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Understanding how behaviours can influence climate change risks

Technical appendices

UK Committee on Climate Change

23 April 2020

Northern Ireland environment link | sustainability west midlands | sniffer knowledge brokers for a resilient Scotland | LONDON climate change PARTNERSHIP

Quality information

Quality Information		
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Prepared for:

Committee on Climate Change

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Appendix A Literature Review Protocol

A.1 Purpose and overall process

The purpose of this protocol is to describe all decisions regarding how the literature review will be undertaken – from retrieval of literature to synthesis of findings.

A systematic review methodology will help ensure that as much of the relevant UK and international research as possible is retrieved. In addition, the research protocol will help with management of the review.

A.2 Databases and search terms

A review will be undertaken of broader web and academic journals to identify potentially relevant additional studies. A selection of search engines and databases will be searched to identify relevant literature using a range of keywords.

Figure A 1: Flow chart of overall literature review process

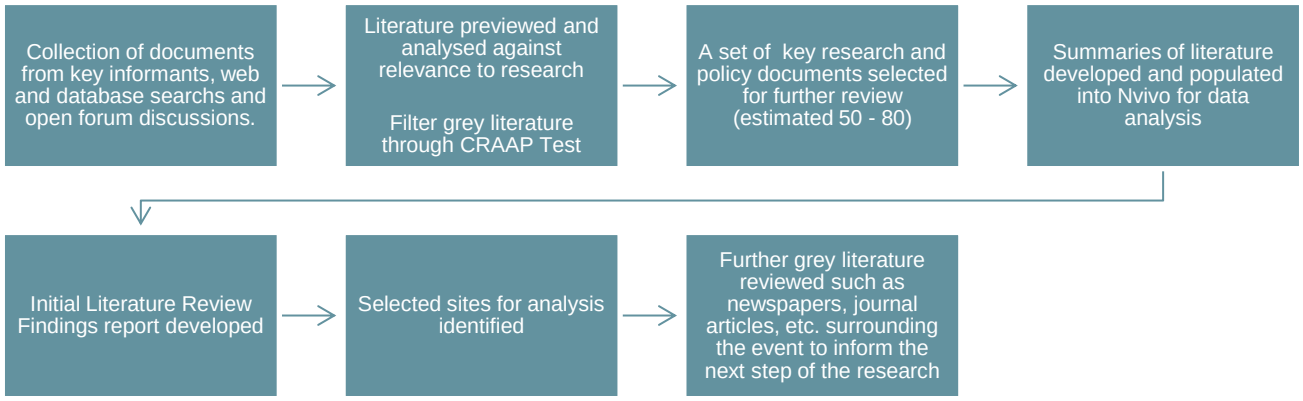

Table A 1: Databases for the search

Subscription and non-subscription databases	Initial list of institutions and organisations for grey literature
Science Direct Database	Government
Agricultural & Environmental Science Database	UK Department of Energy & Climate Change (DECC)
Research Gate	Committee on Climate Change
Academic Search Complete	Research/academic institutions
Zetoc	Chatham House
EconLit	Grantham Institute
PubMed	Environmental Change Institute
Ethos	Institute for International Environmental Development
BASE (Bielefield Academic Search Engine	Priestley International Centre for Climate
EPPI centre	Cabot Institute for the Environment
Scopus	Non-profit
EU ClimateADAPT	The Carbon Trust

Table A 2: Relevant search terms

List A: Terms to identify demographic variables	List B: Terms to identify behaviours	List C: Terms to identify factors	List D: Terms to identify interventions	List E: Terms to identify climate events
List A1: Socioeconomic variables	List B1: Generic terms	List C1: Generic terms	List D1: Generic Terms	List E1: Generic terms
Age	Behaviour traits	Factors	Digital innovation	Factors
Male	Climate adaptation behaviour	Norms	Intervention	Norms
Female	Climate behaviour	Bias	Incentive	Bias
Gender	Adaptation behaviour	Motivation	Incentivise	Behaviours
Income	Coping response	Heuristics	Technology	Heuristics
Health	Adaptive behaviour	Decision-making	Climate communication	Decision-making
List A2: Location variables		Determinants	Climate services	List E2: Risk terms:
Cities			Climate opportunity	Resilience
Rural			Public perception	Disaster risk
Coastal			Promotion	Disaster risk reduction
Peri-urban				Disaster risk management
UK				Preparedness
List A3: Target groups				Response
Businesses				Recovery
Land managers				List E3: Climate events
SMEs				Flooding
Households				Coastal flooding
Individuals				Acute flood risk
Communities				Heatwave
				Extreme cold
				Extreme heat
				Storms
				Climate event
				Climate hazard

A.3 Inclusion/exclusion criteria

Preference will be given to studies published in peer reviewed journals; however, the nature of the topic will likely mean that grey literature is of equal importance. It is also recognised that very recent studies may be of high quality but have not yet been through peer review for publication, therefore they will be screened and assessed for robustness accordingly (see below).

Inclusion/exclusion criteria applied to the search specification:

- Time period: since 2009
- Location: priority will be on UK studies, but global examples will be useful to construct a comprehensive understanding of behaviours and factors.
- Language: the studies pulled will be in English, but there will be no standards on the original language, so long as there is a translated version with English keywords available.

Inclusion/exclusion criteria for titles and abstracts

The titles and/or abstracts will need to reference climate change adaptation or response to climate events.

Inclusion/exclusion criteria for full text

Literature was included if it met the following requirements:

- Relevance to research questions
- Article has been peer-reviewed (see grey literature for further description of non-peer-reviewed inclusion)
- Exposure of interest (e.g. to the one of the stated climate events)

A.4 Grey literature

Whether literature is peer-reviewed or 'grey' will be established by considering two key questions:

- Whether the literature is published or sponsored by a professional scholarly society, professional association, or university academic department, and whether it describes itself as a peer-reviewed publication.
- Whether it is found through online academic or professional databases. Other factors that may indicate that a publication has been peer reviewed include:
    - There is an abstract at the beginning
    - It has footnotes or citations of other sources
    - It has a bibliography or list of references at the end
    - The author's credentials are listed
    - The article is based on either original research or authorities in the field (as opposed to personal opinion)
    - It is written for readers with some prior knowledge of the subject.

The CRAAP test (evaluating Currency, Relevancy, Authority, Accuracy, and Purpose) will be used to evaluate all pieces of grey literature. This test will determine the credibility of grey literature. By developing an amended set of questions the assessment can be done in a time-effective approach. An extract of the assessment tool is presented in Figure A1.

Figure A 2: CRAAP assessment for grey literature

CRAAP assessment for grey literature proposed to be considered in the literature review for Understanding how behaviour change can influence climate change risks and opportunities.

Date of Assessment: Click here to enter text.
Literature title: Click here to enter text.
Author: Click here to enter text.

Direction of use: Select a Yes, No or Unsure answer to the following set of Questions provided in the table below. When completed, calculate only the number of 'Yes' answers.

The following criteria determines whether the Grey Literature can be considered for the literature review:

- Below 15: Not an acceptable source and therefore not to be used in the literature review.
- Between 15 and 17: Consult with Project Manager and internal panel further.
- Between 18 and 21: Can be considered for the literature review.

Table: Evaluating Sources using an amended 'CRAAP' approach originally developed by *Blakesee, Sarah (2004)*

QUESTIONS	Yes	No	Unsure
Currency: The timeliness of the information.			
Was the information published or posted after 2012?	☐	☐	☐
Has the information been revised or updated?	☐	☐	☐
Does your topic require current information, or will older sources work as well?	☐	☐	☐
Relevance: The importance of the information			
Does the information relate to the topic?	☐	☐	☐
Is the intended audience of the report applicable to the topic?	☐	☐	☐
Is the information at an appropriate level (i.e. not too elementary or advanced)?	☐	☐	☐
Has this paper been sourced in other literature?	☐	☐	☐
Authority: The source of the information.			
Is the publisher/source/sponsor evidently in a field applicable to the topic?	☐	☐	☐
Is the author qualified to write on the topic?	☐	☐	☐
Is there contact information, such as a publisher or email address?	☐	☐	☐
Accuracy: The reliability, truthfulness and correctness of the content.			
Is where the information comes from a database, key informant in the project, government entities, or a credible source/trusted website?	☐	☐	☐
Is the information supported by evidence?	☐	☐	☐
Has the information been reviewed or refereed?	☐	☐	☐
Can the information be verified in another source or from professional knowledge?	☐	☐	☐
Does the language or tone seem unbiased and free of emotion?	☐	☐	☐
Are there spelling, grammar or typographical errors?	☐	☐	☐
Purpose: The reason the information exists			
Is it the purpose of the information to inform, teach and not sell, entertain or persuade?	☐	☐	☐
Do the authors/sponsors make their intentions or purpose clear?	☐	☐	☐
Is the information fact based on fact and not opinion or propaganda?	☐	☐	☐
Does the point of view appear objective and impartial?	☐	☐	☐
The information does not show any political, ideological, cultural, religious, institutional or personal biases?	☐	☐	☐
Total number of Yes answers			

A.5 Documenting findings

The literature identified and gathered for review will be recorded in a spreadsheet where a number of factors will be used to rank and weight the sources for further detailed review. Whether the literature is peer reviewed or 'grey' will be one of these factors. Other factors will include date of publication, source and author level of

relevance to the research questions, and the extent to which the evidence is based on primary or secondary data and analysis.

A.6 Review of this protocol

This protocol will be updated concurrently with any material changes in the method document.

Table A 3: Summary of literature reviewed

Reference	Relevance to research questions				Relevant Target Groups				
	1	2	3	4	Households	Small businesses	Communities	Land Managers	Large Businesses
Burke, Miriam & Ockwell, David & Whitmarsh, Lorraine. (2018). Participatory arts and affective engagement with climate change: The missing link in achieving climate compatible behaviour change? Global Environmental Change. 49. 95-105.									
Wamsler, Christine & Brink, Ebba. (2018). Mindsets for Sustainability: Exploring the Link Between Mindfulness and Sustainable Climate Adaptation. Ecological Economics. 151. 55-61.									
Wang, Susie & Leviston, Zoe & Hurlstone, Mark & Lawrence, Carmen & Walker, Iain. (2018). Emotions predict policy support: Why it matters how people feel about climate change. Global Environmental Change. 50. 25-40.									
Chu, Haoran & Yang, Z. Janet. (2018). Taking climate change here and now – mitigating ideological polarization with psychological distance. Global Environmental Change. 53. 174-181.									
Clifford, Katherine & Travis, William. (2018). Knowing climate as a social-ecological-atmospheric construct. Global Environmental Change. 49. 1-9.									
Brink, Ebba & Wamsler, Christine. (2018). Citizen engagement in climate adaptation surveyed: The role of values, worldviews, gender and place. Journal of Cleaner Production. 209. 1342-1353.									
Gifford, Robert & Comeau, Louise. (2011). Message framing influences perceived climate change competence, engagement, and behavioral intentions. Global Environmental Change. 21. 1301-1307.									
Hussain, Mudassar & Liu, Guijian & Yousaf, Balal & Ahmed, Rafay & Uzma, Faiza & Ubaid Ali, Muhammad & Ullah, Habib & Butt, Abdul Rahman. (2018). Regional and sectoral assessment on climate-change in Pakistan: Social norms and indigenous perceptions on climate-change adaptation and mitigation in relation to global context. Journal of Cleaner Production. 200. 791-808.									
Di Falco, Salvatore & Sharma, Sindra. (2018). Investing in Climate Change Adaptation: Motivations and Green Incentives in the Fiji Islands. Ecological Economics. 154. 394-408.									
Helm, Sabrina & Pollitt, Amanda & Barnett, Melissa & Curran, Melissa & Craig, Zelieann. (2018). Differentiating environmental concern in the context of psychological adaption to climate change. Global Environmental Change. 48. 158-167.									
Babutsidze, Zakaria & Chai, Andreas. (2018). Look at me Saving the Planet! The Imitation of Visible Green Behavior and its Impact on the Climate Value-Action Gap. Ecological Economics. 146. 290-303.									

Reference	Relevance to research questions				Relevant Target Groups				
	1	2	3	4	Households	Small businesses	Communities	Land Managers	Large Businesses
Findlater, Kieran & Donner, Simon & Satterfield, Terre & Kandlikar, Milind. (2018). Integration anxiety: The cognitive isolation of climate change. Global Environmental Change. 50. 178-189.									
Chapman, Daniel & Corner, Adam & Webster, Robin & Markowitz, Ezra. (2016). Climate visuals: A mixed methods investigation of public perceptions of climate images in three countries. Global Environmental Change. 41. 172-182.									
Dai, Jing, Kesternich, Martin, Löschel, Andreas and Ziegler, Andreas. (2015). Extreme weather experiences and climate change beliefs in China: An econometric analysis. Ecological Economics. 116. 310-321.									
Niles, Meredith & Mueller, Nathaniel. (2016). Farmer perceptions of climate change: Associations with observed temperature and precipitation trends, irrigation, and climate beliefs. Global Environmental Change. 39. 133-142.									
Arunrat, Noppol & Wang, Can & Pumijumnong, Nathsuda & Sereenonchai, Sukanya & Cai, Wenjia. (2016). Farmers' intention and decision to adapt to climate change: A case study in the Yom and Nan basins, Phichit province of Thailand. Journal of Cleaner Production. 143. 672-685.									
Masud, Muhammad & Azam, Mohammad & Mohiuddin, Muhammad & Banna, Hasanul & Akhtar, Rulia & Alam, A S A Ferdous & Begum, Halima. (2017). Adaptation Barriers and Strategies towards Climate Change: Challenges in the Agricultural Sector. Journal of Cleaner Production. 156. 698–706.									
Frondel, Manuel, Simora, Michael & Sommer, Stephan. (2017). Risk Perception of Climate Change: Empirical Evidence for Germany. Ecological Economics. 137. 173-183.									
De Sousa, Kauê & Casanoves, Fernando & Sellare, Jorge & Ospina, Mayra & Gabriel Suchini, Jose & Aguilar, Amilcar & Mercado, Leida. (2018). How climate awareness influences farmers' adaptation decisions in Central America? Journal of Rural Studies. 64. 11-19.									
Senvolo, Mmapatla Precious & Long, Thomas B. & Blok, Vincent & Omta Onno. (2018) How the characteristics of innovations impact their adoption: An exploration of climate-smart agricultural innovations in South Africa. Journal of Cleaner Production. 172. 3825-3840.									
Bulla, B. R, Craig, E. A, & Steelman, T. A. (2017). Climate change and adaptive decision making: Responses from North Carolina coastal officials. Ocean & coastal management, 135, 25-33.									
Dayamba, Sidzabda & Ky-Dembele, Catherine & Bayala, Jules & Dorward, Peter & Clarkson, Graham & Sanogo, Diaminatou & Mamadou, Lamine & Traoré, Issa & Diakité, Adama & Nenkam, Andree & Nyemeck Binam, Joachim & Ouedraogo, Mathieu & Zougmore, Robert. (2018). Assessment of the use of Participatory Integrated Climate Services for Agriculture (PICSA) approach by farmers to manage climate risk in Mali and Senegal. Climate Services. 12. 27-35.									
Nidumolu, Uday & Lim-Camacho, Lilly & Gaillard, Estelle & Hayman, Peter & Howden, Stuart. (2018). Linking climate forecasts to rural livelihoods: Mapping decisions, information networks and value chains. Weather and Climate Extremes. In Press.									
Howlett, Michael. (2014). Why are policy innovations rare and so often negative? Blame avoidance and problem denial in climate change policy-making. Global Environmental Change. 29. 395-403.									
Bruno Soares, Alexander, M & Dessai, S. (2018). Sectoral use of climate information in Europe: A synoptic overview. Climate Services. 9. 5-20.									

