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# Knowledge and evidence gaps limiting the value of the Adaptation Reporting Power process to the organisations involved

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Report prepared by the Adaptation and Resilience in the Context of Change network

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## ARCC network

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The Adaptation and Resilience in the Context of Change (ARCC) network is hosted by the UK Climate Impacts Programme (UKCIP) and funded by the Engineering and Physical Sciences Research Council (EPSRC).

UKCIP helps organisations, sectors and government adapt to the changing climate through practice-based research and by providing support and advice. The programme is based at the Environmental Change Institute, University of Oxford.

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Supplementary report to: Understanding the value of the Adaptation Reporting Power process to the reporting organisations involved

[www.arcc-network.org.uk/ARP](http://www.arcc-network.org.uk/ARP)



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# Introduction

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To assist in evaluating the second Adaptation Reporting Power process (ARP2), the Adaptation and Resilience to a Changing Climate (ARCC) network explored with a number of reporting organisations in the infrastructure sector the effectiveness and value of the reporting experience to the organisations involved. In addition to seeking to understand the value of the ARP2 process, this initiative also looked to identify ways in which future ARP rounds could be directed to make the process and resulting reports more valuable, and to provide greater overall benefit.

As part of this work, gaps or shortfalls in knowledge and evidence from research that reporting organisations believed prevented them from realising greater value from the ARP process were identified. A brief summary of these gaps or shortfalls was included in the final report<sup>1</sup>. This short paper draws on further evidence from the interviews conducted and from the ARP2 reports to provide more details and to supplement and enhance the evidence gaps already identified in the recent second national Climate Change Risk Assessment (CCRA2)<sup>2</sup>. It also highlights the general view of reporting organisations that addressing research requirements needs to be seen as a rolling process providing up-to-date scientific knowledge and evidence suitable to inform action rather than in terms of specific shorter and longer-term requirements associated with particular deadlines (e.g. subsequent ARP rounds or CCRA reports).

The details of knowledge and evidence gaps are presented in this manner to associate the ARP requirements for research to support the on-going needs of infrastructure organisations with those identified as supporting the CCRA. Overall, this information can be used to help inform the academic community and future research council and other funding agency investments in terms of linking research with potential benefits, for example in supporting future ARP rounds. It can also be used to help direct sector-led coordinated research and innovation programmes, and work by boundary organisations looking to facilitate knowledge exchange and the translation of climate research to support policy and practice. And in the short-term, the information in this paper may also be used to identify opportunities to advance existing research to address specific evidence gaps.

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1 Street, R., Hayman, V. & Wilkins, T.M. (2017) Understanding the value of the adaptation reporting power process to the reporting organisations involved. UKCIP, University of Oxford.

2 Committee on Climate Change. Climate Change Risk Assessment Evidence Report, 2016.

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## Background

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Information on research and evidence gaps was gathered from 42 reporting organisations in the infrastructure sector<sup>3</sup>.

As part of the work evaluating the value of the ARP to the organisations involved, the ARCC network carried out semi-structured, qualitative interviews with 18 reporting organisations. These interviews included discussion on the specific question: 'Were there any gaps or shortfalls in knowledge, evidence or guidance available that limited the impact and value of reporting?' This evidence was then augmented by information extracted from a literature review of the ARP2 reports submitted by these and a further 24 reporting organisations.

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<sup>3</sup> Sub-sectors covered were IT, water companies, regulators, electricity generators, transmitters and distributors, gas transporters, road & rail, airport operators, harbour authorities (see Annex 1 for full listing)



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## Findings

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A significant number of gaps and shortfalls in the knowledge and evidence available from research were identified during the interviews and from the ARP2 reports. These ranged from the need for very detailed scientific information on specific climate variables and their potential impacts, through innovative and user-friendly decision-support tools, to the need for effective knowledge exchange processes to facilitate the provision of useful research outputs.

Many of these findings complement and enhance the evidence gaps identified in the CCRA2 Evidence Report (2016<sup>2</sup>) and additional information added at the subsequent Research Needs conference (hosted by the Climate Change Committee, November 2017<sup>4</sup>). To present an overview of evidence gaps, and to highlight similarities and differences, the material extracted from the ARP process has been mapped onto the CCRA2 findings in Table 1. The focus is on those knowledge, information and data gaps listed in CCRA2 Chapter 4 on Infrastructure, but there also are strong links with Chapter 8 on Cross-cutting issues, and also with Chapter 5 on People and the Built Environment.

