyCRS\\_bWUxoJuZ5MueERVDf62S76ZnuJ](https://www.youtube.com/playlist?list=PLgyCRS_bWUxoJuZ5MueERVDf62S76ZnuJ)

change. Over 300 invited participants debated the climate science and possible climate impacts, how far current and planned adaptation efforts go to manage the risks, and what more would need to be done to prepare (<https://www.ukclimaterisk.org/learn-more/conference-is-the-uk-on-track-to-adapt-to-climate-change/>).

- **An online Programme Assembly** was organised, to help guide the direction of the programme, such as the priorities for synthesis ([https://www.ukclimateresilience.org/wp-content/uploads/2021/10/UKCR-Assembly-Sept-21-Workshop-Report-FINAL\\_6p.pdf](https://www.ukclimateresilience.org/wp-content/uploads/2021/10/UKCR-Assembly-Sept-21-Workshop-Report-FINAL_6p.pdf)).

The effectiveness of these activities was greatly enhanced by the skilled and experienced communications support in the Champion team and a dedicated programme website. This not only provided news, blogs and information about the funded work and a popular archive of webinars, but also community links through social media (the programme has over 2,200 followers on Twitter/X) and a regular newsletter that reached over 2,250 subscribers.

As the pandemic eased and UKCR entered its final year, programme activities focused on programme-level synthesis of messages on common themes from the funded work, including two end of programme events. The first was an in-person ‘Showcase’ (<https://www.ukclimateresilience.org/news-events/climate-adaptation-project-outputs-showcased-in-hull/>) in Hull, in October 2022, designed to celebrate the work of the programme through performances, tool demonstrations and opportunities to discuss enhanced application of programme findings and outputs and stimulate discussion on climate risks and how to manage them. The second event, an end of programme conference (<https://www.ukclimateresilience.org/ukcr-final-conference/>) in London in March 2023, presented the programme’s research advancements and discussed its implications for policy and practice.

Many UKCR projects were both interdisciplinary (involving several academic disciplines) and transdisciplinary (involving stakeholders in knowledge production). The academic disciplines involved included the arts and humanities, engineering, social science and natural science. The nature of some UKCR projects required cross-community participation to develop their outputs, such as the National Framework for Climate Services (<https://www.ukclimateresilience.org/wp-content/uploads/2022/11/Recommendations-UK-NFCS-AUG22.pdf>) and a

guidance standard for climate services.<sup>2</sup> This cross-community collaboration also helped to build connections and share experience. Another collaborative, community-wide task was the programme's contribution to the Technical Report of the third Climate Change Risk Assessment (CCRA3); UKCR co-funded the project lead and developed an open access special issue of the journal *Climate Risk Management* [1] (<https://www.sciencedirect.com/journal/climate-risk-management/special-issue/105D9F0R4PQ>), a compilation of new research on UK climate risk assessment and management to support the evidence base for CCRA3.<sup>3</sup>

## 2 NOVEL EVIDENCE

The SPF UKCR programme produced a range of novel research outputs across the three research themes: characterising and quantifying climate-related risks, managing climate-related risks through adaptation and co-producing climate services. These outputs are already enhancing the UK's capacity for climate risk assessment and improving the nation's climate resilience. The range of outputs are described earlier in this volume; here, we highlight areas of particular novelty and progress that form an important part of the UKCR programme's legacy.

An important aspect of UKCR has been the inter- and transdisciplinary nature of many of the projects that is essential for addressing real-world problems that inevitably cut across academic disciplinary boundaries. This has contributed to our understanding of how people, organisations and policy contribute to adaptation at different scales. For example, projects have provided new understanding of community-based flood resilience [2] (<https://www.communityactionforwater.org/>) and adaptive responses for both staff and residents in care settings [3]. Several projects (<https://riskycities.hull.ac.uk/>) and embedded researchers trialled innovative arts and humanities approaches to build climate awareness and agency, helping communities reflect on identity, loss and learning from the past in order to become more flood

<sup>2</sup> <https://www.ukclimateresilience.org/wp-content/uploads/2021/01/Climate-Services-Standard-Final-for-Publication.pdf>

<sup>3</sup> Of the 12 published papers, eight were funded by UKCR.

resilient. New learning on approaches to co-producing knowledge and communicating risks was also developed, as detailed in Chapters 3–6.