Reference	Relevance to research questions				Relevant Target Groups				
	1	2	3	4	Households	Small businesses	Communities	Land Managers	Large Businesses
Vaughan, Catherine & Dessai, Suraje & Hewitt, Chris & Baethgen, Walter & Terra, Rafael & Berterretche, Mercedes. (2017). Creating an enabling environment for investment in climate services: The case of Uruguay's National Agricultural Information System. Climate Services. 8. 62-71.		■		■		■	■	■	
Fatorić, Sandra & Seekamp, Erin. (2017). Evaluating a decision analytic approach to climate change adaptation of cultural resources along the Atlantic Coast of the United States. Land Use Policy. 68. 254-263.		■					■		
Horita, Flávio & De Albuquerque, Joao & Marchezini, Victor & Mendiondo, Eduardo. (2017). Bridging the gap between decision-making and emerging big data sources: An application of a model-based framework to disaster management in Brazil. Decision Support Systems. 97. 12-22.				■		■		■	
Bardsley, Douglas & Palazzo, Elisa & Pütz, Marco. (2018). Regional path dependence and climate change adaptation: A case study from the McLaren Vale, South Australia. Journal of Rural Studies. 63. 24-33.		■						■	
Singh, C., Dorward, P., & Osbahr, H. (2016). Developing a holistic approach to the analysis of farmer decision-making: Implications for adaptation policy and practice in developing countries. Land use policy, 59, 329-343		■						■	
Müller-Fürstenberger, Georg & Schumacher, Ingmar, 2015. Insurance and climate-driven extreme events. Journal of Economic Dynamics and Control. 54. 59-73.		■		■		■			
Phadke, Roopali & Manning, Christie & Burlager, Samantha. (2015). Making it Personal: Diversity and Deliberation in Climate Adaptation Planning. Climate Risk Management. 41. 62-76.		■					■		
Grothmann, Torsten & Patt, Anthony. (2005). Adaptive capacity and human cognition: The process of individual adaptation to climate change. Global Environmental Change. 15. 199–213.		■					■	■	
Few, Roger & Brown, Katrina & Tompkins, Emma. (2007). Public Participation and Climate Change Adaptation: Avoiding the Illusion of Inclusion. Climate Policy. 7. 46-59.		■					■	■	
Semenza, J. C., Hall, D. E., Wilson, D. J., Bontempo, B. D., Sailor, D. J., & George, L. A. (2008). Public perception of climate change: Voluntary mitigation and barriers to behavior change. American Journal of Preventive Medicine. 35. 479-487.		■		■			■		
Deressa, Temesgen & Hassan, Rashid & Ringler, Claudia. (2011). Perception and adaptation to climate change by farmers in the Nile basin of Ethiopia. The Journal of Agricultural Science. 149. 23 - 31.	■							■	
Gifford, Robert. (2011). The Dragons of Inaction: Psychological Barriers That Limit Climate Change Mitigation and Adaptation. American Psychologist. 66. 290-302.		■					■		
Lowe, Thomas & Brown, Katrina & Dessai, Suraje & De, Miguel & Doria, Miguel & Haynes, Katharine & Vincent, Katharine. (2006). Does Tomorrow Ever Come? Disaster Narrative and Public Perceptions of Climate Change. Public Understanding of Science. 15. 435-457.		■					■		
Wolf, Johanna & Adger, W. & Lorenzoni, Irene & Abrahamson, Vanessa & Raine, Rosalind. (2010). Social Capital, Individual Responses to Heat Waves and Climate Change Adaptation: An Empirical Study of Two UK Cities. Global Environmental Change. 20. 44-52.		■					■		
Brody, Samuel & Zahran, Sammy & Vedlitz, Arnold & Grover, Himanshu. (2008). Examining the Relationship Between Physical Vulnerability and Public Perceptions of Global Climate Change in the United States. Environment and Behavior. 40. 72-95.		■					■		
Spence, Alexa & Poortinga, Wouter & Butler, Catherine & Pidgeon, N.F.. (2011). Perceptions of Climate Change and		■					■		

Reference	Relevance to research questions				Relevant Target Groups				
	1	2	3	4	Households	Small businesses	Communities	Land Managers	Large Businesses
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Brondízio, Eduardo & Moran, Emilio. (2008). Human dimensions of climate change: The vulnerability of small farmers in the Amazon. Philosophical transactions of the Royal Society of London. Series B, Biological sciences. 363. 1803-9.									
Reser, Joseph & Bradley, Graham & Ellul, Michelle. (2014). Encountering climate change: 'Seeing' is more than 'believing'. Wiley Interdisciplinary Reviews: Climate Change. 5. 521-537.									
Akompab, D. A., Bi, P., Williams, S., Grant, J., Walker, I. A., & Augoustinos, M. (2013). Heat waves and climate change: applying the health belief model to identify predictors of risk perception and adaptive behaviours in adelaide, Australia. International journal of environmental research and public health. 10. 2164–2184.									
Dessai, Suraje & Adger, W. & Hulme, Mike & Turnpenny, John & Köhler, Jonathan & Warren, Rachel. (2004). Defining and Experiencing Dangerous Climate Change. Climatic Change. 64. 11-25.									
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Taylor, Andrea & Bruine de Bruin, Wändi & Dessai, Suraje. (2014). Public perception of climate risk and adaptation in the UK: A review of the literature. Climate Risk Management. 4-5. 1-16.									
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Mayer, Adam & Smith, E. Keith. (2018). Unstoppable climate change? The influence of fatalistic beliefs about climate change on behavioural change and willingness to pay cross-nationally. Climate Policy. 19. 1-13.									
Javeline, Debra & Kijewski-Correa, Tracy. (2018). Coastal homeowners in a changing climate. Climatic Change. 152. 259-274.									
Baron, Nina & Kjerulf Petersen, Lars. (2015). Climate change or variable weather: rethinking Danish homeowners' perceptions of floods and climate. Regional Environmental Change. 15. 1145-1155.									
Kazmierczak, A., & Bichard, E. (2010). Investigating Homeowners' Interest in Property-Level Flood Protection. International Journal of Disaster Resilience in the Built Environment. 1. 157-172.									
Cornes, Isabel & Cook, Brian. (2018). Localising climate change: heatwave responses in urban households. Disaster Prevention and Management: An International Journal. 27. 159.									
Raymond, Christopher & Lechner, Alex & Lockwood, Michael & Carter, Oberon & Harris, Rebecca & Gilfedder, Louise. (2015). Private land manager capacity to conserve threatened									

Reference	Relevance to research questions				Relevant Target Groups				
	1	2	3	4	Households	Small businesses	Communities	Land Managers	Large Businesses
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Whitmarsh, Lorraine. (2008). Are flood victims more concerned about climate change than other people? The role of direct experience in risk perception and behavioral response. Journal of Risk Research. 11. 351-374.		■					■		
Twyman, Chasca & Adger, W. & Thomas, David. (2010). Evaluating Successful Livelihood Adaptation to Climate Variability and Change in Southern Africa. Ecology and Society. 15. 27.		■					■	■	
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Connon, ILC. (2017) Extreme weather, complex spaces and diverse rural places: An intra-community scale analysis of responses to storm events in rural Scotland, UK. Journal of Rural Studies. 54, 111-125.		■					■		
Harvatt, Joanne & Petts, Judith & Chilvers, Jason. (2011). Understanding householder responses to natural hazards: Flooding and sea-level rise comparisons. Journal of Risk Research. 14. 63-83.	■	■		■	■			■	
Grothmann, Torsten & Reusswig, Fritz. (2006). People at Risk of Flooding: Why Some Residents Take Precautionary Action While Others Do Not. Natural Hazards. 38. 101-120.		■			■			■	
Wedawatta, Gayan & Ingirige, Bingunath. (2012). Resilience and adaptation of small and medium-sized enterprises to flood risk. Disaster Prevention and Management: An International Journal. 21. 474-488.	■			■		■			

Reference	Relevance to research questions				Relevant Target Groups				
	1	2	3	4	Households	Small businesses	Communities	Land Managers	Large Businesses
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Reference	Relevance to research questions				Relevant Target Groups				
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Reference	Relevance to research questions				Relevant Target Groups				
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Reference	Relevance to research questions				Relevant Target Groups				
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Reference	Relevance to research questions				Relevant Target Groups				
	1	2	3	4	Households	Small businesses	Communities	Land Managers	Large Businesses
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Appendix B Literature Review Findings

B.1 Behaviours

Research question 1: *What behaviours do different groups adopt in anticipation of a chronic or acute climate event, or when affected by a climate event? Do the behaviours vary by geographic region and/or land use type?*

Understanding typologies of adaptation behaviour

Figure B 1: Biagini et al. (2014) adaptation typologies.

Biagini et al. (2014) adaptation typologies.

1. Capacity-building
2. Management and planning
3. Practise and behaviour
4. Policy
5. Information
6. Physical infrastructure
7. Warning or observing systems
8. Green infrastructure
9. Financing
10. Technology

The literature review provided insight into the current behavioural practices that people and organisations adopt in preparation or response to climate risk. Broadly, adaptation behaviours are divided into two time-dependent categories - proactive and reactive - as well as two resource-dependent categories – 'hard' and 'soft' adaptation (where 'hard' adaptations typically refer to physical alterations or investments, whereas 'soft' adaptations refer more to capacity-building activities such as developing an evacuation plan). Smit et al. (2000) developed the first systematic review of adaptation behaviours typologies, noting that behaviours typically can be typed in at least one of five main areas: 'timing relative to stimulus (anticipatory, concurrent, reactive), intent (autonomous, planned), spatial scope (local, regional, national), form (e.g. technological, behavioural, financial, institutional), and degree of necessary change (incremental, [transitional], transformational)'. This provides a grounding orientation around the often unconscious aims of adaptation.

Biagini et al. (2014) expands on Smit et al. by identifying 158 adaptation activities (including actions taken by supra-national entities) and categorizing them into ten adaptation typologies, listed in Figure B.1. These typologies aid in understanding the method of adaptation, where the typology defined by Wamsler and Brink (outlined in Section 2) describes the intended effect of the adaptation and its impact on risk.

Evidence of event-specific behaviours.

Different climate events obviously require different responses and, furthermore, elicit different reactions from target groups depending on their nature. Resilience literature broadly distinguishes chronic and acute climate hazards, where chronic hazards include slow-moving occurrences such as sea-level rise and average temperature increase, and acute hazards include events like fluvial flooding and wildfire. The geographic boundaries of these events also impact the types of behaviours that are taken in advance or in response. Finally, the perception of the event and its causes can also impact people's behaviours.

Generally, extreme cold and heat events elicit coping responses (Porter, Dessai, and Tompkins 2014). This is largely due to the widespread nature of these hazards and hazard avoidance is difficult – one cannot evacuate heatwave conditions in the same way one can evacuate a flood-risk area because they tend to be regional (e.g. a household could potentially stay with friends and family outside of a flooded area, whereas its more likely that friends and family would also be impacted by a heatwave). However, it should be noted that long-term migration out of areas of changing climate and extreme heat is a historical pattern. Zografos et al. (2016) identify that local level response to heatwave almost exclusively involves short-term coping behaviour. Similarly, Wolf et al. (2010) identify means of responding to heatwaves in London and Norwich, evidencing coping responses as the primary method of response.

In the UK, autonomous adaptation to flooding includes more vulnerability reduction and preparedness for response mechanisms, in part because it has historically been a common occurrence and is arguably the most well-publicised climate impact in the UK. Moreover, flood risk zones are clearly defined the UK, although at present there is a lack of integration of measures to build back better after an event occurs.

However, the literature indicates that target groups are more likely to act in response to fluvial and pluvial flooding than to coastal flooding associated with sea level rise. Target groups typically took fewer actions to address creeping hazards like sea level rise and coastal erosion, largely because respondents either did not feel immediately threatened or because – overall – these hazards created a detachment response in target groups (Thomas et al. 2015). Typically, property-owners experiencing coastal erosion feel and often are more dependent

on public sea defence schemes, whereas those at risk of fluvial and pluvial flooding have more agency to improve the resilience of their property and their behaviours.

Current knowledge of non-governmental autonomous adaptation in the UK

The literature review identified upwards of 50 behaviours relevant in the UK. A list of these behaviours can be found in Appendix A. Defra conducted a 2013 study focusing on local, household, and organisational contributions to national adaptation (Evans et al. 2013). The study identified behaviour adopted in response to heatwaves, coldwaves, water stress and droughts, and flooding, detailing both indicative costs of actions, potential for uptake, and the importance to the UK's resilience. This study noted that their modelling indicated an unlikely uptake of adaptation actions under future conditions without state intervention. This was especially true for heatwaves and coldwaves, both of which had associated uncertainty to the point where the study could not undertake a quantitative assessment. Flood resilience measures were estimated to cost between £2.5 to 3.7 billion for all households for which they would be economically useful (Evans et al., 2013, p. 47).

For organisations, the Defra PREPARE study (Evans et al. 2013) noted that 38% of interview organisations were taking adaptation action, a 12% increase from 2009/10. Moreover, 15% of these noted they were taking 'extensive adaptation actions' (p. ii). An interesting finding was that organisations indicated plans to adapt to flooding from rain and snow, likely because these were the events with which most organisations had recent experience. The factor of direct past experience as a motivator for autonomous adaptation will be discussed further in Section 5.3. Of note, smaller businesses noted that they found climate change to be less relevant to them, although lack of financial resources for adaptation was noted as a potential constraint (Evans et al. 2013).

Porter, Dessai, & Tompkins (2014) developed the most recent systematic review of autonomous adaptation in the UK. This paper identified behaviours that were coping responses, adaptation to current risks, or adapting to potential risks. The authors concluded that autonomous adaptation is already occurring in the UK, but adaptations are typically short-term and incremental. Transformational change and measures focusing on vulnerability reduction or hazard avoidance are unlikely to occur autonomously without state support.

Agricultural land managers are more likely to proactively manage climate risk because they are more sensitive to variations in climate and weather. As a result, estate managers are also increasingly integrating climate risk into business resilience strategies to proactively adapt to climate change. Overall, the literature indicates that organisational autonomous adaptation tends to be more proactive, largely due to the wider range of skills, capital, and understanding of operational risk posed by climate hazards.

A prevalent theme to note that came up in several separate studies was the tendency of elderly populations to exhibit optimism bias (see Section 0) in response to heatwaves (Wolf et al. 2010; Singh & Ryvola, 2018). Wolf et al. identify that social capital actually has the ability to decrease the likelihood of elderly populations undertaking autonomous adaptation to heatwaves because strong social networks with each other reinforces the narrative that they are not at risk of heatwaves and/or can cope with them when they do occur.

