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Understanding how behaviours can influence climate change risks

Main report of research findings

UK Committee on Climate Change

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

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Executive Summary

Background

The third UK Climate Change Risk Assessment (CCRA) will be published by the government in January 2022, and the Department for Environment, Food and Rural Affairs (Defra) has asked the Committee on Climate Change (CCC) to produce the accompanying independent Evidence Report by summer 2021. AECOM, in partnership with Sustainability West Midlands (SWM), Sniffer, Northern Ireland Environmental Link (NIEL) – which runs the Climate Northern Ireland (CNI) programme - and London Climate Change Partnership (LCCP), was commissioned to undertake a research project to understand how climate risks affect people's behaviour and vice versa, taking into account different hazards, target groups, landscape types, and socioeconomic circumstance. This study aimed to explore the following research questions:

1. What behaviours do different groups adopt in anticipation of or in response to a chronic or acute climate event? Do the behaviours vary by geographic region or land use type?
2. How do these behaviours impact on risk and does that change depending on the frequency or magnitude of the event?
3. Which factors influence these behaviours?
4. How can effective behaviours be further incentivised?
    - How might data or digital innovations affect decision-making?
    - What are the barriers which could prevent these interventions from being implemented or effective?

Box 1: Variables considered in the report

Groups: Households, communities, small and medium-sized enterprises, large businesses, land managers

Climate events: Flooding and coastal erosion, extreme heat, extreme cold, storms, drought

Demographic variables: Age, income, physical health, gender

Nations: England, Northern Ireland, Scotland, Wales

Land types: Cities, rural, coastal, islands

Approach

To investigate these research questions, this study used a mixed-method approach, collecting data using the following methods:

- In-depth literature review considering both peer-reviewed and 'grey' literature;
- Semi-structured expert interviews with researchers and practitioners; and
- Case studies (involving surveys and semi-structured interviews) reflecting specific locations and target groups with heightened exposure and/or vulnerability to one or more types of climate events.

As a means to evaluate the impact of behaviours on climate risk, this study developed a metric, termed the 'National Impact Score,' that scored current extent of adoption of a specific behaviour, current influence on risk, and the wider impacts of that behaviour, for each combination of climate-related event, target group, and behaviour. This metric provides a high-level means to investigate the uptake of behaviours and potential impact on risk under present day and future climate scenarios. The variables considered in this study are set out in Box 1.

As a means to categorise the behaviour to make the analysis and discussion more manageable, this study used a typology of behaviours identified in Wamsler & Brink (2014), set out in Table 1 and referred to throughout the report.

Table 1 Categorisation of behaviours

Behaviour type	Description	Examples
Hazard reduction	To limit or avoid exposure to current and future hazards	Move to a new property to avoid coastal erosion
Vulnerability reduction	To reduce current and future vulnerability to hazards	Install removable flood barriers
Preparedness for response	To provide functional and flexible mechanisms and structures for disaster response	Have a household emergency kit prepared
Coping during crisis	To provide short-term solutions to mitigate harm during a hazard; solutions cannot be prepared for in advance	Take cool showers during a heat wave
Preparedness for recovery	To provide functional and flexible mechanisms and structures for disaster recovery	Have tools on hand to remove debris after a storm

Case study summary

In addition to a desktop literature review, this study conducted six case study sets of interviews, identified in Table 2.

Due to the large number of variables that can affect adaptation behaviours, the research analysis of the case studies was largely qualitative, although counts were used from survey responses. Representative samples were not sought, and it was not possible to establish causal links with high generalisability, nor to draw direct comparisons between each case study. Rather, the study's case study approach aimed to conduct an in-depth, qualitative exploration of the research questions and to provide some insights based on real-world experience.

Table 2. Case study locations

Climate event	Location	Survey respondents	Semi-structure interviews
Non-event specific	Orkney Islands	106	6
	Peebles, Scottish Borders	45	0
	Northern Ireland	32	6
Flooding	Llechyrd, Wales	12	4
	Greater Manchester	29	3
Extreme heat and/or drought	London Borough of Lewisham	47	1
	UK water companies	6	4

Key findings per case study

Orkney Islands

Extreme weather (e.g. storms and associated coastal flooding) is a common occurrence in Orkney. As such, residents indicated they felt well-prepared to handle most climate events and few suggested they would do anything significantly different in the future.