**Table 1. Evidence gaps identified from the ARP2 process mapped onto findings from CCRA2 Evidence Report Chapter 4: Infrastructure, and at the follow-up Research Needs conference.**

CCRA2	ARP2
<b>A lack of knowledge of how climate change will alter the intensity and frequency of certain meteorological processes inhibits assessment of some infrastructure risks:</b>	
a. Persistent climatic events (e.g. repeated sequence of storms or floods, in the same or multiple locations).	<ul style="list-style-type: none"> <li>• Extreme weather events including changing return periods, e.g. intense storms, extreme drought, severe lightning</li> <li>• Climate change thresholds that start to trigger extreme weather events such as flooding or storms</li> <li>• Impact of extreme weather events in conjunction with longer term climate-related impacts</li> <li>• Quantifying the economic costs of extreme weather</li> <li>• Understanding behavioural changes during extreme weather (e.g modal shifts in transport use)</li> </ul>
b. Joint hazard events (e.g. wind storm coupled with flooding).	<p>Combinations or sequences of events, and changing return periods, e.g.</p> <ul style="list-style-type: none"> <li>• strong winds following prolonged rainfall</li> <li>• hot summer periods combined with low wind</li> <li>• high rainfall following drought</li> <li>• high intensity or prolonged rainfall and high tides</li> </ul>
c. Landslips – issue for water, road, rail.	<ul style="list-style-type: none"> <li>• Scale and frequency of landslips</li> <li>• Understanding and mapping ground movement including subsidence</li> </ul>
	Likelihood and impact of unprecedented climatic conditions
	<p>Guidance on using complex climate information, including looking towards UKCP18</p> <ul style="list-style-type: none"> <li>• translation of ukcp09 projections</li> <li>• Information on changes from ukcp09 to ukcp18 (including where there are no changes)</li> <li>• Treatment of uncertainty especially to support longer term infrastructure decisions</li> <li>• Information on downscaling climate projections</li> <li>• Using ukcp18 in decision-making frameworks</li> </ul>
	<p>Information on links between projected climate and actual impacts</p> <p>Needed at the local, regional and national level to help assess operational effects, e.g the impact of frequency of severe events, the degree, extent and depth of flooding, increased rates of erosion and the exacerbation of land movement etc. Will be of relevance across sectors.</p>

CCRA2	ARP2
<b>Risks to some infrastructures have been recognised as potentially significant, but understanding is particularly limited for:</b>	
a. Bridges and pipelines from high river flows and bank erosion.	<ul style="list-style-type: none"> <li>• Bridge scour</li> <li>• Sedimentation patterns and levels</li> <li>• Projections of changing river levels</li> </ul>
b. Energy, transport and digital infrastructure from high winds and lightning, including increased vegetation growth rates on future risks of damage from falling trees during storms.	<ul style="list-style-type: none"> <li>• Wind speeds and direction</li> <li>• Lightning</li> <li>• Increased vegetation growth rates and extended growing seasons</li> </ul>
c. Offshore infrastructure from storms and high waves, including renewables.	
d. ICT due to limited knowledge of network location and connectivity to other infrastructures.	
e. UK infrastructures as a result of their international interactions.	
	<p>Risks to coastal infrastructure.</p> <ul style="list-style-type: none"> <li>• Coastal flooding forecasts</li> <li>• Sedimentation patterns and levels</li> <li>• Rates and patterns of coastal erosion</li> <li>• Probability and severity of tidal surges</li> </ul>
<b>The effects of weather and climate on the short and long term performance of infrastructure</b>	
a. Performance and reliability of flood risk management infrastructure is particularly challenging because of its safety critical role, but limited failures and occasions when it is 'loaded' by extreme events pose particular challenges.	<p>Changing flood risk:</p> <ul style="list-style-type: none"> <li>• how flood risk maps are changing, e.g. rate of change of flood extent and depths</li> <li>• projections of groundwater flooding</li> <li>• regional groundwater modelling</li> </ul>
b. A robust, forensic and consistent approach to monitoring and recording failures.	
c. Better recording of infrastructure failures, and conditions under which they fail, to develop fragility functions.	