B.2 How behaviours influence risk

Research question 2: *How do these behaviours affect (positively or negatively) the impact of different types of climate event? How does the size of the effect vary depending on the magnitude and frequency of the event?*

Positive or neutral impact on risk reduction

The literature review found few studies that focused on the degree to which specific adaptation behaviours influenced risk or had the potential to change the impact of the climate event, either positively or negatively. The literature instead focused on the factors that prompt proactive or reactive behaviour change, with the underlying implication that *any* adaptation action has a positive or neutral effect on the risk, but the authors found no studies that explicitly quantified or qualitatively described the magnitude of this impact.

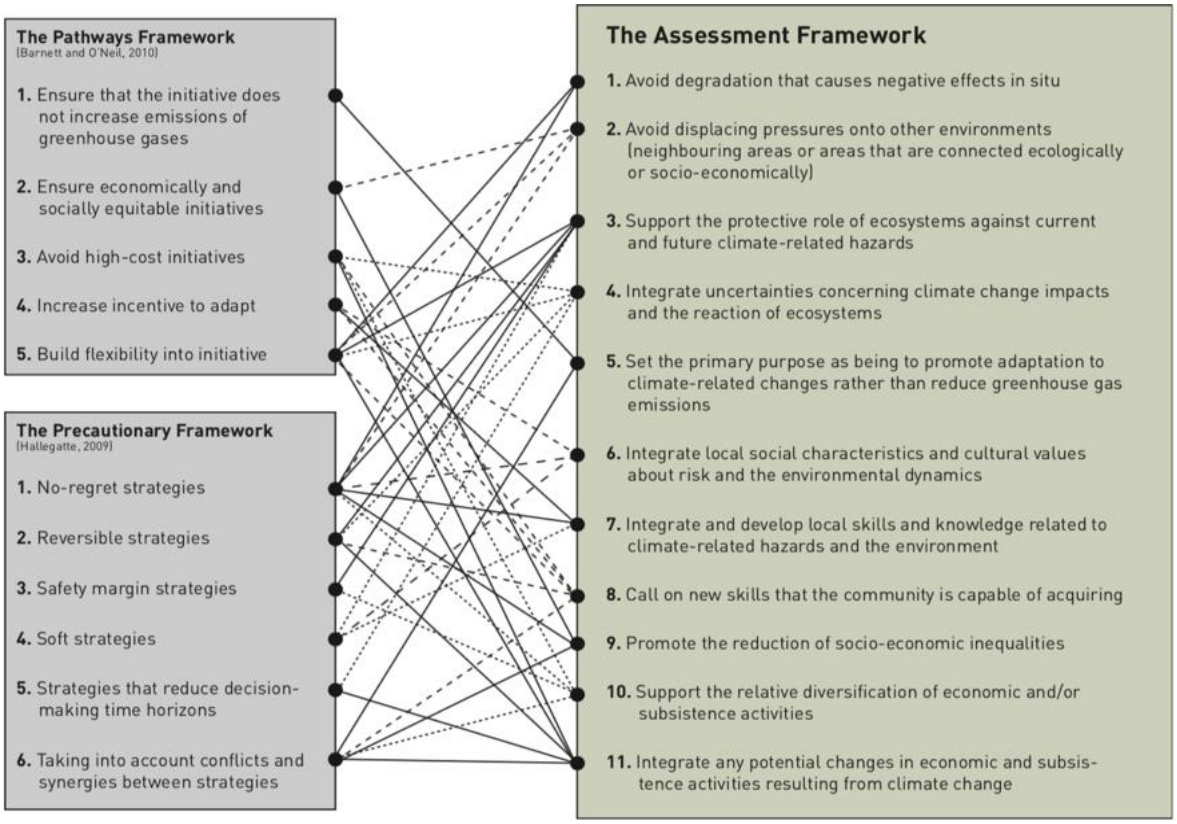
Despite this, the various typologies of behaviour identified in B.1 provide a framework around which to broadly assess the influence of certain types of typology on risk.

Maladaptation

A crucial point to note is that adaptation meausres are not inherently positive, and indeed carry the risk for maladaptation, which describe adaptation behaviours that aim to reduce vulnerability but, in practice, increase the vulnerability of the individual, collective, or organisation undertaking that behaviour, or on an external third party (see Figure B2) .

Examples of maladaptive actions include an individual altering drainage around their property, but inadvertently directing that drainage towards another property, thereby increasing the exposure of another household. Similarly, maladaptation considers trade-offs between climate change adaptation and mitigation; for example, installing AC is adaptive on an individual or business level, but maladaptive in consideration of broader climate change mitigation because of its electricity consumption. A major consideration is that some adaptation measures that are appropriate today may decrease in effectiveness or become increasingly maladaptive in future.

Figure B 2: Frameworks to understand what constitutes maladaptation.



Source: *Magnan, 2014.*

B.3 Factors influencing behaviour (behavioural determinants)

Research question: *What factors have been shown to/are likely to influence behaviours related to climate events? (e.g. past experience (direct and indirect), social acceptability, demographics, knowledge, environmental factors, heuristics, policy landscape)*

Behavioural psychology and climate change adaptation

Humans are not rational actors. As with all decision-making processes, autonomous adaptation is mediated by a number of factors, including cognitive processing, sociocultural influences, and learned behaviour from past experiences (Gifford, 2011) (see Table B.1). Of specific note, cognitive biases and heuristics influence adaptation behaviour because they inform decision making based on automatic judgments based on mental shortcuts and intuition. Heuristics are tremendously valuable, as they enable humans to navigate the majority of daily interactions effectively without requiring active reflection. However, as heuristics are simplifying assumptions they may not be effective for dealing with complicated, nuanced judgements. Reliance on heuristics in such scenarios can therefore lead to poor decision-making or a false sense of confidence. This is particularly relevant in the context of climate change, which require decision-makers to confront the possibility of a future that does not align with the past in which one's heuristics were formed.

Kahneman and Tversky (1979) have distinguished between instinctive and cognitive reasoning by describing two modes of thought: System 1 and System 2. System 1 is defined by emotional, default, and quick processing (including use of heuristics) whereas System 2 is slower, deliberative, and reflective. In periods of stress, System 1 is the typical decision-making default. Thus, reactive adaptation actions (and, indeed, many proactive adaptations) are often the result of System 1 thinking and are, as a result, not necessarily the most effective and can be maladaptive.

Understanding the influence of biases on decision-making is crucial to understanding autonomous adaptation at present and under future climate conditions. It similarly informs the underlying factors identified in the literature review which are discussed in Section Section 5.3. A study by the Red Cross Climate Centre (Singh & Ryvola, 2018) identifies five common biases that occur within climate risk management:

- Planning fallacy
- Commitment heuristic
- Availability heuristic
- Optimism bias
- Single action bias.

Additional relevant biases have been added to Table B 1. These biases aid in understanding the observed patterns of autonomous adaptation.

Table B 1: Relevant biases

Bias or heuristic	Definition
The planning fallacy	Belief that current plans will proceed as planned; assumption that the best case scenario will occur. In climate adaptation, this manifests in plans that assume the worst case scenario will not occur (e.g. a 1 in 700 year drought), or at least not occur imminently, providing people a false sense of security.
The commitment heuristic	The commitment heuristic is analogous to the sunk cost fallacy, in which continued investment in an action is pursued even if new evidence suggests that action is not the most effective course of action.
The availability heuristic	Refers to a tendency to base conclusions about the occurrence of events on memories that come most easily to mind. This means rare yet memorable events can seem more frequent. For some people, a vivid experience of the February 2017 cold snap (e.g. becoming stranded on a motorway) may cause them to overestimate the frequency of such weather events. This could be exacerbated by the colloquial name afforded this event – The Beast from the East – which adds to the ease with which the event may be recalled.
The optimism bias	The tendency to believe they are at a lower risk of experiencing an event than others.
The single action bias	The assumption that taking one action, even if it is not the most effective or, indeed, effective at all, significantly reduces vulnerability. In the context of climate

	adaptation, taking any action reduces people's negative affect brought on by the threat of an event.
Loss aversion	Based on 'prospect theory' (Kahneman & Tversky, 1979), it has been found in a range of behavioural studies that when outcome is uncertain, most people are more motivated by avoidance of loss than achievement of a gain. In a climate adaptation context, this can play out in several ways: - A land manager may forego the implementation of sustainable drainage systems in response to floodrisk because of the upfront capital costs, even though the system will pay for itself in the long-term via avoided damages. - A business owner who is financially affected by an extreme event may be more inclined to enter into a risky venture in future in order to recoup losses.

Source: Adapted from Singh & Ryvola, 2018.

Demographic factors

The literature identified several common demographic factors cited as driving or inhibiting climate adaptation, while also evidencing a series of underlying motivators that are more closely linked to heuristics and biases in decision-making.

The common socio-demographic factors cited were age, income, gender, political orientation and value orientation. Van der Linden (2015) included these factors within a full climate change risk perception model (CCRPM), which found that these factors accounted for 70% of the variance in climate risk perception.

On average, studies found that age was a predictor of adaptive behaviour, with those roughly between 30 and 60 more likely to autonomously adapt (Rapaport et al. 2018). This is due to a combination of factors, including place attachment and potential property ownership. Additionally, gender is a predictor of autonomous adaptation, with women being more likely to undertake risk-reducing behaviour (van der Linden, 2015; Grothmann & Reusswig, 2006; Koerth, Vafeidis, & Hinkel, 2017; Brink & Wamsler, 2018). While several studies indicated that income itself is not a predictor of climate adaptation, it was a barrier in that households or businesses that would like to adapt are unable to due to financial constraints (Kent et al. 2013).

However, studies indicated that these factors had a lesser influence than more affective factors like perceived self-efficacy or negative affect in response to climate risk. Van der Linden (2015) noted that, of the set of socio-demographic factors considered in the study, income and age had no significant association with climate risk perception. Other studies have also supported these findings (Akompab et al. 2013).

Affective factors

While demographic factors are more likely to enable certain adaptive behaviours (e.g. those with higher levels of educational attainment may have better ease of access to information), affective factors are the underlying drivers of whether the target group decides to act or not. Following the review, the authors narrowed down these affective factors to perceived response-efficacy, perceived self-efficacy, ownership, negative affect, direct past experience, and social norms. Table B 2 outlines factors influencing behaviour. These factors typically encourage risk-reducing action, but can also act to reinforce inaction or maladaptation (Singh & Ryvola, 2018).

For perceived response efficacy, individuals were more likely to undertake adaptation actions if they thought those actions would be effective, regardless of if this was factually accurate (Bryan et al. 2018; Demuth et al. 2016; Fox-Rogers et al. 2016). Within perceived response efficacy, long-term cost recovery was a factor that drove proactive adaptation behaviours when compared to actions that involved coping during crisis or preparedness for recovering. For example, Bryan et al. (2018) conducted a study of drought perception and potential action in Exeter. The study found that, while drought was perceived as low likelihood, participants were willing to undertake actions that were viewed to be low-cost yet effective. Moreover, individuals' perceived self-efficacy mediated adaptation action; if they thought they had the skills and capability to undertake the action, then they were more likely to do it (Fox-Rogers et al. 2016). That is, these adaptation actions were those that the individual or community felt were doable according to that individual or communities' standard and the resources to which they had access (Koerth et al. 2017; Samaddar et al. 2014; Thompson et al. 2017).

Across all study groups, ownership was an important factor in whether or not adaptation actions were undertaken. Specifically, homeowners and landowners were much more likely to undertake adaptation actions to pre-empt damage to their own property (Elrick-Barr, 2015; Wedawatta, Ingirige & Proverbs, 2011). This was often reinforced by the length of tenure in a community or piece of property, indicating that attachment to place

influenced behaviours (Poussin, 2014). For example, Shao et al. (2017) noted home ownership as a key driver in the voluntary purchase of flood insurance. However, Thomas et al. 2015 noted that place attachment with regard to coastal erosion can potentially decrease adaptive action as these target groups may actually have to relocate. In these cases, there was a mental distancing for potential risk.

In some cases, high levels of ownership and control in communities was linked to distrust of official information or assistance. Renters and transient communities, such as young professionals and those experiencing housing instability, may be less likely to implement proactive adaptation responses because they either do not have the authority to do so on rental property or will not reap the longer term benefit of making capital improvements. This in part explains why age influences autonomous adaptation – rates of property ownership increase with age, meaning young professions are, on average, less likely to have the ability or desire to make significant vulnerability reduction interventions on their property. Farmers with larger landholdings were also more likely to undertake adaptation actions (Singh, 2016).

Table B 2: Factors influencing behaviour – households/communities

Factor	Description	References
Demographic	Age (30 – 60) is a predictor of undertaking autonomous adaptation.	Van der Linden, 2015; Rapaport et al. 2018; Kent et al. 2013
Perceived response efficacy	The belief that the behaviour will be effective.	Singh, Dorward & Osbahr, 2016; Gifford, 2011; Brody, Zahran, Vedlitz & Grover, 2008; Fox-Rogers, Devitt, O'Neill, Brereton & Clinch, 2016; Samaddar, Chatterjee, Misra, & Tatano, 2014; Elrick-Barr, 2015; Richert; Erdlenbruch & Figuieres, 2013.
Perceived self-efficacy	The belief that one has the capability to undertake a behaviour.	Speakman, 2017; Koerth, Vafeidis & Hinkel, 2017; Bonaiuto et al. 2016; Fox-Rogers et al. 2016; Singh, Dorward & Osbahr, 2016; Elrick-Barr, 2015; Richert, Erdlenbruch & Figuieres, 2014; Samaddar, 2014; Gifford, 2011; Gifford & Corneuac, 2011; Harvatt, Petts & Chilvers, 2010; Grothmann & Reusswig, 2006.
Ownership/ place attachment	Ownership of land or property drives adaptation behaviour.	Koerth, Vafeidis & Hinkel, 2017; Masud et al. 2017; Shao et al. 2017; Demski, 2016; Singh, Dorward & Osbahr, 2016; Elrick-Barr, 2015; Osberghaus, 2015; Kazmierczak & Bichard, 2010; Brondizio &. Moran, 2008.
Direct past experience	Previous experience of a climate event impacts negative affect and learning, driving future adaptive behaviour.	Brink & Wamsler, 2018; Zhai, 2018; Adaptation Scotland, 2017; Frondel, Simora & Sommer, 2017; Speakerman, 2017; Averchenkova, 2016; Demski et al. 2016; Niles & Mueller, 2016; Dai et al. 2015; Osberghaus, 2015; Phadke, Manning & Burlager, 2015; Porter, Dessai,& Tompkins, 2014; Poussin, Botzen & Aerts, 2014; Reser, Bradley & Ellul, 2014; van der Linden, 2014; Agrawala, 2011; Koerth, 2013; Bubeck, Botzen & Aerts, 2012; Linnenluecke, Griffith & Winn, 2012; Spence et al. 2011. Hornsey, et al., 2015;
Social norms/ capital	The norms of the local context and the actions of neighbours; social ties and links; sense of community.	Babutsidze & Chai, 2018; Brink & Wamsler, 2018; Rapaport et al. 2018; Bamberg, 2017; Koerth, Vafeidis & Hinkel, 2017; Li et al. 2017; Lo & Chan, 2017; Smith, 2017; Babcicky & Seebauer, 2016; De Dominicis,et al. 2015; Osberghaus, 2015; Thomas et al, 2015; Taylor, Dessai & Bruine de Bruin, 2014; Gifford, 2011; Osbahr, 2010; Stein, Dueñas-Osorio, & Subramanian, 2010; Wolf et al. 2010.