The programme has advanced climate service development and delivery in the UK through establishing a roadmap for a national climate service (<https://www.ukclimateresilience.org/wp-content/uploads/2022/11/Recommendations-UK-NFCS-AUG22.pdf>), aligned with the Global Framework for Climate Services. Other achievements include developing demonstrator climate services and decision support tools, for example, an urban service (<https://www.ukclimateresilience.org/projects/prototype-development-meeting-urban-user-needs/>) that has delivered climate city packs to 30 UK councils to raise awareness of and manage climate risks. Support for future climate services has been enhanced through a new, fully tested toolkit, which will help scale up pilot projects to reach a wider range of users, plus a voluntary standard to improve the quality of climate services (<https://www.ukclimateresilience.org/projects/climate-services-standards-and-value/>). For more on climate services and decision support tools, see Chapters 7 and 8.

Novel aspects of the research relating to an improved understanding of climate hazards and risks include demonstrating the application of event attribution to more impact relevant metrics. For instance, for extreme rainfall [4] and heat-related mortality [5] UKCR has improved the characterisation of compound hazards, including joint surge and river flooding around the UK coastline [6, 7] and for agricultural relevant impacts [8]. An important new dataset provided in UK Climate Projections (UKCP18) comes from the climate simulations made using convective permitting models, and UKCR has been able to exploit this new data to better understand urban interactions with climate [9] and the future evolution of intense storms. Further novel hazard-related work in UKCR has provided a toolkit for estimating sea-level rise along the UK coastline, which is relocatable around the globe, and a new dataset of river flows and drought metrics for the UK [10]. Finally, UKCR has also produced a new resource of analysed EURO-CORDEX climate hazard data for the UK region allowing it to be used alongside UKCP18 climate results to better sample uncertainty in future projections. For further information, see Chapter 9 of this volume.

Another area of innovation, and a missing ingredient from previous UK risk assessment, is a national scale set of socioeconomic scenarios that are consistent with global and regional shared socioeconomic pathways that are used in many international climate studies [11–13]. These scenarios

are enabling improved treatment of future exposure and vulnerability in UK risk assessments, as referenced in Chapters 3, 7 and 11.

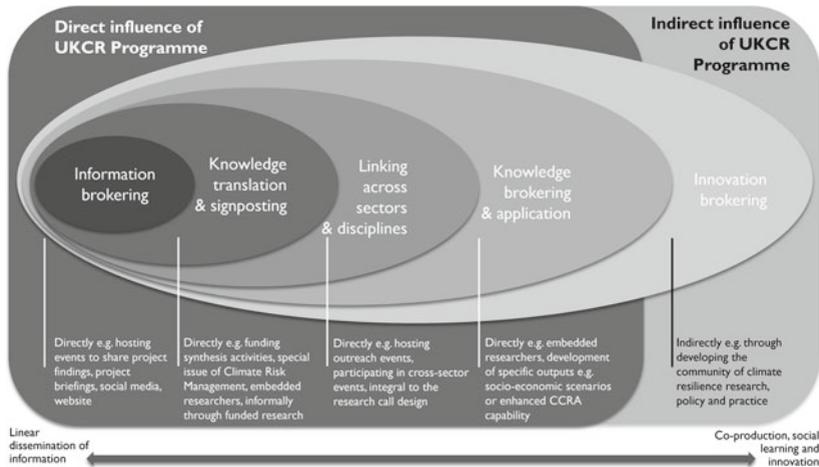
Alongside the advances in hazard and socioeconomic scenarios, UKCR has produced a step change in climate change risk assessment capability with the development of a new framework (OpenCLIM). This enables a linked set of existing and new spatially explicit impact models to be driven by consistent sets of climate and socioeconomic data and adaptation, interventions. It can be applied at a range of scales from national to local and will facilitate more quantitative spatial modelling in future national risk assessments. Other key developments in spatial risk assessment by UKCR include the use of catastrophe modelling techniques, more usually applied in the insurance industry, to issues of longer term climate risk and resilience decision-making. These new methods complement datasets of risk informed hazard metrics for a range of emission scenarios and global warming levels that were produced in the earlier stages of UKCR and used widely in CCRA3, and by a range of organisations via web interfaces. See Chapters 10 and 11 for more.