Typically, Orcadians employed low-cost methods (e.g. use surge protectors to protect against power surges during electrical storms, using guy ropes to secure items to the ground) although semi-permanent measures were more common in Orkney than in most other case studies (e.g. installing back-up generators). These methods decreased sensitivity to impacts of high winds and storms.

A key factor influencing respondents' behaviour was learning from neighbours. This was particularly true for new residents who had not previously had experience with Orkney's or similar weather extremes.

The Orkney case study highlights the need for further integrating flexibility and redundancy into localised and broader systems (e.g. backup generators on-site for localised strategies vs. hotels taking last-minute reservations for Orcadians stuck on different islands due to ferry or road closures from poor weather).

Peebles, Scottish Borders

Respondents in Peebles discussed past experience with heavy snow, high winds, and heavy rain and associated flooding (pluvial and fluvial).

Many respondents indicated that they would have a store of sandbags on hand in preparation for a flood. This was a common thread throughout the literature review and case studies, though there is debate about the effectiveness of using sandbags for property-level flood protection.

Respondents noted that financial support and learning from neighbours were key factors influencing personal adaptive action. The majority of respondents indicated they would take action if they had more information around the specific measures they should be taking that would be most effective.

Northern Ireland

Respondents most commonly discussed past experiences of flooding during the surveys and semi-structured interviews. Mobile alerts were the most common method by which people were informed of floods and severe storms.

Northern Ireland has a Homeowner Flood Protection Grant available to eligible households that had previously been impacted by flooding, with up to £10,000 available to undertake property-level protective measures. 15% of survey respondents had received financial support as part of the grant, and had undertaken protective measures including replacing carpeted areas with tile and installing impact resistant windows and doors.

Respondents felt strongly that it is the responsibility of the government to protect properties from flooding, although respondents also indicated they would be more likely to undertake personal protective measures if they received financial support from the government or private sector.

Greater Manchester

The River Irwell has experienced significant flooding, with over half of survey respondents reported being impacted by the 2015 Boxing Day Floods. Following this and other flooding events, common protective measures respondents indicated they had taken included moving electrical sockets further up the walls, replacing carpeted floors with tile or concrete, and raising household appliances.

Similar to Northern Ireland, grants of up to £5,000 were offered to residents impacted by flooding. Some residents used this money to purchase flood walls or doors. Again, respondents indicated they would be more likely to undertake adaptive action if they had more financial support available to them from the government.

Llechryd, Wales

Respondents in Llechryd reported experiencing flooding, high winds and heavy rain. The most common protective action that respondents reported taking was putting together a household emergency plan in case of a flood event, with a quarter of respondents also indicating that they had taken permanent property-level protective measures. Respondents generally

agreed that they would be more likely to undertake actions if they had more information on the most effective options and if they had more financial resources available to them if those actions required significant upfront capital (e.g. installing flood doors).

They also reported that they wanted to see government taking action, and that evidence of the government taking the issue of climate impacts seriously – e.g. through reduced or well-designed floodplain development – would make them feel that their own actions had more significance.

London Borough of Lewisham

The case study in Lewisham used two schools – Tidemill Academy and John Burns - as a means to reach out to potential respondents. This case study focused on extreme heat events.

Respondents indicated they had mostly taken coping measures to deal with extreme heat, and few had changed their daily routines. Measures included using indoor fans, keeping windows open at night, and drawing curtains. Only one respondent currently had an air-conditioning unit, although purchasing air-conditioning units was cited by others as a potential option if heatwaves became more frequent or intense. However, those respondents that indicated they would consider purchasing a unit wanted to know how effective a window unit would be before making the investment, indicating that information and financial resources are two components driving action.

UK water companies

This case study interviewed senior experts within water companies as a means to elucidate consumer behaviour for water use. In response to the 2018 heatwave, respondents stated that they had seen customer water use increase, although this was anticipated in all of their drought management plans. Additionally, no discernible changes in water use (either positive or negative) occurred following the heatwave.

Most companies surveyed noted that rural households and those with older occupants appear more likely to exhibit water-saving behaviours. Interviewees noted their perception was that elderly customers had had life experience that made them more receptive to ‘rationing’ mentalities, and that rural customers were more intimately aware of changes to their environment and, as a result, were more likely to conserve water in the face of drought or extreme heat circumstances.