Previous and recent experience of a climate event can make people more likely to autonomously adapt. Past experience may provide people with a concrete understanding of the consequences and associated negative emotions (Sharma and Patt, 2011). Additionally, it provided them with learning opportunities that could mediate perceived response efficacy, where they are better able to understand what adaptation measures will be the most effective. Finally, it impacted negative affect because they were better able to conceptualise negative impacts and, thus, negative affect was based on tangible emotional experience.

Negative affect can be informed by past experience but can also drive those without direct experience of hazards to proactively adapt (Demuth et al. 2016). Negative affect may include feelings of worry, hazard intrusiveness, and perceived dread. For example, if a land manager had significant concern regarding a local stream flooding their fields during a heavy rain event and damaging crops, they could be more likely to adapt to reduce the risk of occurrence. Bubeck et al (2012) noted a small positive relationship between negative emotions such as fear or worry and the adoption of flood mitigation measures.

Finally, the adaptation actions of others had bearing on whether individuals, communities, and businesses undertook adaptation actions themselves, and this was particularly reinforced when individuals and communities had high social capital [knowing one can depend neighbours, having many social networks for information and support; trusting those in one's community). However, Arunrat et al. (2016) and Wolf et al. (2010) noted that, in some cases, social capital could create perverse incentives where, much like the levee effect[1], households and communities felt less necessity to adapt to potential hazards because of their perceived social capital (Terpstra, 2011). Regarding social capital, it is important to highlight that higher social capital and community resilience was associated with higher education levels, martial statues, and age.

Factors influencing business decision-making

Businesses have unique factors driving adaptation actions (see Access to information and the necessary resources to implement adaptation action were also noted as key factors to drive adaptation behaviour within businesses. This includes having in-house expertise to evaluate adaptation options (Averchenkova et al. 2016; Hertin et al. 2003) and to support in understanding costs and benefits of different adaptation actions, the financial implications of those actions, and how to integrate them into business processes. Moreover, businesses that have strong relationships with actors who drive, implement, and provide input into adaptation actions, perceptions, and policies can support companies in undertaking adaptive action (Seafish to the UK Government, 2016; Agrawala et al. 2011; Morton et al, 2011; Hertin et al. 2003).

For one, company size can positively or negatively influence behaviour. Some studies indicated that adaptation can be more difficult for larger companies because they are less mobile (Surminski et al. 2017); however, they may also have access to more resources, and with size may be able to more easily absorb impacts, and enter into strategic collaborative arrangements with suppliers (Welsh Government, 2019; Surminski et al. 2018; Agrawala et al. 2011). Adaptation behaviour is also dependent on the sector in which the company operates. Certain sectors may possess greater flexibility in production and/or operations, allowing greater adaptability in the event of disruption. However, others organisations producing highly specialised products may have a very specific supply chain, making it more difficult to put contingencies in place (Agrawala et al. 2011). Additionally, businesses with a strong public-facing customer base such as retail are more attuned to reputational impacts, which could be a contributing factor in a decision to undertake behaviours to manage perceived risks to reputation (Surminski et al. 2018). Studies indicated that companies may undertake adaptive action in order to demonstrate preparedness and achieve recognition, with the underlying intention to increase profit, enhance value of their assets or services, and win and keep businesses. Additionally, this mentality can allow companies to more readily invest in opportunities that climate change may present to them (Agrawala et al. 2011).

Regulatory frameworks, standards and reporting requirements have been noted in the literature as a major driver of corporate decision-making around adaptation. Transparent and consistent regulatory processes reduce uncertainty for firms in decision-making, thereby creating a more stable environment for adaptation investment (Surminski et al. 2018; Hertin et al. 2003; IEMA, 2013; Linnenluecke, Griffith &. Winn, 2012). Regulatory frameworks such as building codes largely dictate the adaptation behaviour that certain firms must take or implement in their work (Morton et al. 2011; Surminski et al. 2018). Reporting requirements (Surminski et al. 2018) and voluntary codes of practice (Seafish to the UK Government, 2016) also encourage adaptation behaviour because both have reputational implications, and over time may become viewed as industry norms.

[1] The levee effect denotes feelings of false safety that result from infrastructure or other governmental interventions. The name comes from the perception that having levees in a community reduces flood risk to nearly zero. As a result, no further adaptation is taken.

Similarly, stakeholder expectations and values impact businesses' propensity to undertake adaptive behaviours (Haque & Islam, 2015; IEMA, 2013; Linnenluecke, Griffith &. Winn, 2012; Morton et al. 2011).

Of specific relevance to public companies is the Task Force on Climate-related Financial Disclosures (TCFD), which began as a voluntary disclosure mechanism but has gathered traction, leading to directives around climate risk disclosure by financial regulators in several countries, including the UK. TCFD gives regard to both physical risks (e.g. flood exposure of property portfolio) and transition risks, the latter referring to the effect of a transition to a low carbon economy on an organisation's value chain (e.g. potential devaluation of fossil fuel assets; shifts in preferences among more climate-savvy consumers affecting demand for certain products). Transition risk is notoriously hard to evaluate, as the consequences of a low carbon transition on factors such as energy prices are uncertain.

Over 340 investors who manage over £34 million in assets are now asking companies to report under TCFD. Businesses are increasingly following TCFD's recommendations to disclose information on climate-related risks and opportunities, with reputational benefits and investor pressures as the top two reasons firms cite for disclosing. However, TCFD's most recent status update report acknowledges that there needs to be a better understanding on how disclosing climate-related financial information is changing corporate strategies on adaptation, and how investors are using the disclosed information to inform their decisions (Task Force on Climate-related financial disclosures, 2019).

The Bank of England's Prudential Regulation Authority published a statement in April 2019 noting that it expects firms to undertake scenario planning to identify climate risks, and "to engage with wider initiatives on climate-related financial disclosures and to take into account the benefits of disclosures that are comparable across firms" (Prudential Regulation Authority, 2019). It also suggests that firms should expect that disclosure will be mandated in the near future. This is potentially critical as, contrary to mitigation, companies are often reluctant to share information on adaptation. Not only can adaptation measures and its benefits be more difficult to communicate, the information could be a source of competitive advantage or disadvantage (Task Force on Climate-related financial disclosures, 2019; Agrawala et al., 2011).

Access to information and the necessary resources to implement adaptation action were also noted as key factors to drive adaptation behaviour within businesses. This includes having in-house expertise to evaluate adaptation options (Averchenkova et al. 2016; Hertin et al. 2003) and to support in understanding costs and benefits of different adaptation actions, the financial implications of those actions, and how to integrate them into business processes. Moreover, businesses that have strong relationships with actors who drive, implement, and provide input into adaptation actions, perceptions, and policies can support companies in undertaking adaptive action (Seafish to the UK Government, 2016; Agrawala et al. 2011; Morton et al, 2011; Hertin et al. 2003).

Table B3: Overview of factors driving business adaptation behaviour

Factor	Observations	References
Company size	Most studies suggested larger companies have the benefit of scale and resources, though one study suggested their size makes them slower to respond.	Surminski,et al.2018; Welsh Government, 2018; Seafish to the UK Government, 2016; Agrawala et al. 2011.
Sector in which company operates	Reliance on fixed or natural assets requires adaptation that accounts for climate risks far into the future and build in early alternatives and strategies to avoid 'lock in' and over-reliance on a certain asset. Some sectors are seizing early adaptation opportunities, such as tourism and insurance.	Surminski et al. 2017; Acclimatise, 2016; Agrawala et al. 2011.
Location	Climate risks are partly determined by local hazards and exposure to them, and those businesses located in risk prone areas are more likely to adapt, largely out of necessity.	Surminski et al. 2017; Agrawala et al. 2011; Linnenluecke, Griffith &. Winn, 2012.
Experience with climate impacts	Although experience with extreme weather event raises awareness of the risk, this alone is not always sufficient to encourage action.	Adaptation Scotland, 2017; Averchenkova et al. 2016; Agrawala et al. 2011; IEMA,

Factor	Observations	References
	When financial losses were incurred adaptation was more frequently prioritised.	2013; Linnenluecke, Griffith &. Winn, 2012.
Policy and regulatory frameworks	As studies indicated that businesses often view climate adaptation as a matter of public policy-making and not of corporate decision-making, there is an important role to play for policy- and regulatory frameworks. Evidence was less conclusive about voluntary requirements, as communicating about adaptation is often less appealing and straightforward than mitigation (PR incentive).	Task Force on Climate-related financial disclosures, 2019; Surminski, 2017; Averchenkova, 2016; Seafish to the UK Government, 2016; Agrawala, 2011; Linnenluecke, Griffith &. Winn, 2012; Berkhout; Hertin & Gann, 2006; Hertin et al. 2003.
Access to knowledge	Strong knowledge on costs and benefits as well as a detailed understanding of the risk triggers adaptative behaviour. Strong relationships with stakeholders driving and implementing adaptation increase knowledge.	Task Force on Climate-related financial disclosures, 2019; Surminski, 2017; Averchenkova, 2016; Seafish to the UK Government, 2016; Agrawala,, 2011; Morton et al. 2010; Hertin et al. 2003.
Stakeholder and shareholder expectations	Public pressure can influence corporate behaviour	Acclimatise, 2016; Haque & Islam, 2015; IEMA, 2014; Linnenluecke, Griffith &. Winn, 2012; Morton et al. 2010.
Risk management processes	As climate risks have a different nature to other risks, integrating adaptation into existing risk management processes might not suffice.	Hertin et al. 2003
Competitive advantage	Obtaining a competitive advantage is a key driver for corporate decision-making. Where opportunities were identified to gain a better market position and potentially increase profits, businesses were more eager to adapt.	Acclimatise, 2016; Averchenkova, 2016; IEMA, 2014; Agrawala, 2011; Morton et al. 2010; Hedger; Connell & Bramwell, 2006.
Company culture	Belief that climate change is an ethical concern and a matter for public policy-making rather than businesses decision-making [16]	Averchenkova, 2016; IPPR Institute for Public Policy Research, 2016; IEMA, 2013; Morton et al. 2010.

B.4 Incentivising risk-reducing behaviours

The body of literature dedicated to understanding how best to incentivise risk-reducing behaviours has grown significantly in the past ten years. Businesses, policymakers, and organisations have worked to integrate behavioural science into climate change communication and policy mechanisms. For example, USAID (2019) has recently developed a guiding framework for encouraging adaptation using behavioural science principles, indicating that this field will become more nuanced as the principles are better understood and integrated into climate change adaptation planning and policy.

The role of fiscal and other incentives

A major takeaway from the literature and initial interviews is that anticipatory adaptation measures that require significant upfront capital are unlikely to occur without provision of material public or private sector support. These include grants or subsidies for structural adjustments.

Many of flood-related proactive adaptation behaviours were linked to insurance premium reductions, where households and businesses who undertook specified adaptations would have a decreased premium because they had attempted to decrease their risk of damage (Shao et al. 2017; Brody et al. 2016; Müller-Fürstenberger & Schumacher, 2015; Bichard & Kazmierczak, 2012; Wedawatta, Ingirige & Proverbs, 2011; Harvatt, Petts &

Chilvers, 2010; van den Bergh, 2009). However, insurance transparency was one factor that dictated whether abatement activities were or were not undertaken (Müller-Fürstenberger & Schumacher, 2015). Additionally, one study indicated that women had a lower willingness to pay (WTP) for flood insurance than men (van den Bergh, 2009), reflecting the theme of women more readily undertaking adaptation behaviours than men. It has been noted, however, that private insurance mechanisms are better supplemented by government mechanisms like 'subsidizing insurance premiums, managing insurance schemes, acting as a monopolistic insurance provider, or simply providing ad-hoc post-disaster aid (Institute for Government, no date). Another insurance-related barrier to consider is that there is evidence that flood mapping in some countries (for example, the US) may significantly underestimate exposure, which has implications for national insurance programmes. Notably, studies indicate that voluntary flood insurance coverage that is outside of designated flooding zones is skewed to those with higher education (Shao et al. 2017).

Moreover, existence of fiscal incentives did not necessarily spark greater uptake. This relates to the importance of getting climate and risk communication right. Broadly, communication that is better-targeted is one means of spurring behaviour change (Brink & Wamsler, 2018; Arunrat et al. 2017; Salama & Aboukoura, 2017; Doell, 2017; Valdez, Peterson & Stevenson, 2017; Huang, Lindell. & Prater, 2016; Thomas et al, 2015; Taylor, Dessai, & Bruine de Bruin, 2014; Dominicis, 2014; Poussin, Botzen & Aerts, 2014; Bichard & Kazmierczak, 2012; Grothmann & Reusswig, 2006; Baan & Klijn, 2004). The literature focused on various communication techniques, including framing and using visuals

Communication and framing

Within the realm of communication, framing was highlighted as a driver or deterrent of adaptation action (Di Falco & Sharma, 2018; Chapman et al. 2016; Gifford & Comeau, 2011). Negative framing was associated with feelings of powerlessness and helplessness, decreasing peoples' perception of their or their community's response efficacy (Chu & Yang, 2018; Gifford & Comeau, 2011). An interesting area to further explore is the intersection of negative framing and negative affect. Given that negative framing can reinforce feelings of response inefficacy, is there a way in which climate hazards have been framed that both induce negative affect, one of the factors highlighted in section 2, and response efficacy simultaneously?[2] Benefit framing often made people more receptive to the idea of climate change on the whole (Gifford & Comeau, 2011). Additionally, highlighting emotional attachments like 'objects of care' increased adaptive behaviour or intentions (Wang et al. 2018). Interviewees also cited better responses if the problem was not framed in the context of climate change (excepting the study discussing benefit framing). For example, this could be framing climate events as a public health threat.

Visuals were also highlighted as a means to increase adaptive behaviour. One study noted that images of climate 'solutions' increased positive feelings about climate change and adaptation (Chapman et al. 2016). This could potentially link to feelings of response efficacy and perceived self-efficacy if households and businesses can see examples of adaptation which similar cohorts have implemented. Another study noted that cartograms helped to facilitate discussion on climate risk (Doell, 2017).

Finally, climate services are a burgeoning means to communicate climate information and solutions more directly to individuals, communities, businesses, and land managers (Dayamba et al. 2018; Vaughan et al. 2017; James, 2015). One such intervention, which was also noted as an adaptation behaviour (Harvatt, Petts & Chilvers, 2010) was the Automated Voice Messaging System – however, households must sign up for this service, so it would first be necessary for one to know about the service. Businesses can sign up for the Targeted Flood Warning Service. One study noted that climate services and similar knowledge should consider local knowledge when communicating information (Koerth, Vafeidis & Hinkel, 2017). Given the continued proliferation of smart phones and social networking, climate services are an increasing area of opportunity for communicating not only risk and hazard information but also better disseminating information about solutions. Moreover, they may be opportunities to share knowledge among groups who have undertaken various types of autonomous adaptation, although no study focused on this specifically.