### 3 REFLECTIONS ON DEVELOPING A TRANSDISCIPLINARY RESEARCH PROGRAMME

All SPF-funded research had a requirement to link to government research and innovation priorities, which for UKCR included the Department for Environment, Food and Rural Affairs (Defra) and the Climate Change Committee (CCC). The programme used the Fig. 1 to think through how to enhance research usefulness and usability. The diagram illustrates the range of approaches that can be taken by research projects and programmes to encourage the use of research outputs. ‘Linear dissemination’ and the left end of the spectrum can be achieved through ‘knowledge products’ (e.g. academic papers, briefing notes and tailored information packs). As you move towards the ‘co-production’ end of the spectrum, the increasing importance of human and relational skills in knowledge brokering come to the fore. Here, the roles become more about convening conversations, building relationships and sharing practice-based (and more ‘tacit’) knowledge that may be harder to capture and share through knowledge products. This again emphasises the importance of the ‘glue’ roles and mechanisms needed to convene, signpost,

connect and synthesise across different projects, systems and organisations, to ensure the programme was more than simply the sum of its parts (Fig. 1).

The UKCR Science Plan, and the legacy items described within it, provided an overview of what the programme aimed to achieve. Given the focus of SPF funding, annual and final programme evaluations augmented the criterion for ‘research excellence’, demonstrated by the production and citation of peer-reviewed papers, with additional criteria such as effectiveness of partnerships and co-production and the value of the research to intended users. The Champion team also managed a small, flexible fund for synthesis activities that could be drawn on to enhance the accessibility of project findings, or to synthesise findings of different projects on a common theme.<sup>4</sup> The programme, therefore, awarded small amounts of additional funding for synthesis and engagement (e.g. through infographics), recognising the importance of targeting user groups through non-academic means.



**Fig. 1** UKCR’s knowledge brokering, translation and application roles building on [14–16]

<sup>4</sup> Example, <https://www.youtube.com/watch?v=UgSvmxczbgc&t=18s>.

Several projects attempted some degree of intentional co-production (see Chapter 3) to ensure research outputs are usable by policymakers and practitioners. As discussed in that chapter, ‘co-production’ captures a broad spectrum of approaches, each with challenges limiting the extent to which long-term relationships can be established and maintained, although much of this is solvable through new approaches to research.

An expectation for non-academic partner involvement in the research was set up through the requirements of the research calls, e.g. stating the research must have ‘strong stakeholder engagement through the research process’ or ‘clear co-design, co-production and vision for creating impact’. Careful consideration of research design to enhance mutual learning was encouraged from early in the research process when there was the greatest opportunity for shaping goals, outputs and approach. Projects found that the research scoping phase was also an opportunity to share understanding of core concepts and language, and agree ways of working to ensure alignment across differing organisational incentive structures and cultures. Periodic ‘pause points’ to jointly review progress provided additional opportunities to check the research remained fit for purpose for all.

The Embedded Researcher scheme (see Chapter 4) was deliberately designed to enhance the relevance and use of outputs, shifting the traditional approach of academic-led identification of research questions to enable non-academic partners to state their research needs and ensure the research was designed to meet them. Host organisations, including city councils, government departments, agencies, non-governmental organisations and the Church of England, enriched the UKCR network, both contributing to and benefiting from access to the wider programme.

The new connections across disciplines and with non-academic partners needed for transdisciplinary research take time to build. As funding bid schedules were often rushed to fit funding deadlines, this limited the creative potential of new relationships and the design of innovative responses to research calls. Non-academic partners were included in programme activities where possible, for example, chairing funding panels and responding to academic webinars. These inputs provided an important ‘reality check’ on the significance of the funded research for practice.

Standard UKRI funding is only available for researchers, and therefore, non-academic partners had to be self-funding, creating an imbalance of influence on the research focus and design. While the Met Office was less

restricted in bringing in non-academics through external calls, it was not possible to have common funding pots between the two organisations. This limitation was navigated by allocating different funding types to UKRI and Met Office as appropriate, which included open research calls, single tenders and open tenders. Like the Embedded Researcher scheme, open tenders funded through the Met Office enabled non-academics, such as consultancies, to bid for the work. Future programmes would benefit from providing a more even playing field for non-academic and academic partners.

## 4 RESEARCH GAPS AND FUTURE DIRECTIONS

While the SPF UKCR programme has made significant steps forward in the consideration of risk and resilience in the UK, there remains much to do. Given limited time and budget, the programme had to make choices about where to focus to have most significant and lasting impact. Here, we offer thoughts on future priorities, in terms of both *what* to research and *how* to do it. We hope this will be useful as we enter the fourth UK Climate Change Risk Assessment and National Adaptation Programme cycle.