Of note, both the literature review and interviews indicated that in-school education was one of the most effective methods for influencing water use. There was a generational component where anecdotal evidence suggested that schoolchildren who learn to be ‘water wise’ often bring this information back home to their parents, sharing knowledge. These in-school educational methods offer a potential avenue to explore with reference to adaptation actions more broadly.

Key findings

1. What behaviours do different groups adopt in anticipation of or in response to a chronic or acute climate event? Do the behaviours vary by geographic region or land use type?

Table 3. Summary of behaviours by typology

#	Behaviour type
1	Hazard reduction
50	Vulnerability reduction
11	Preparedness for response
21	Coping during crisis
2	Preparedness for recovery
86	**Total number of behaviours**

This study identified **86 unique behaviours** (see Appendix I), which are taken in advance of, during, or in response to an extreme weather event (see Table 3 for their breakdown by typology).

The most common behaviours identified in this study were classed as vulnerability reduction or preparedness for response.

The types of behaviours taken vary according to several different factors, including the type of climate event being experienced. Extreme cold and heat events tend to elicit reactive coping responses rather than proactive strategies before the event. Conversely, adaptation to flooding includes more proactive vulnerability reduction and preparedness for response mechanisms. More analysis would need to be conducted to assess why this is the case.

The evidence reviewed from both the literature review and case studies suggests that vulnerability reduction behaviours are the most common across target groups and climate events. The case studies indicated the few households undertook permanent modifications to their property in preparation for climate events. From the case studies and literature review, the evidence suggests that agricultural land managers were more likely to undertake permanent protective measures compared to the other groups included in the study.

Adaptation from large businesses tended to also be more proactive than individuals or households, seemingly due to the wider range of skills, capital, and understanding of operational risk posed by climate hazards.

Storm behaviours were found to be rare due the minority of communities that experience frequent storm events.

With regards to variation by geographic location or land use type, the literature review and the case studies did not provide sufficient information to undertake a robust analysis. This remains an area for further research.

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?

Based on an analysis from the interviews, a set of **national impact scores** were calculated. The scores were based on an assessment of the adoption of the behaviour, and the resulting impact of that behaviour on risk, using a table of criteria set out in tables 3.4 and 3.5 in the main body of the report.

These scores are intended to demonstrate, given the current level of adoption, to what extent each behaviour is feasible and contributes to risk reduction across the UK relative to other types of behaviours. The scoring sought to provide a high level view as to the impact of different behaviours, and not their desirability in any one location or type of hazard.

Some of the most impactful behaviours by hazard were:

- **Flooding**: applying tanking (a process in which a liquid coating bonds to damp masonry to form a waterproof barrier when it dries) to all ground floor walls; routine clearance of drains; online data back-up; moving vulnerable items within the house as well as static items like sockets up walls; and purchasing flood insurance.
- **Extreme heat**: Seeking shady areas; drinking more water to stay hydrated;; keeping windows open at night; changing clothing, reducing physical activity; and in some cases installing air conditioning in offices where passive cooling methods would be ineffective (though air conditioning can be maladaptive in terms of energy use and expelling waste heat into the environment, see below).
- **Drought**: planning for longer periods of peak water demand; water-efficient landscaping; implementing water saving practices; and climate-smart agriculture.
- **Extreme cold**: Changing clothing; insulating buildings; changing outdoor work practices to minimise outdoor time.
- **Storms**: Installing surge protectors; turn off mains power; unplug electronic devices; tie down potentially loose objects; have salt or sand ready if snowstorm.

Some of the least impactful behaviours (due to limited effectiveness, expense, and/or limited uptake) by hazard were:

- **Flooding**: Stockpiling sandbags (limited effectiveness); and increasing floor elevation (difficult and expensive)
- **Extreme heat**: spraying down pavements (maladaptive – increased water use);; and keeping children home from school (limited uptake and may not reduce exposure)
- **Drought**: installing greywater harvesting systems (difficult and expensive), applying more water to lawns/landscaping (maladaptive – increased water use)
- **Extreme cold**: attend community warming centres (limited uptake)
- **Storms**: Implement backup plan for building access for business (maladaptive as potentially encourages employees to travel to work in unsafe conditions), generate own electricity independent from grid (higher upfront costs)

The majority of the behaviours related to flooding (62%) were classed as vulnerability reduction measures. The National Impact Scores for flood-related measures (Section 5.2.1) indicate that the behaviours undertaken were either reducing exposure to flooding (e.g. relocating) or were reducing the vulnerability of the target group to the impacts of flooding (e.g. having store of sandbags ready).