Behaviour change frameworks

A range of theoretical approaches exist to conceptualise and drive adoption of desired behaviours; these models draw on many of the behavioural determinants described in Sections 2 and 5.4 Two of the most relevant frameworks for this study are described below; these are revisited in Section 5.4 when discussing potential

[2] To be sure, negative affect may have implications for mental wellbeing and therefore any intervention focusing on negative affect must carefully consider this relationship.

approaches that can be adopted in the UK to encourage those behaviours found to have beneficial effects on risk.

Theory of planned behaviour

Modified from the theory of reasoned action (Fishbein and Ajzen, 1975), Ajzen coined the theory of planned behaviour (TPB) in 1985 as a mechanism for explaining and predicting an individual's intention to engage in a behaviour at a specific time and place. Applicable only to behaviours over which people are able to exert self-control, its central tenet is 'behavioural intention', which captures the suite of motivational factors influencing one's intention to undertake a given behaviour. TPB assumes that the more favourable the attitude toward the behaviour and the subjective norm, and the higher the perceived level of control over the behaviour, the more likely it is to be adopted.

The key elements of TPB are as follows:

- **Attitude toward behaviour:** The extent to which the behaviour is viewed as favourable.
- **Subjective norms:** Beliefs about whether significant others figures (e.g. friends, family, broader society) would expect the behaviour to be performed.
- **Perceived behavioural control:** An individual's perception of the ease or difficulty of performing the particular behaviour. This is influenced by perceived power, which refers to the perceived presence of factors that could facilitate one's ability to undertake the behaviour. These can be internal factors, such as availability of knowledge, skills and emotions, and external factors, such as opportunities and dependence on others.

TPB has been used chiefly in the field of health to explain and predict behaviour such as substance abuse, breastfeeding and adherence to treatment programmes. Criticisms levelled at the model include that it does account neither for past experience, nor transient factors such as mood. It also excludes environmental factors (e.g. the setting in which a decision to perform a particular behaviour is made), which can be a particularly relevant omission for decision-making around climate adaptation.

COM-B

Developed by Michie et al. (2011), COM-B is an increasingly popular model for conceptualising and planning behaviour change in the sustainability field. The COM-B model contends that changing behaviour requires a change to one's 'capability' to undertake the behaviour, and/or 'opportunity' and 'motivation' to carry out the behaviour.

The key elements of COM-B are as follows:

- **Physical capability:** Having the physical (not mental) strength, skill, agility or stamina
- **Psychological capability:** Knowledge or psychological acumen (mental capacity or stamina)
- **Physical opportunity:** Related to environmental factors – being physically located in a place that enables the behaviour; having the time or the necessary resources
- **Social opportunity:** Opportunities enabled by social cues and cultural norms
- **Automatic motivation:** Related to 'System 1' thinking – instinctive brain processes such as impulses, inhibitions and application of simplifying heuristics
- **Reflective motivation:** Related to 'System 2' thinking – deliberative and reflective brain processes, such as evaluation of options and plan-making.

Appendix C Thematic Analysis Criteria

Table C 1: The process of thematic analysis

Process	Number	Criteria
Transcription	1	The data have been transcribed to an appropriate level of detail, and the transcripts have been checked against the tapes for 'accuracy'.
Coding	2	Each data item has been given equal attention in the coding process.
	3	Themes have not been generated from a few vivid examples (an anecdotal approach), but instead the coding process has been thorough, inclusive and comprehensive.
	4	All relevant extracts for each theme have been collated.
	5	Themes have been checked against each other and back to the original data set.
	6	Themes are internally coherent, consistent, and distinctive.
Analysis	7	Data have been analysed – interpreted, made sense of – rather than just paraphrased or described.
	8	Analysis and data match each other – the extracts illustrate the analytical claims.
	9	Analysis tells a convincing and well-organised story about the data and topic.
	10	A good balance between analytical narrative and illustrative extracts is provided.
Overall	11	Enough time has been allocated to complete all phases of the analysis adequately, within rushing a phase or giving it a once-over-lightly.
Written report	12	The assumptions about, and specific approach to, thematic analysis are clearly explicated.
	13	There is a good fit between what you claim to do, and what you show you have done – ie, described method and reported analysis are consistent.
	14	The language and concepts used in the report are consistent with the epistemological position of the analysis.
	15	The researcher is positioned as active in the research process; themes do not just 'emerge'

Source: Braun & Clarke, 2006.

Appendix D Iterations of methodology

D.1 Initial literature review (scoping)

An initial review of literature has been necessary to help refine the method. This has not been an in-depth review of evidence around behaviours in response to climate events, but rather has focused on establishing a foundational understanding of:

- The extent to which 'behaviours' is a commonly used construct in the climate adaptation research and how the term should be treated for the purposes of this study.
- Existing examples of where typologies of behaviours or adaptation actions and their impact on risk have been created in order to assist risk assessment processes.
- Factors influencing decision-making and behaviours. This has considered research specifically into decision-making in the context of risk and climate adaptation, as well as more general insights into behavioural factors from sociological and behavioural economics research.
- Examples of past and current approaches to incentivising adaptation behaviours.
- Past severe weather events across all nations of the UK that could form suitable case studies in the next stage of the process. This has included review of publically available Local Climate Impacts Profiles (LCLIPs) previously produced by local authorities. This will be complemented by input from regional stakeholders to form a long-list of possible case study events and locations.

A literature review protocol was developed to guide the early stages of the project. This is now being revised in light of the revised variables agreed in this document, as well as outcomes of practitioner interviews described in Section D.2. It will be attached to this document upon completion.

The updated protocol will set out the terms and operations to be used when searching for literature, the databases and websites to be accessed, and the method for prioritising materials for more detailed analysis. The 'CRAAP' test (evaluating Currency, Relevance, Authority, Accuracy, and Purpose) will be used to evaluate all pieces of grey literature and determine if they are suitable for inclusion in the study.

D.2 Expert panel

An internal team workshop was convened in early November to discuss the research questions set out in the CCC's specification. Subsequent discussions were held with the CCC to better understand its perspective on the questions and understand if any were considered to be of a higher priority. It was advised that assessing the impact of different behaviours on residual impact of events were of highest priority and that arriving at policy recommendations was not a specific aim of this project.

The research questions and a working draft of this Method Document were discussed further with the Expert Panel on 14 December 2018. Members of the Panel are shown in Table D1 below; minutes are provided as Appendix B.

Table D 1: Expert panel members

Name	Organisation
Jamie Clarke	Climate Outreach
Christina Demski	Cardiff University
Gianluca Pescaroli	University College London
Ross Thompson	Public Health England
Sari Kovats	London School of Hygine and Tropical Medicine
Jim Poole	Natural Resources Wales
Alex Nickson	Thames Water
Andrew Tucker	Thames Water

Name	Organisation
Robert Hall	Resilience First
Swenja Surminiski	Grantham Research Institute
Agnes Jung	Public Health England
Josie Bateman	Environment Agency (EA)

D.3 Proposed variables and revised research questions

Based on the literature review work to date, advice from the Expert Panel, and discussions with the CCC project manager, Table D 2 provides suggested revisions to the initial research questions, along with a rationale for the each proposed change.

The CCC's initial scope lists several categories of 'climate impact' (referred to instead below as 'climate events'), target groups and other variables for consideration. However, it has acknowledged it will not be possible to investigate all permutations and combinations of these variables within the resourcing limitations of this study. Following the Expert Panel meeting, a proposed set of revised variables has been developed (Table D 3).

Table D 2: Potential revised research questions

#	Initial research question	Rationale	Revised research question
1	What are the observed behaviours different groups adopt in anticipation of a climate-related impact, or when they experience a climate-related impact?	It was agreed with Expert Panel that framing around anticipating climate 'impacts' is somewhat ambiguous. It may be easier to engage and generate findings around climate hazards/events (e.g. a specific flood or heatwave). Stakeholders can then report how they were impacted by a given event, which will vary.	What observed behaviours do different groups adopt in anticipation of a chronic or acute climate event, or when affected by a climate event? Do the behaviours vary by geographic region and/or land use type?
~~2~~	What are the observed behaviours different groups adopt in anticipation of, or when they experience a climate change opportunity or benefit?	Few stakeholders (perhaps some businesses) are likely to relate to the construct of a 'climate change opportunity or benefit'. No relevant literature has been found to date, and it is noted that the CCRA2 has a considerably smaller focus on opportunities than risks. Based on these factors, it is recommended not to carry forward this question.	Question not carried forward. Broadening of question 1 to focus on 'events' enables opportunities to be captured as an when they are identified.
~~3~~ 2	What factors have been shown to / are likely to influence these behaviours? ○ Do these behaviours vary depending on where people, businesses and communities are located, in terms of both geographical regions (including differences among and within the four UK nations) and for different land types (cities, coastal, rural etc.)? ○ What are the differences in behaviour between those who have experience of a climate-	As opposed to having multiple sub-questions citing specific variables to be considered, it is recommended to rationalise these multiple questions into a clear single question covering the range of possible factors influencing behaviour. Also the first sub-question around spatial variation in behaviour may be more appropriate as part of question 1.	What factors have been shown to/are likely to influence behaviours related to climate events? (e.g. past experience (direct and indirect), social acceptability, demographics, knowledge, environmental factors, heuristics, policy landscape)

#	Initial research question	Rationale	Revised research question
	related impact or opportunity and those who have none? ○ How do perceptions of what is acceptable or tolerable affect behaviour? ○ How do socioeconomic factors such as age, income, physical or mental health such as anxiety, stress or trauma affect behaviour?		
~~4~~ 3	What impact do these behaviours have on the resulting net impact from the event? Do they have positive or negative effects? How much do they reduce or increase the resulting impact? How would the behaviours change the size of the impact in the future? Is the effect always likely to be constant, for example given the different size of potential future impacts under global temperature rises of 2°C and 4°C?	Several members of the Expert Panel emphasised that this is an extremely challenging question. It was suggested that quantitative findings could only be generated through agent based modelling work that goes well beyond the timescales and budget of this study. It was also strongly advised to reconsider the aspect of this question relating to the effect of behaviours for 2°C and 4°C worlds. We suggest that findings may be more useful if expressed in terms generalised events of different magnitudes (e.g. effect of a given behaviour in 1% vs 0.1% ARI flood events).	How do these behaviours affect (positively or negatively) the impact of different types of climate events? How does the size of the effect vary depending on the magnitude and frequency of the event?
~~5~~ 4	Could those behaviours that are effective be further incentivised and by which interventions? ○ How might data or digital innovations affect decision-making? ○ What are the barriers which could prevent these interventions from being implemented or effective?	No change recommended. Most Expert Panel members (particularly those from practitioner backgrounds) emphasised that this question is of greatest potential value to them. Significant work has already been done around incentivising behaviour change around flood risk, particularly by the EA. In an effort to reduce duplication of effort, an in-principle agreement has been reached with EA to share outcomes of ongoing research projects in this area.	Could those behaviours that are effective be further incentivised and by which interventions? ○ How might data or digital innovations affect decision-making? ○ What are the barriers which could prevent these interventions from being implemented or effective?

Table D 3: Variables in CCC specification and agreed changes

Variable type	Listed in CCC proposal	Rationale	Revised variables
Groups	Homeowners Businesses Communities Land managers and owners	Expert Panel members observed that 'Homeowners' excludes the critical cohort of renters. 'Land owners' was also considered to be excessively broad. Experts noted that there is a significant difference between small and large businesses, therefore suggested that one category for all businesses is not suitable. Since more evidence exists focusing on the behaviour of corporations, was agreed to focus research on SMEs; however, study will also make comment on the extent of existing research behaviours by larger organisations.	Households Small and medium enterprises (SME) Communities Land managers
Climate events	Flooding and coastal erosion	Broadly speaking, research should focus on the highest priority risks in	In order of priority: - Flooding and coastal erosion

Variable type	Listed in CCC proposal	Rationale	Revised variables
	Heat and cold Water availability (including drought) Other types of extreme weather (e.g. rain or wind storms).	CCRA2. Expert Panel members also emphasised the important of considering multi-hazard events and interdependencies.	- Extreme heat and cold - Water availability (including drought). Consideration should also be given to at least one multi-hazard event.
Demographic variables	Age Income Physical or mental health	Gathering data around mental health presents privacy challenges and would be challenging to classify/interpret. Opinions from Expert Panel and Stakeholder Group members were conflicting on this topic. Overall, it is proposed to exclude mental health as a stated variable of interest, although consideration will be given to integrating ONS4 questions on personal wellbeing into surveys where practicable. To improve efficiency, using existing socio-spatial vulnerability indices, such as the Joseph Rowntree Foundation 'Climate change, justice and vulnerability' index should also be explored in lieu of gathering demographic information data directly from individuals.	Age Income Physical health Gender
Nation	England Wales Scotland Northern Ireland	It is critical that the study considers behaviours across all nations of the UK.	No change
Land type	Cities Rural Coastal Highlands	Some stakeholders queried the focus on Highlands given the comparatively low population density. However, it is important to include this land use type given it presents a unique context for adaptation. Noted by several stakeholders that climate change risks can manifest differently on Islands and hence should also be considered. It was agreed to seek a case study from an Island if possible.	Cities Rural Coastal Highlands Islands

Appendix E Case Study Social Risk Indices

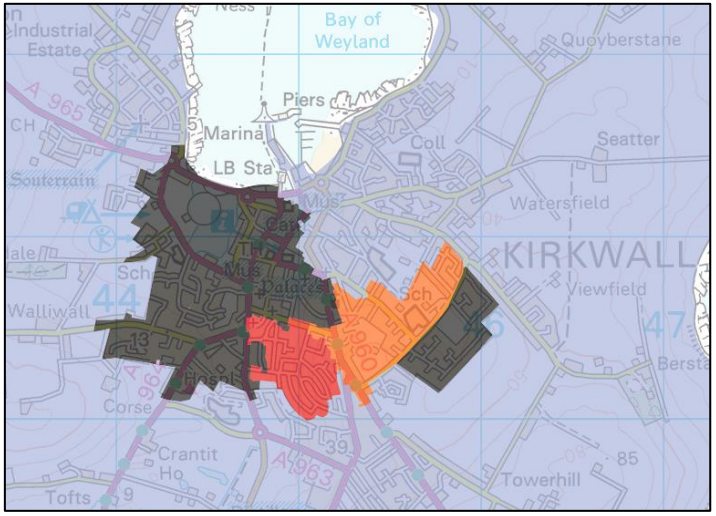
E.1 Orkney

Social Flood Risk Index – surface water flooding (2017)