CCRA2	ARP2
d. Environmental deterioration processes and their relationship to infrastructure performance.	
	Considering socio-economic aspects and expectations (of failure) in terms of infrastructure performance and services. Uncertainties in demographic changes, population growth, and inter-region migration
<b>Challenges around providing modelling tools to support a national climate change risk assessment could be addressed by a modelling framework that is collectively owned and maintained by the wider infrastructure community:</b>	
a. Information at risk is studied at a range of different scales and locations, many locations have limited detailed study, a comprehensive platform would record and identify gaps.	<ul style="list-style-type: none"> <li>• Opportunities to increase sharing of information (including observational data and models) at all scales</li> <li>• New national data sets e.g. on landslips.</li> </ul>
b. Many climate risk assessments rely on the same derived data products (e.g. NaFRA flood probability maps are used in a number of key evidence).	
c. Climate scenarios are well established, but socio-economic and technology scenarios are all highly varied making inter-comparison challenging.	<ul style="list-style-type: none"> <li>• Need for consistent sets of climate and socio-economic scenarios, at varying scales</li> <li>• Research around possible standardised national data and projections</li> </ul>
<b>Risks and opportunities associated with infrastructure interdependencies:</b>	
Benefits and potential risks from jointly delivered infrastructure adaptation, joint monitoring and management, alternative regulatory structures, and mechanisms to share information across sectors, scales and with other parties.	<p>New models/methods for understanding interdependencies, including aspects of:</p> <ul style="list-style-type: none"> <li>• Short to medium term regional interdependencies:</li> <li>• Sub-sector interdependencies – where are the vulnerabilities?</li> <li>• Supply chain resilience.</li> <li>• Route dependencies, risks and responsibilities</li> <li>• How to take account of uncertainties</li> </ul>



CCRA2	ARP2
<b>New decision-support approaches are required to:</b>	
a. Reflect the value of climate resilience in infrastructure design, delivery and appraisal processes.	<p>New approaches to understanding risks and the implications for decision-making including:</p> <ul style="list-style-type: none"> <li>• prioritising the impacts of climate change among other corporate risks</li> <li>• understanding when to take a decision</li> <li>• achieving robust decision-making for new investment</li> <li>• discussion on precision and uncertainty and the level of detail required for decision-making</li> <li>• the costs and benefits of adaptation options and evaluating the suitability of the measures chosen guidance on metrics for success in adaptation risk management</li> </ul>
b. Fairly compare 'soft' and 'hard' infrastructure adaptation options.	
c. Assess the performance of infrastructure in meeting climate change objectives.	
d. Design flexible strategies or real options to transition infrastructure networks towards greater climate resilience.	
<b>Better understanding of resilience of non-regulated bodies</b>	
<b>More work on looking at standards in a consistent way e.g. Eurocode.</b>	
	Lack of national standards on appropriate levels of adaptation actions
<b>Creation of new meteorological datasets to investigate relationships with failures.</b>	
<b>Better utilisation of knowledge of staff/people at sites/ on ground.</b>	
	<b>Resilience of infrastructure building stock.</b>
	<ul style="list-style-type: none"> <li>• Heating and cooling capacity of organisation's building stock</li> <li>• Understanding the potential impact of air conditioning load</li> </ul>

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## Discussion

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Significant progress has been made in recent years in the understanding of climate change and its impacts as the science has evolved and matured. This is reflected in the list of current evidence and knowledge gaps which go well beyond understanding impacts and adaptation options to focus increasingly on research to help inform new approaches for understanding risks, the implications for timely decision-making, and for assessing the costs and benefits of action.

But it is clear from the ARP2 reports that a large number of gaps in evidence (data and analysis) that require further research remain and also that there are significant areas of knowledge where reducing current uncertainty would help support the decision-making process.

On the timing of evidence needs, reporting organisations did not tend to differentiate between shorter- and longer-term requirements. Many aspects of research have both short and long term components and are also dependent on the availability of related research and/or data etc. Reporting organisations reflect the latest progress in scientific understanding on timescales primarily driven by their varying sector control cycles, and only tangentially affected by the ARP process. This is in contrast to the policy process, where the five-yearly CCRA cycles mean that research outputs are needed by 2019 to inform CCRA3 and by 2024 for CCRA4.

From the perspective of the ARP process and the need for evidence to inform action on adaptation in the infrastructure sector, the following overarching areas were highlighted:

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### UK climate projections

The single most valuable scientific input to the ARP process to date has been the UK Climate Projections, 2009 (UKCP09). These projections are currently being updated (UKCP18) and a number of the on-going requirements listed in Table 1 reflect requirements from UKCP18 in terms of specific variables, particular spatial and temporal resolutions etc.

To inform investment decisions, many organisations are looking for improved spatial resolution to aid local and regional level planning. Increased certainty in specific variables and products is needed as the level of uncertainty in the projections remains a barrier to making major investment decisions especially in the medium and long-term. And information on the likelihood and impacts of multiple extreme weather events (repeated, prolonged and/or joint hazard events) would help inform risk management process.

When considering the use of UKCP18 by reporting organisations, a key aspect will be the understanding of the implications of changes between the UKCP09 projections and the new UKCP18 projections. Clear information on differences between the two sets of projections will be needed as will guidance on whether past decisions based on UKCP09 remain valid (i.e. is the business case still based on the best available scientific information). There is also a continued need for data formats and user guidance that allows companies to incorporate the scientific information into their own on-going analysis, including in research commissioned directly by industry.