The behaviours related to extreme heat that were undertaken were typically vulnerability reduction measures and are largely easy to adopt (except for installing air conditioning), applicable across the UK and typically decrease sensitivity to heat impacts. A significant barrier to adaptation for extreme heat is the commonly voiced perception that increasing temperature will be a welcome change, particularly in northern parts of the UK. As noted in CCRA2, high temperatures already pose a risk to health and can exceed the levels with which current infrastructure and practices are currently designed to cope.

For drought specifically, most of the current behaviours identified from both the literature review and case studies relate to land managers and businesses, who are highly dependent on water availability. No households reported undertaking any specific water-saving behaviours under present conditions.

With regard to storms, respondents typically took vulnerability reduction, coping, and preparedness for response measures. Behaviours typically decreased the sensitivity to the impacts and, in some cases, increased adaptive capacity.

Some behaviours are likely to be carry some maladaptive risk, whereby they increase the vulnerability and/or exposure of the person/organisation in question or others to the risk, or create trade-offs with other objectives such as climate change mitigation. This is particularly common for behaviours in response to drought and extreme heat because behaviours that mitigate the impacts of these climate events for individuals – including using air-conditioning and increasing water use – compound the impacts more broadly. For example, air-conditioning places increased pressure on electricity networks

which can already face vulnerabilities during extreme heat events. Additionally, air-conditioning can contribute to carbon emissions if the energy used comes from non-renewable sources, and expels waste heat into the air which can exacerbate the urban heat island in urban areas. Increasing water use during heatwaves or droughts compounds the pressures acting on the water supply. It is possible that these maladaptive behaviours may decrease in the future due to improved information and awareness about their negative impacts. However, the evidence reviewed and collected suggests that air-conditioning use could continue to increase as heatwaves become more intense and frequent in the future, unless incentives are put in place to limit uptake or provide more attractive alternatives.

3. Which factors influence these behaviours?

Box 2 details the key factors identified from this study that were found to influence behaviours. Age, direct past experience, and social norms were found to be the most common factors driving behavioural change among households and small and medium-sized enterprises. Conversely, income was noted as a barrier or enabler of adaptation, but not a driver itself.

In addition to these factors, the case studies demonstrated that behaviours and the factors affecting behaviours vary according to local context, as different communities have collective mindsets shaped in part by their historical and cultural backgrounds, which therefore influence their behaviours.

The propensity for past experience to drive behaviour may mean that some behaviours will become more widely adopted as the frequency and severity of climate impacts increase. For example, many flood risk-reducing behaviours may increase in the UK as more areas became flood prone and those areas that are currently flood prone experience more frequent and intense flooding. Drought-risk reducing actions could become more common, particularly among agricultural land managers, and the ecological and economic co-benefits of climate-resilient agriculture and land management become more well-known and widely referenced in the policy environment (e.g. through the implementation of the government's 25-Year Environment Plan).

Additionally, the literature review indicated circumstances that can disproportionately increase people's sense of preparedness or decrease their sense of risk. For example, people living in a community where there already are visible hard flood defences may feel that it is unnecessary to take any further precautions. Similarly, target groups who took one action only may feel that this action is sufficient, and overestimate their preparedness because they have taken some sort of action rather than none at all. Finally, there is evidence that communities that currently experience frequent extreme weather may be overconfident in their ability to cope with a range of future, more extreme weather events.

This study also found that there are various barriers that mean adaptation behaviours are not being adopted now and may not be adopted in the future even with greater experience of climate events. The study points towards the issue that the automatic connection between increasing extreme weather events and climate change is not often made. Moreover, the case study evidence suggests that people tend to associate adaptive measures with 'hard' adaptation actions, while low-cost, flexible solutions, which can increase adaptive capacity and reduce sensitivity, are typically the most easily accessible. Therefore, educating communities and individual stakeholders on what adaptation could look like (e.g. beyond obvious structural modifications) could likely have benefits in reducing the negative impacts of climate events, potentially through innovative measures like integrating information into in-school education. For example, many case study respondents did not realize that 'non-structural' behaviours they had undertaken, such as drinking more water or closing curtains during hot weather, may have reduced their risk. This misconception that adaptation only includes structural or property adjustments could be deterring greater action.