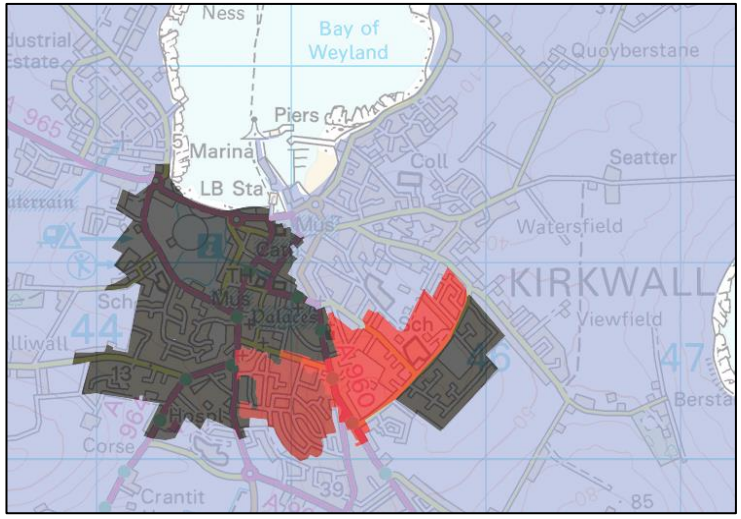
Orkney

Sayers et al. 2017

Current day



2050s - 4°C warming scenario



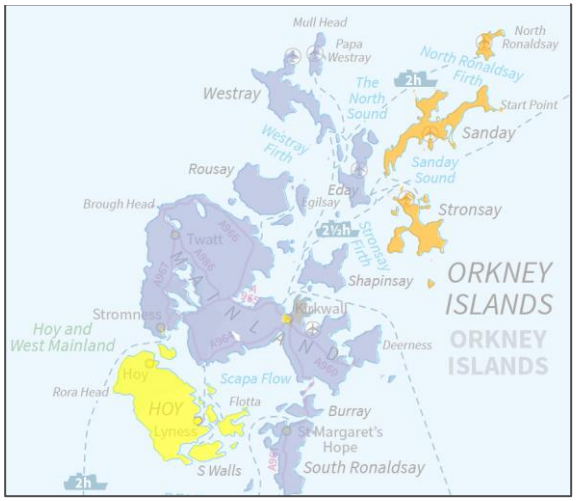
- Exposed, NFVI below the UK mean
- Low
- Moderate
- High
- Very high
- Acute
- Extreme
- No exposed population

Social Flood Risk Index – river and coastal flooding (2017)

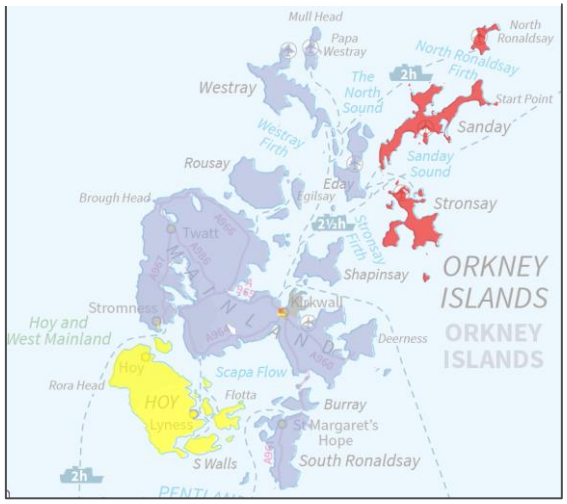
Orkney

Sayers et al. 2017

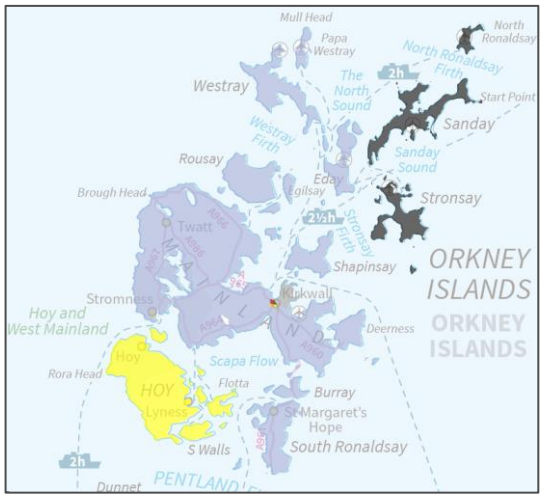
Current day



2050s – 2°C warming scenario



2050s - 4°C warming scenario



- Exposed, NFVI below the UK mean
- Low
- Moderate
- High
- Very high
- Acute
- Extreme
- No exposed population

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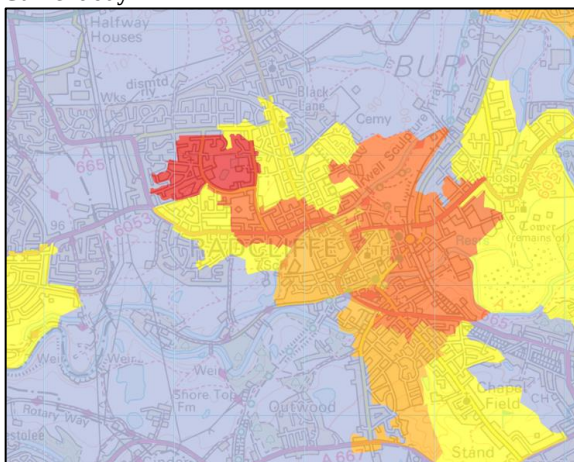
E.2 Greater Manchester

Social Flood Risk Index – surface water flooding (2017)

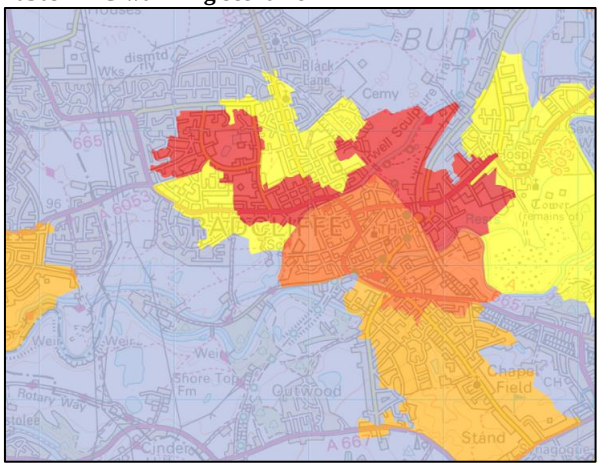
Radcliffe

Sayers et al. 2017

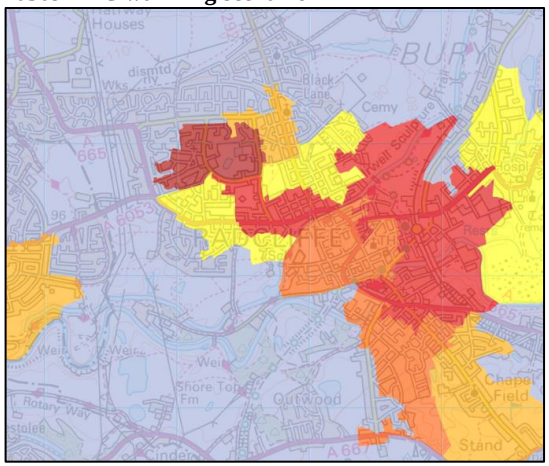
Current day



2050s - 2°C warming scenario



2050s - 4°C warming scenario



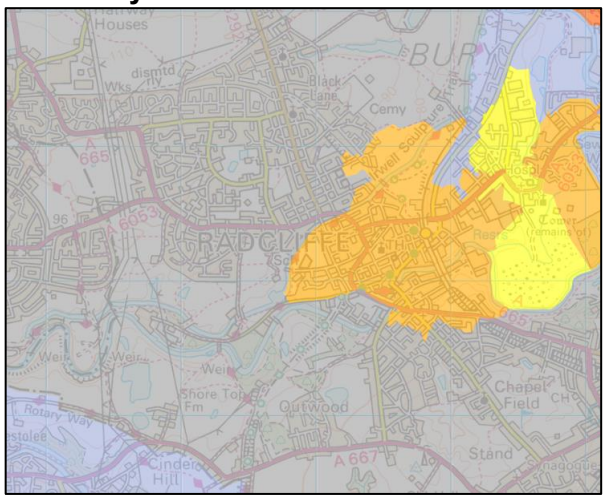
- Exposed, NFVI below the UK mean
- Low
- Moderate
- High
- Very high
- Acute
- Extreme
- No exposed population

Social Flood Risk Index – river and coastal flooding (2017)

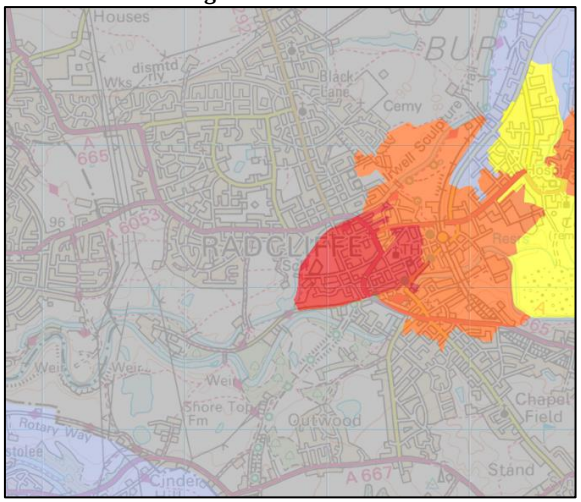
Radcliffe

Sayers et al. 2017

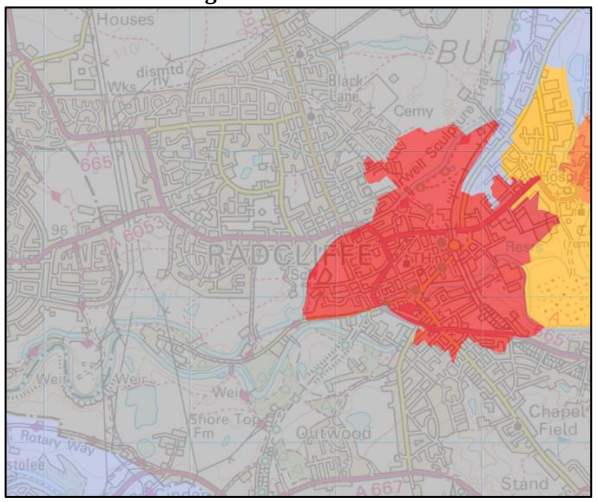
Current day



2050s - 2°C warming scenario



2050s - 4°C warming scenario



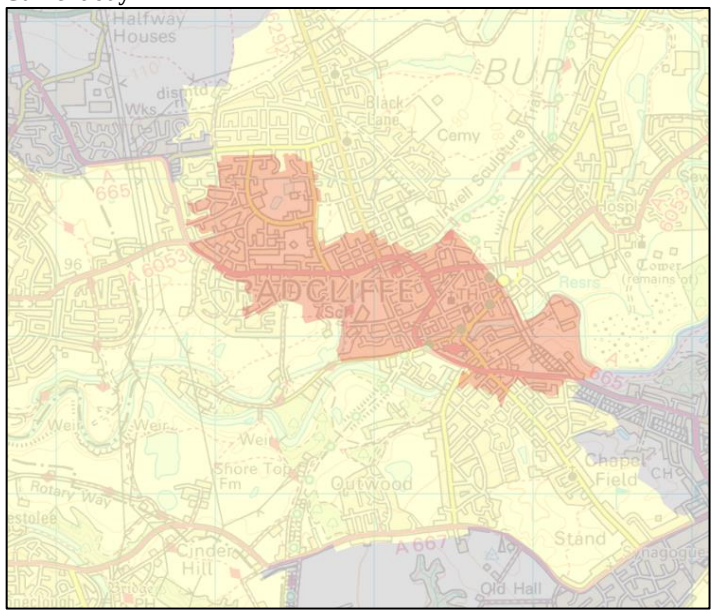
- Exposed, NFVI below the UK mean
- Low
- Moderate
- High
- Very high
- Acute
- Extreme
- No exposed population

Social Heat Vulnerability Index (2011)

Radcliffe

Lindley et al. 2011

Current day



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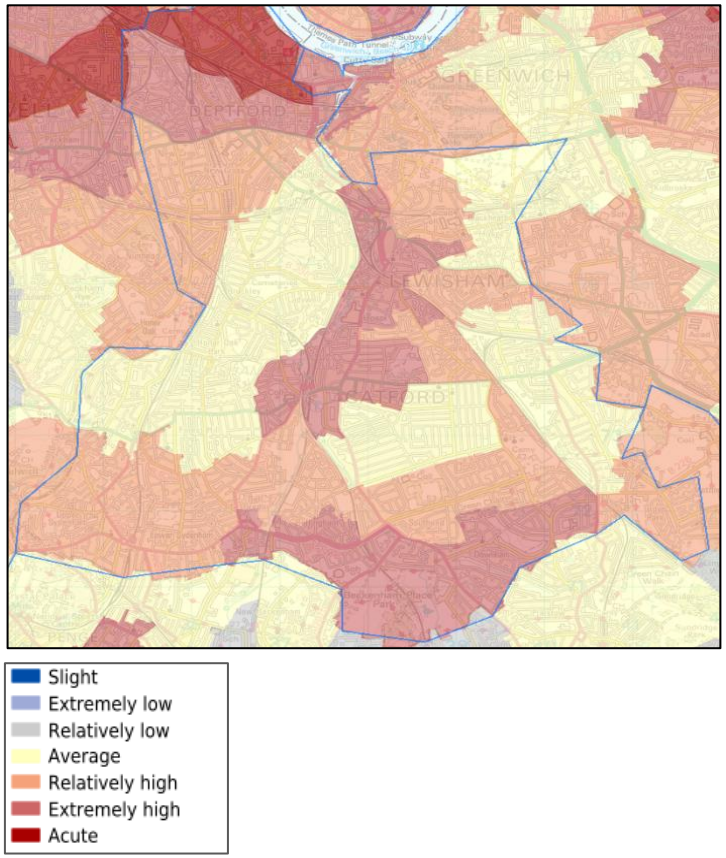
E.3 London Borough of Lewisham

Social Heat Vulnerability Index (2011)

Lewisham

Lindley et al. 2011

Current day



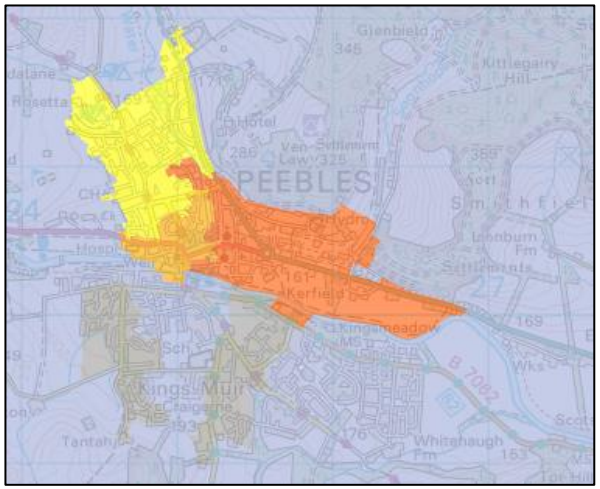
E.4 Peebles

Social Flood Risk Index – surface water flooding (2017)