In support of this, a number of reporting organisations are involved in the UKCP18 user groups (often through sector-based organisations), which should help ensure that the new projections meet the evolving needs of decision-makers in the infrastructure sector.

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## Consideration of interdependencies

Understanding dependencies and interdependencies was highlighted as a significant issue both within and across sectors, and with respect to supply chains. Many reporting organisations mentioned this as an area of concern but acknowledged that there is no easy way forward given the complexity of the issue, difficulties in identifying and assessing high risk interdependencies and in considering who is responsible for the response.

Several organisations noted the recent work by the Environment Agency's Infrastructure Operators Adaptation Forum (IOAF) in this area and there may be on-going opportunities through the IOAF to share information and to work with the research community to develop guidance and mechanisms to help progress work on interdependencies.

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## Risk management and decision-support tools

Adapting to climate change is just one of many risks considered by infrastructure organisations in their overall risk management strategies. And there is considerable interest in better understanding how adaptation can be addressed within cross-cutting corporate structures including aspects of timings (when to make a decision), dealing with uncertain information especially in the longer term, and how best to track and evaluate adaptation measures and metrics for success. Information to support consideration of different approaches e.g. adaptation pathways is needed as are decision-support tools that are user-driven and are practical to use in terms of organisational resources and capacity required.

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## Translating and sharing of information

There are many areas where evidence and knowledge from research can be used to inform practice. However, the disparity between academic outputs and industry requirements continues, despite on-going efforts by both sides, with research outputs often too generic and/or based at the national-level to enable use by industry. Activities which help with the access, understanding, synthesis and translation of research to provide salient outputs for infrastructure organisations continue to be needed. The value of a national platform in helping to coordinate climate research and to act as an interface with consultants, policy and practice was raised. Such a platform could play a strong role in helping to integrate research, in signposting to relevant scientific information including learning from other countries, and to avoid duplication.

Sharing of information at an organisational level is also important. As is to be expected, the evidence needs highlighted in the ARP2 reports focus on the specific requirements of individual organisations but the reports themselves contain a wealth of information on how organisations have tackled the challenge of adapting to climate change. Organisations recognise the opportunity now to share knowledge, including across sectors, on, for example, comparing and contrasting how operators are assessing, monitoring and reviewing risks and by sharing case studies and best practice. Some organisations also have data sets gathered from operational activities which could be used more widely in-house and possibly shared. In some cases, sector-level bodies are taking a lead in the sharing of information, and many organisations expressed a willingness to learn from the experiences of others.

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## Summary

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Consideration of information from discussions with reporting organisations and from ARP2 reports has identified evidence and knowledge gaps where further research could help enhance the value of the ARP process to reporting organisations in the infrastructure sector.

By linking the findings from this work with the broader research gaps identified in the CCRA2 report, an overall summary of evidence needs and knowledge gaps to support adaptation action in the infrastructure sector has been compiled. This can be used to help guide on-going research and future research investments to ensure that evidence and outputs continue to be aligned with evolving user needs.



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## Annex 1. ARP2 reports consulted

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\* indicates reporting organisation interviewed

### Communications

- Tech UK\*

### Water companies

- Anglian Water
- Affinity Water
- Bournemouth Water
- Portsmouth Water \*
- Severn Trent Water \*
- South East Water
- Southern Water
- Thames Water \*
- United Utilities \*
- Wessex Water
- Yorkshire Water \*

### Regulators

- Civil Aviation Authority
- Ofgem \*
- Ofwat

### Electricity generators

- Energy UK and industry members of their Working Group on Resilience and Adaptation (the report was submitted on behalf of Centrica Energy, Drax Power, E.ON UK, EDF Energy, GDF SUEZ, InterGen, RWE npower, Scottish Power Generation and SSE) \*

- Scottish and Southern Energy Power Distribution

#### Electricity transmitters

- Energy Networks Association (the report was prepared by the task group of electricity distribution and transmission network operator members) \*
- National Grid

#### Electricity distributors

- Electricity North West
- Northern Powergrid
- SP Energy Networks
- UK Power Networks
- Western Power Distribution

#### Gas transporters

- National Grid
- Northern Gas Networks
- SGN
- Wales and West Utilities Limited \*

#### Road and rail

- Highways England \*
- Network Rail \*
- Transport for London \*

#### Strategic airport operators

- Birmingham Airport
- Gatwick Airport Ltd
- Glasgow Airport Ltd
- Heathrow Airport \*
- Manchester Airports Group \*
- Stanstead Airport Ltd

#### Ports

- Associated British Ports (Hull, Humber, Immingham, Southampton) \*
- Milford Haven Port Authority
- PD Teesport Ltd
- Port of Dover \*
- Port of Felixstowe
- Port of London Authority \*

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