Among the studied groups, businesses were found to have unique factors driving adaptation actions. Large companies tend to be motivated to undertake adaptive action in order to demonstrate preparedness and achieve recognition, with potentially different underlying intentions to other groups, such as increasing profit, enhancing the value of their assets or services, and to win and keep business. Finally, regulatory frameworks, standards and reporting requirements are key drivers for business adaptation actions.

Box 2: Factors found to influence behaviours

Factors primarily influencing households and SMEs

- ***Perceived response-efficacy***: The belief that the behaviour will be effective.
- ***Perceived self-efficacy***: The belief that one has the capability to undertake a behaviour.
- ***Direct past experience:*** Previous experience of a climate event impacts negative affect and learning, driving future adaptive behaviour.
- ***Social norms/capital:*** The norms of the local context and the actions of neighbours; social ties and links; sense of community.
- **Socio-demographic factors**: age, marital status, gender, income, political orientation and value orientation.

Factors primary influencing large businesses

- ***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.
- ***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.
- ***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.
- ***Direct past experience:*** Previous experience of a climate events may spur action, particularly if financial losses were incurred.
- ***Policy and regulatory frameworks***: businesses often view climate adaptation as a matter of public policy-making and no of corporate-decision-making
- ***Access to knowledge***: Strong knowledge on costs and benefits as well as a detailed understanding of the risk triggers adaptive behaviour. Strong relationships with stakeholders driving and implementing adaptation increase knowledge.
- ***Stakeholder and shareholder expectations***: Public pressure can influence corporate behaviour
- ***Risk management processes***: As climate risks have a different nature to other risks, integrating adaptation into existing risk management processes might not suffice.
- ***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.
- ***Company culture****:* Belief that climate change is an ethical concern drives adaptive action.

4. Could those behaviours that are effective be further incentivised and by which interventions?

The analysis in the interviews and literature review consistently found that respondents are missing information about the effectiveness of different behaviours. The analysis found that ensuring tailored and focussed climate risk communication is extremely important, and should be better-targeted, framed appropriately and make use of visuals. This could involve stakeholder engagement to develop these tools in communities. Multiple interviews and survey respondents particularly in England and Wales noted that this should come paired with more information on which measures are most effective. Climate services should consider local knowledge when communicating information and solutions related to climate risks. Another avenue is the use of improving data services (e.g. crowdsourcing platforms, high-resolution geospatial data that is freely available) to aid in supporting understanding of localised risk and potential responses.

It is important to consider behaviour change frameworks that can incentivize autonomous adaptation, such as the COM-B model and the theory of planned behaviour change. Allowing for cognitive biases is important when developing any communication plan or incentive strategy, and in some cases simple nudging tactics (e.g. opt-out versus opt-in) may be more effective than overt efforts to convince people to take a risk-reducing action.

Other considerations and study limitations

This study has considered two different behaviour change frameworks around which to develop incentives. The first is the Capability, Opportunity, Motivation, Behaviour (COM-B) model (Michie et al. 2011). This model notes that changing behaviour requires a change to one's 'capability' to undertake the behaviour, and/or 'opportunity' and 'motivation' to carry out the behaviour. Another useful framework is the theory of planned behaviour change (TPP), which posits 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.

Of note, financial support and knowledge transfer were identified as critical interventions for increasing adaptive behaviours among the different groups. However, this study highlighted the limits of financial support for encouraging behaviours, demonstrating the importance of considering other factors such as social norms, stakeholder pressure and clear policies and regulations.

It is necessary to consider the scope and limitations of this study. The methodology used aimed to provide a qualitative baseline for further research. As such, the findings from the case studies and literature review are not generalisable to the broader population. Selection bias is a clear challenge in the interpretation of the findings; indeed, the case study respondents were in the majority older (50+), property owners, and living in smaller communities. Furthermore, households dominated the case studies, with most information about the behaviours of small and large businesses and land managers sourced from the literature review.