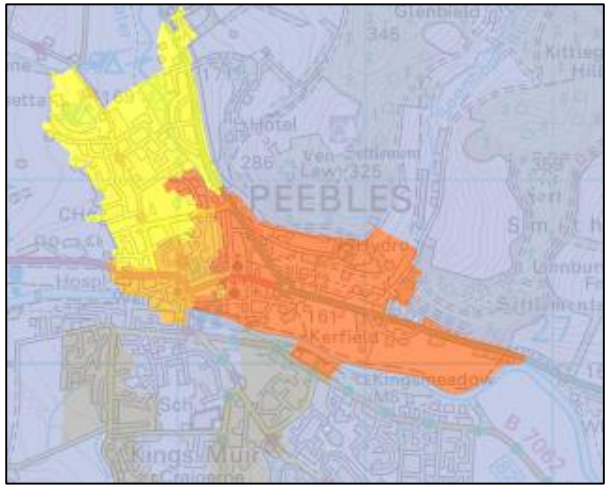
Peebles

Sayers et al. 2017

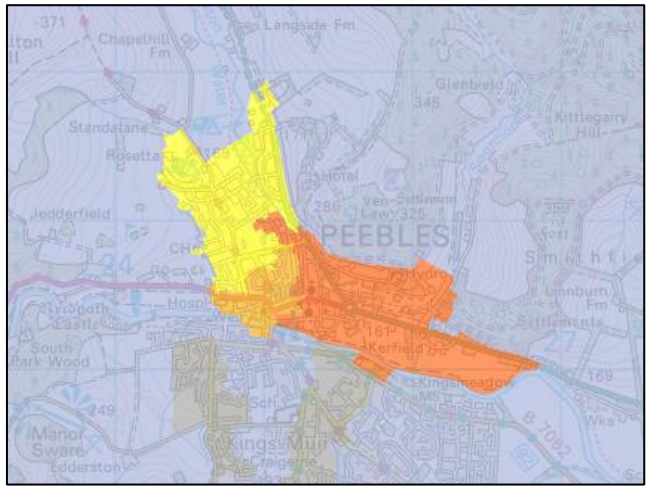
Current day



2050s - 2°C warming scenario



2050s - 4°C warming scenario



- Exposed, NFVI below the UK mean
- Low
- Moderate
- High
- Very high
- Acute
- Extreme
- No exposed population

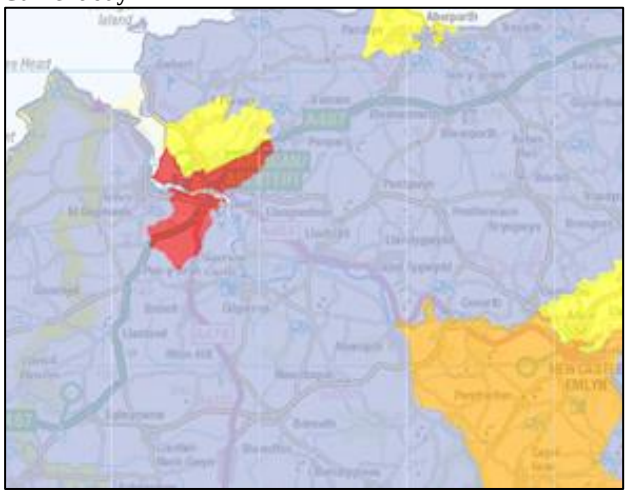
E.5 Llechryd, Ceredigion

Social Flood Risk Index – surface water flooding (2017)

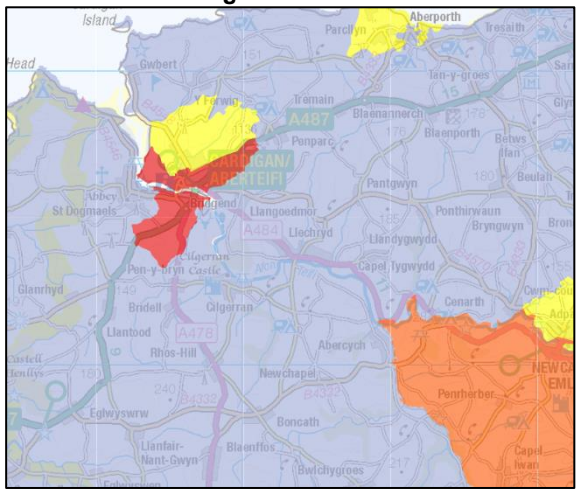
Ceredigion

Sayers et al. 2017

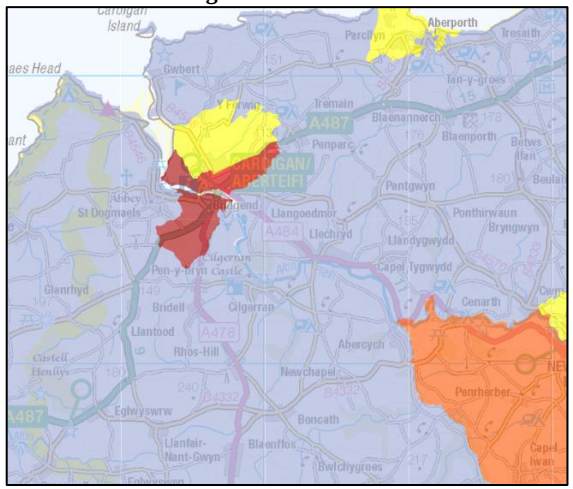
Current day



2050s - 2°C warming scenario



2050s - 4°C warming scenario



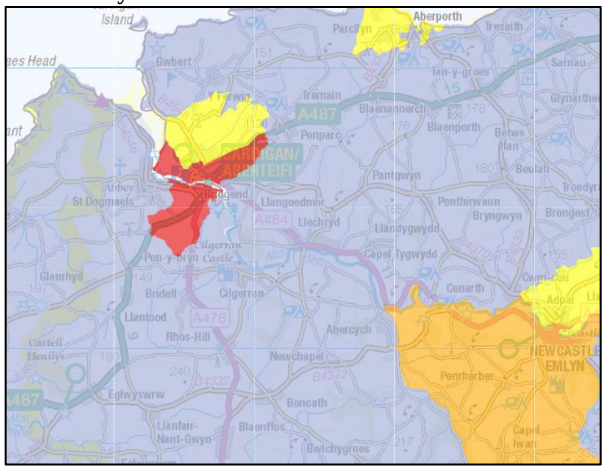
- Exposed, NFVI below the UK mean
- Low
- Moderate
- High
- Very high
- Acute
- Extreme
- No exposed population

Social Flood Risk Index – river and coastal flooding (2017)

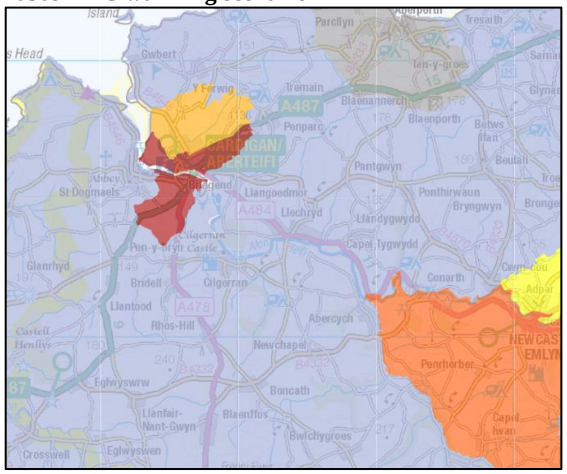
Ceredigion

Sayers et al. 2017

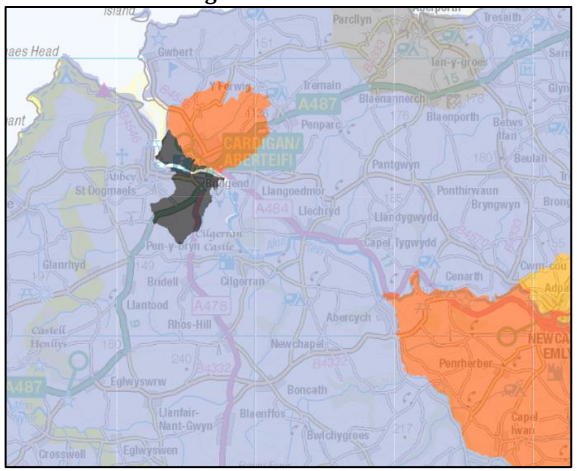
Current day



2050s - 2°C warming scenario



2050s - 4°C warming scenario



- Exposed, NFVI below the UK mean
- Low
- Moderate
- High
- Very high
- Acute
- Extreme
- No exposed population

E.6 UK Water Companies

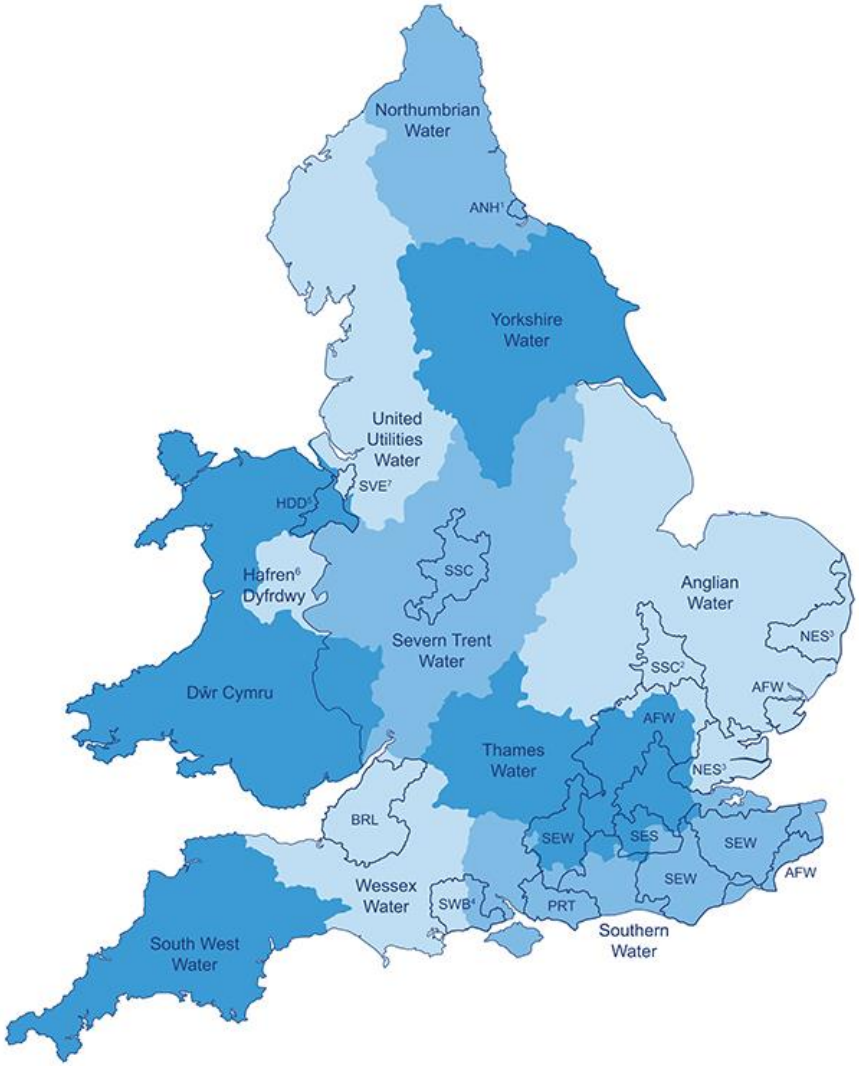


Figure E.1 Water and sewerage companies England and Wales (Ofwat, 2019)

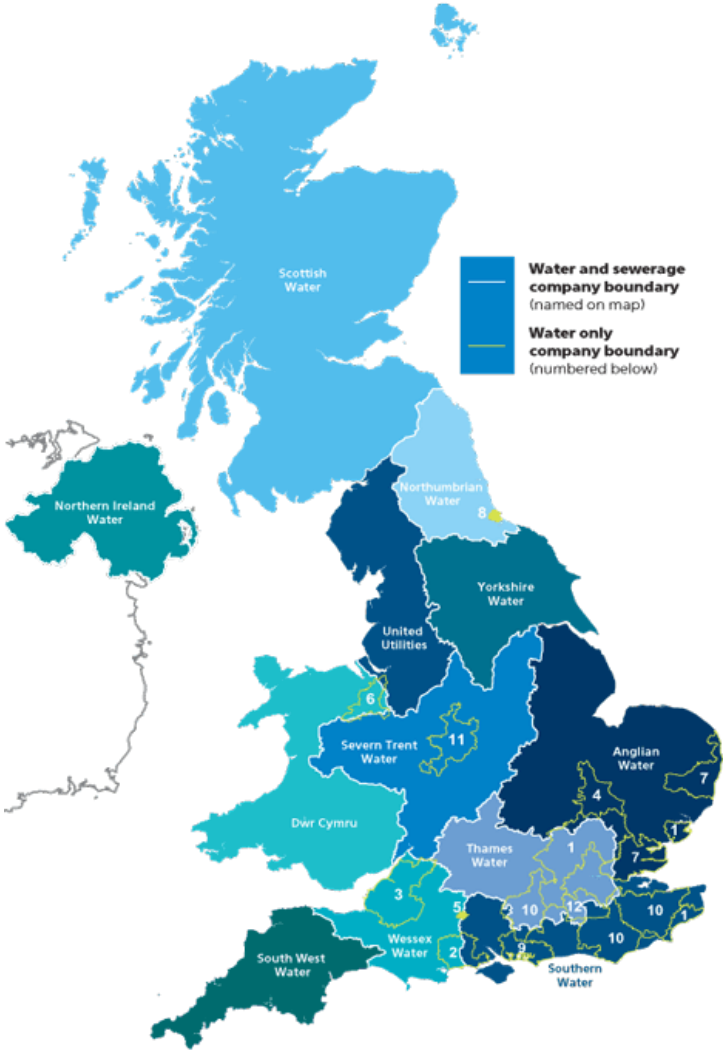


Figure E.2. UK Water companies (CCWater, n.d.)

Appendix F Current behaviours and their assessed influence on risk

This document has been provided to CCC separately due to its file size.