### 4.1 *Transdisciplinary Research*

There is a need to transform resilience research from being fragmented and siloed, to collaborative, learning oriented, just, inclusive, embracing of diverse sources of knowledge, contextualised and experimental [17]. The term ‘transdisciplinarity’ is an academic construct, not recognised by the organisations and networks having to respond to our changing climate. They start with a problem or challenge and build from there. Shifting academic research to a ‘user’ or ‘challenge’ focus requires funding and research models that enable much greater collaboration between all disciplines and enable private and public sector colleagues, policymakers and the public to participate on an equal footing with researchers. For example, funding an initial scoping stage to convene interested parties could support imaginative, co-created and transdisciplinary responses to research calls.

#### 4.2 *Boundary-Spanning Skills*

One of the most pressing needs is the translation of climate science into information that is useful and usable for those tasked to make the UK more climate resilient. This will require a significant scaling-up of boundary-spanning skills, including undertaking co-production, working in transdisciplinary teams, scoping and defining the problem and translating science for users; skills which are currently often treated as of secondary importance after subject knowledge. This should start in undergraduate teaching and through the continuous professional development of researchers, practitioners and those in related industries. Further to the general upskilling of the climate resilience community, there will be increased need for ‘science translators’, likely specialising in different audiences—for instance, what national policymakers need from the science community may differ from what local government needs. These roles need to be budgeted for in research departments and funding bids.

#### 4.3 *Managing the Risk*

Understanding how risks can be reduced through resilience building and adaptation is a priority. While the physical science aspect of this has made strides in the programme, the next phase needs better integration of socioeconomic and behavioural factors, including social inequalities and vulnerability. Location-specific research is still critical for effective adaptation, particularly how to meaningfully include the affected communities from the project planning stage onwards, as well as work on the transferability of adaptation lessons across locations. Capturing the case experience of barriers to and enablers of good adaptation practice at different scales (regional, sectoral and organisational) helps to shed light on why, despite greater understanding and awareness of climate risk, it is still challenging to translate this into adaptation strategy and operational plans. More focus on leadership and governance as a driver for greater action, and the integration of mitigation and adaptation, is now needed.

#### 4.4 *Co-producing Climate Services*

While the programme has demonstrated prototype climate services and lessons on scaling services [18], this must now be put into practice through, for example, innovation accelerators. There is still a tendency for

a ‘science-first’ approach, and while co-development of risk and resilience projects is more widespread, more could be done to ensure that the work is embedded in relevant decision contexts. As implementation proceeds, more work will be needed to monitor, evaluate and learn from resilience building initiatives to both track progress and gather good practice. Further support for the standard for climate services (e.g. converting it to BSI or ISO standards) and implementing the proposed national framework for climate services, aligned with the World Meteorological Organization’s global framework, would add great value to the coherence and quality of the UK’s climate services sector.

#### 4.5 *Hazard to Risk*

The methodologies and datasets developed under UKCR need to be integrated into new risk estimates for the entire UK. This includes improved understanding of storm characteristics from higher resolution models and approaches for dealing with compound impacts on the land and at the coast. There remain significant gaps around transboundary risks, systemic risks and cascading impacts. In particular, there is still a lack of diversity of research approaches to quantifying the system risks that follow from direct climate impacts onto the UK. Improving this could be usefully applied at a spatial detail relevant to adaptation while covering the entire geography of the UK and all sectors of activity. There also remains a need to understand the consistency of the different approaches and datasets. One key UKCR project, ‘OpenCLIM’, has produced a framework that is helping to establish a more consistent approach to place-based risk assessment, but this should now be expanded to a greater range of risks and bring in a wider range of component models from other risk and resilience research.

## 5 CONCLUDING THOUGHTS

The UK Climate Resilience programme has improved our collective understanding of the climate risks we face and the implications of those risks, as well as increasing the availability of tools and information needed to assess them. It has also created a community of interacting researchers, practitioners and policymakers in climate resilience.

There now needs to be a shift in focus towards strengthening the UK’s capacity to adapt. This requires a significantly larger effort and a

more diverse set of actors. We urge future research programmes to appreciate the value of a connected research-practice community for climate resilience, to build strong relationships between academia and organisational or policy practice that allow for quick and clear feedback loops to ensure outputs are relevant and usable. Future programmes should include innovators and entrepreneurs, skilled in developing research insight into practice through innovation hubs and platforms.

The UK Climate Resilience Programme has shown the potential of such a community to advance thinking and practice on climate resilience in the UK. There is considerable appetite to build on this experience, to ensure the UK sustains and enhances this progress for the public good.

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