Appendix G Case study interviews – headline summary

#	Location	Event(s) discussed	Stakeholder	Headline
1	Northern Ireland	Flooding	Household	Interviewee was out of their home for nine months in 2017 due to flood damage. After the event, a group of affected neighbours started a resilience group to communicate ahead weather warnings.
2	Orkney	Storms, flooding, extreme heat	Household	Interviewee has been taking a number of precautionary measures due to long-term experience of storm events. Reference was made to the localised nature of climate change, for example extreme heat events would be beneficial for the local area, due to increased tourism.
3	Orkney	Storms, flooding, extreme heat	Household	Most households in this region have been designed to be resilient during storm events, however the interviewee raised concerns regarding new development still being delivered on floodplains.
4	Orkney	Storms, flooding	Household	Risks from sea level rise and flooding influenced where the interviewee chose to live when they moved to the area. Additionally, the interviewee has been sure to storm-proof extensions to their property and highlighted the importance of local areas being self-resilient.
5	Wales	Flooding, drought	Household	Interviewee recently moved to a newly-developed property, which they extensively planned to be climate resilience. They mentioned the importance of community resilience groups to bring together resources and shared their concerns about large-scale development still being placed on floodplains.
6	Northern Ireland	Flooding, storms	Household	Affected by flooding four times in a two-year period, highlighted the emotional stress. Interviewee noted not being able to sell the house due to the flooding, even if they considered moving.
7	Northern Ireland	Flooding	Household	Interviewee noted that their property is a listed building, which limits the changes they are allowed to make to adapt to climate change.
8	Northern Ireland	Flooding	Community organisation	Interviewee noted the hard work that households and community groups are putting in, but that wider infrastructure upgrades are needed and should be government-led.
9	Orkney	Storms, Flooding	Household	Interviewee noted the worsening of severe weather in recent years and stated that they would choose the location of their household more carefully if they were to move again.
10	Northern Ireland	Flooding	Household	Interviewee noted the importance of aligning adaptation with neighbours; living in a semi-detached house implies that structural adjustments should be done in coordination to not displace the effects to your neighbours' house.
11	Radcliffe	Flooding, extreme heat	Household	Following the boxing day floods, the interviewee received a £5,000 grant from the Council for flood adaption measures and now takes preventative action and has signed up to EA flood alerts. The interviewee called for more robust planning of new development on flood plains.
12	Radcliffe	Flooding, extreme heat	Household	Interviewee experienced flooding in 2012 and 2015 and received financial support for flood gates. They highlighted the importance of clearing drains, using social media and supporting the community before and during extreme events. The interviewee also raised concerns that development was still occurring in areas of high flood risk.
13	Orkney	Storms, flooding	Household	Interviewee experienced flooding at a previous household, and as a result houses in the community put in a number of flood prevention measures, which encouraged other households to do the same.

#	Location	Event(s) discussed	Stakeholder	Headline
14	Wales	Flooding	Household	Interviewee highlighted sea level rise as a major concern for those living by the coast. They stated that recent flooding had brought the local community together, however properties that had experienced multiple flood events were starting to have problems acquiring insurance.
15	Wales	Flooding, drought, extreme heat	Household	Interviewee from a low-lying coastal community, stated that climate change is a key driver when planning household changes. They highlighted the need for rural areas to become self-sufficient and raised concerns that climate change will encourage uptake of mal-adaptive actions (e.g. switching from cycling to driving and installing air conditioning).
16	Northern Ireland	Flooding, storms, drought, extreme heat	Household	Interviewee lives in a high-risk flood zone and had witnessed flooding and droughts. They noted generous flood schemes for land owners, however stated that the council needed to take more action in response to climate events.
17	Wales	Flooding, storms, extreme heat	Household	Interviewee had experienced previous flooding and storms, however due to their household being high up, they were mainly affected by disruptions to transport and energy supply.
18	Radcliffe		Household	Following the boxing day floods, the interviewee prepared a flood disaster plan, registered for flood alerts, and is planning to move within the next few years.
19	Orkney	Storms, flooding, extreme heat, drought	Land owner	Interviewee owned a small farm and referred to using nature based-solutions, which are still rarely implemented among land managers. The interviewee had previous moved from another area of land due to extreme heat and noted that the main driver for the land ultimately determines the resilience measures that will be taken.
20	Lewisham	Extreme heat, drought	Household	Interviewee noted that extreme heat events were becoming a regular occurrence. They currently use fans but may look to install air conditioning in the future. The interviewee wanted local councils to be more transparent about their climate actions.
21	Water sector	Drought, flooding	Water company	Interviewee revealed that climatic impacts of water resources are location specific and can be difficult to model and predict, however substantial work has been undertaken to improve water-efficiency and forecast demand.
22	Water sector	Drought	Water company	Interviewee stated that water restrictions have not been required in all areas of the UK, due to differences in the reliability of water sources. Water companies have planning in place to meet peak demands, and mechanisms in place if they need to reduce demand. When demand needs to be reduced, effective communication must be carefully thought out.
23	Water sector	Drought	Water company	Interviewee revealed that water companies have a drought management plan in place and operate in reaction to changes in the weather, by monitoring and balancing supply and demand. Interestingly, metered customers tend to use less water because of the financial benefit.
24	Water sector	Drought	Water company	Interviewee stated that heatwaves and droughts are the main drivers of water demand, however they have to be considered separately. Water shortages are location specific and depend on the source used by the water company.

Appendix H Example Survey

The Committee on Climate Change (CCC) is working with AECOM, Sustainability West Midlands (SWM), London Climate Change Partnership (LCCP), Sniffer and Climate Northern Ireland to undertake research into how people behave when faced with extreme weather and climate change risks. The research will help improve future efforts to support UK communities to cope with extreme events and the effects of climate change. This survey will be open for responses until [2 weeks from issue date] and will take no more than XX minutes to complete.

The project team takes your privacy seriously – this study is conducted in accordance with the Privacy Statement found here. Your response to this survey will not be shared with any third parties and you will not be personally identifiable in any reports produced for this project. You are able to withdraw from the questionnaire at any point, including after you have submitted it to the researchers. Your personal data will be kept on the project team's secure servers and will be destroyed after the project is completed.
If you have any questions or concerns, you can direct them to Antje Lang – antje.lang@aecom.com.

Part 1

1. **Has your property been adversely affected (for example, damaged, disrupted communications or physical access cut off) by an extreme weather event before?**

☐ Yes ☐ No ☐ Unsure

If yes, what types?

☐High winds
☐Flooding
☐Frost damage
☐Heavy snow
☐Extreme heat
☐Drought
Other_____

Please provide details: _____

2. **Was your property affected by the [INSERT DESCRIPTION AND DATE OF EVENT HERE]?**

☐Yes ☐No

3. **Thinking about [INSERT DESCRIPTION AND DATE OF EVENT HERE]…**

   a) **How would you describe the overall impact on your life?**

☐ Extreme
☐ High
☐ Moderate
☐ Low
☐ I wasn't affected
☐ I wasn't living here then

   b) **Which aspects of your life were adversely affected?**

☐ Ability to travel locally
☐ Mental health
☐ Physical health
☐ Family relationships
☐ Physical damage to my property
☐ Missed work/lost income
☐ Other

Provide more detail on the impact if possible: _____

c) Was there a financial cost?

☐ Yes ☐ No ☐ Unsure
If yes, approximately how much? (optional) _____

d) How long did it take you and fellow occupants to recover from the event?

☐ Less than a week
☐ 1 week to 1 month
☐ 1 to 6 months
☐ 6 months to 1 year
☐ Between 1 and 2 years
☐ More than 2 years
☐ I/we have not recovered

e) What would you do differently if you had to cope with a similar event in the future?
_____

4. If you received advance warning of the event, how did you receive this warning?

☐ Government website
☐ News website
☐ Television
☐ Radio
☐ Friends
☐ Family
☐ Neighbourhood group
☐ Mobile alerts
☐ Automated voice messaging system
☐ Social media
☐ Email
☐ Other_____

5. What, if any, temporary action(s) did you take to prepare for the event?

Please select all measures you took and if you think they helped

	Did you take this measure?		**Do you think it helped?**			
	Yes	**No**	**Yes, they reduced the impact of last event**	**No, it made no difference**	**No, it made things worse**	**Not sure if it made a difference**
Shuttering windows						
Coordinate with neighbours						
Check on safety/preparedness of relatives, friends and/or vulnerable neighbours						
Covering windows and doors						
Trim trees and branches near my property						

	Did you take this measure?		Do you think it helped?			
	Yes	**No**	**Yes, they reduced the impact of last event**	**No, it made no difference**	**No, it made things worse**	**Not sure if it made a difference**
Secure loose objects around my property						
Put together household emergency kit						
Have flashlights handy						
Stay with friends or family out of the area						
Changing plans to home during the event						
Turn off main power						
Turn off main gas lines						
Move loose items away from windows						
Move items to higher floors						
Have store of sandbags ready						
Have removable flood barriers handy						
Have salt or sand ready if snowstorm						
Seeking advice from others						
Follow evacuation orders						
Allow for others to be entered						

6. Before the event, what, if any, permanent protective measures did you take to prepare your property?

Please select all measures you took and if you think they helped

	Did you take this measure?		Do you think it helped?			
	Yes	**No**	**Yes, they reduced the impact of last event**	**No, it made no difference**	**No, it made things worse**	**Not sure if it made a difference**
Remove or do not plant large trees close to house						
Install storm shutters						
Install impact-resistant windows						

Change roof pitch to minimise wind damage						
Install water-resistant skirting boards						
Install shear walls and strapping						
Raise household appliances						
Install quick release internal doors						
Move electrical sockets higher up the wall						
Install water tanks						
Replace wooden floors or carpets with concrete or tile						
Allow for others to be entered						

7. Since the event, what, if any, permanent protective measures to prepare your property from future events?

☐ Remove or do not plant large trees close to house
☐ Install storm shutters
☐ Install impact-resistant windows
☐ Change roof pitch to minimise wind damage
☐ Install water-resistant skirting boards
☐ Install shear walls and strapping
☐ Raise household appliances
☐ Install quick release internal doors
☐ Move electrical sockets higher up the wall
☐ Install water tanks
☐ Replace wooden floors or carpets with concrete or tile
☐ None

Other: _____

Part 2

To what extent do you agree with the following statements?

	Strongly disagree	Somewhat disagree	Neither agree nor disagree	Somewhat agree	Strongly agree
I live in a tight-knit community					
My home is at risk of flooding during a heavy rainfall event					
If know where to go for advice on preparing my property for flooding					
I feel a strong personal attachment to my home					
My community could experience drought conditions in future					
I cannot afford to spend money on measures that protect my home from severe weather events					
It is the Government's responsibility to protect people's homes from flooding					
I don't need to do anything else to prepare myself for extreme weather events					
My neighbourhood would pull together and help each other when an extreme weather event happens					
I have much bigger problems to worry about than extreme weather events					
I talk to my neighbours regularly					
I would be more likely to install flood resilience measures in my property if my neighbours did it too					
My home is at risk of flooding from the sea					
It is my responsibility to protect my property from flooding					
I regularly worry about my home being damaged by an extreme weather event					
I have a 'Plan B' if my home was damaged by an extreme weather event					
There is nothing I can do to protect my house from weather-related damage					

Part 3

I would be more likely to take actions to protect my home from future extreme weather events if…

	Strongly disagree	**Somewhat disagree**	**Neither agree nor disagree**	**Somewhat agree**	**Strongly agree**
My local or county council provided more information on the risks					
There was more financial support available from the Government					
I had more information on what I could do					
I knew others in my neighbourhood were taking actions					
I had the skills required to make changes					
My insurance company lowered my premiums if I took action					
The Met Offices provided more information on the risks					
I had more money					
I had more time					
I saw Government taking more action					
I knew the most effectives ways to address the extreme weather risks I face					
If I saw other neighbourhoods taking actions					

Background information

This background information about you will only be used in our analysis and you will not be personally identifiable to anyone outside the project team. All background information is optional to provide; however, providing this information will help us come up with more useful conclusions that can help improve how communities are supported to cope with extreme events in future.

1. **Name (optional): ___**

2. **Are you happy to be contacted with follow-up questions regarding this survey?**
   ☐Yes
   ☐No

3. **Contact email: ___**

4. **Contact number: ___**

5. **Postcode:_____**

6. **Type of dwelling**
   ☐ Freestanding house, cottage or bungalow
   ☐ Semi-detached house
   ☐ Flat/apartment (ground floor)
   ☐ Flat/apartment (upper floor)
   ☐ Terrace/townhouse
   ☐ Other

7. **Your age:**
   ☐ Less than 18
   ☐ 18 – 35
   ☐ 36 – 49
   ☐ 50 – 69
   ☐ 70 +

8. **Marital status:**
   ☐ Married
   ☐ Widowed
   ☐ Divorced
   ☐ Separated
   ☐ Never married

9. **Total number of people living in household: ___**

10. **Home ownership:**
    ☐ Owner-occupier
    ☐ Renter
    ☐ Living in property owned by other family member(s)
    ☐ Other

11. **Length of time at current residence**
    ☐ Less than 1 year
    ☐ 1 – 5 years
    ☐ 5 – 20 years
    ☐ 20+ years

12. **Total number of people under the age of 18 living in household: ___**

13. Annual household income (before tax):

☐ £0 - £12,500
☐ £12,501 - £25,000
☐ £25,001 - £45,000
☐ £45,001 - £70,000
☐ £70,001 - £100,000
☐ £100,001 - £150,000
☐ £150,000+

1 Appendix I Full list of actions per event type

Preparendess for Response Actions	Vulnerability Reduction actions	Hazard avoidance actions	Coping during Crisis Actions	Preparedness for response
Stockpiling sandbags	Online data back-up	Relocate	Stay with family or friends outside of the area	Have chainsaw to move downed trees
Dig water channels or build provisional channels	Install pumps		Put towels down	Increase ringfenced budget for repair costs
Develop a household evacuation plan	Move electrical sockets up walls		Follow evacuation orders	
Prepare or purchase a household emergency kit	Elevate electrical appliances		Decrease activity	
Document evidence for future preparedness	Structural changes or reinforcements		Change clothing to cool down	
Produce and enact written flood disaster plan	Increase flood elevation		Use personal fans at work	
Establish community warming centres	Purchase flood insurance		Wear hats when outdoors	
Have stockpile of non-perishable food	Install air brick covers		Seek protection in shady areas when outdoors	
Develop or update business continuity plan	Have removable flood barriers handy		Change transport mode of taking children to school	
Peer-to-peer information sharing via Internet	Change irrigation practices		Keep children from school	
Listen to radio for information	Routine clearance of drainage systems		Go to a public air-conditioned location	
	Landscaping for drainage		Take cold showers	
	Apply tanking to all ground flood walls		Stay at home	
	Apply waterproof paint		Change routines to avoid the heat of the day	
	Plastic lining membranes etween brickwork and plaster		Increase water-saving information campaigns (water companies)	
	Move items to higher floors		Apply more water to lawns or landscaping	
	Install flood doors		Increase clothing layers	
	Keep windows open at night		Change dietary intake to hot meals and drinks	
	Drink water to stay hydrated		Change work practice to avoid coldest/snowiest parts of the day	
	Place personal fans in home		Attend community warming centres	

			Draw curtains
			Use sunscreen
			Provide sunscreen to employees
			Provide protective clothing to employees
			Spray down pavement
			Install air conditioning unit
			Water companies plan for long peak demand
			Apply agro-ecology principles
			Climate-smart agriculture
			Insulate buildings
			Impact-rate windows and entry doors
			Shutter windows
			Install sealed roof decks
			Cover windows and doors
			Trim trees and branches near buildings
			Have flashlights on hand
			Move loose items away from windows
			Have salt or sand ready if snow/ice storm
			Install outward-facing doors
			Park cars in the direction of the wind
			Implement backup plan for building access
			Install surge protector
			Generate own electricity independent of grid
			Secure or remove items stored on roofs

			Turn off power mains
			Turn off gas connections

1

			Tie down potentially loose objects
			Bricks to secure loose objects
			Install generators
			Gather information and data on risks
			Build internal capacity to understand climate risks
			Introduce flexible working arrangements
			Public disclosure of climate change risk exposure

Legend

Event		Type of behaviour	
F	Flooding	HR	Hazard reduction
H	Extreme heat	VR	Vulnerability reduction
D	Drought	PRec	Preparedness for response
C	Extreme cold	CC	Coping during crisis
S	Storms	PRes	Preparedness for recovery
M	Multiple hazards		