Ultimately, this study has highlighted four key points:

1. Vulnerability reduction and preparedness for response measures, which are generally lower-cost and more flexible, are the most common behaviours adopted before, during or after a climate event; however, the type of behaviour varies depending on the nature of the event and the target group.
2. Age, direct past experience, and social norms were found to be the most common factors driving behavioural change among households and small and medium-sized enterprises. Conversely, income was noted as a barrier or enabler of adaptation, but not a driver itself.
3. Small and medium-sized enterprises have unique factors driving adaptation actions including company In addition, SMEs and particularly large businesses also have unique factors driving adaptation actions, including company size, sector and location; access to information and resources; and sector-specific regulations, standards or reporting requirements. Most behaviours identified would reduce the impacts of climate events on people to a certain extent, with the exception of some maladaptive behaviours that have negative outcomes.
4. People want to know more about the effectiveness of different adaptation measures that they can take, and want support to take the best actions. Public and private sector support is necessary for encouraging adaptation measures. However, it is critical to ensure that climate and risk communication contains information on the most effective measures and is designed with specific target groups in mind.

The findings also point to several avenues for future research. For example, detailed statistical analysis will be required to determine the key factors influencing behaviour and how these differ among communities. It will also be useful to undertake more in-depth analysis on the incentives found to encourage behaviour uptake, and whether these incentives are indeed effective at reducing risk to climatic events. Moreover, it is suggested that future research could attempt to quantify the impact of the behaviours identified in this study on risk in order to enhance the NIS methodology outlined and create a more robust metric by which to prioritise which behaviours to incentivise.

Glossary

Term	Definition
Adaptation	The process of adjustment to actual or expected climate and its effects. In human systems, adaptation seeks to moderate or avoid harm or exploit beneficial opportunities.
Adaptation project	In this study, an adaptation project can be a mix of different interventions (actions and activities) with the potential to moderate or avoid the risk of harm from severe weather events and climate change.
Adaptive capacity	The ability of systems, institutions, humans and other organisms to adjust to potential damage, to take advantage of opportunities, or to respond to consequences (IPCC, 2018).
Behavioural determinant/factor	Perceptions, feelings, or beliefs shaped by socioeconomic, political, and cultural factors that can support or prevent the adoption of a specific behaviour.
Climate services	A field that aims to connect climate information to practitioners to ensure decision-making is available on all levels, not only with the realm of science and policy.
Disaster recovery	In this study disaster recovery refers to the process of building back post-disaster, including of livelihoods, physical assets and emotional and social networks and wellbeing. This study refers to the behaviour typology 'preparedness for recovery,' in which actors undertake behaviours that will support them to build back post-disaster.
Disaster response	In this study, disaster response refers to the behaviours that actors undertake that will support them during a disaster event. This study refers to the behaviour typology 'preparedness for response,' in which actors undertake behaviours that will support them to respond to a disaster event as it occurs. Typically, these behaviours are undertaken in advance of a disaster (e.g. preparing a household emergency kit.'
Exposure	The presence of people, livelihoods, species or ecosystems, environmental functions, services, and resources, infrastructure, or economic, social, or cultural assets in places and settings that could be adversely affected (IPCC, 2018.
Impact	Medium or long-term consequences of an outcome or outcomes. The primary focus of this project has been the impact on risk, but actions may have a range of other impacts that do not specifically relate to risk reduction (e.g. improved amenity).
Hazard	The potential occurrence of a natural or human-induced event with the potential to cause loss or damage to life, livelihood, physical infrastructure, services, and health or wellbeing.
Maladaptation	Actions that may lead to increased *risk* of adverse climate-related outcomes, including via increased *GHG* emissions, increased *vulnerability* to *climate change*, or diminished welfare, now or in the future. Maladaptation is usually an unintended consequence.
Risk	The potential for negative consequences where something of value is at stake and where the outcome is uncertain.
Sensitivity	Susceptibility to harm in the event of exposure to a hazard.
Vulnerability	The propensity or predisposition to be adversely affected. This is a function of sensitivity and adaptive capacity (IPCC, 2018).

List of acronyms

Acronym	Definition
AC	Air-conditioning
ARI	Average recurrence interval
AONB	Area of Outstanding Natural Beauty
AR5	Fifth Assessment Report (from the Intergovernmental Panel on Climate Change)
BBC	British Broadcasting Corporation
BRE	Building Research Establishment
CAQDAS	Qualitative data analysis software
CCC	Committee on Climate Change
CCRA	Climate Change Risk Assessment
CEO	Chief Executive Officer
CMO configurations	Context, mechanism and outcome pattern
CNI	Climate Northern Ireland
CdC	Coping during crisis
COM-B	Capability, opportunity, motivation
DAERA	Department for Agriculture, Environment and Rural Affairs
DCLG	Department for Communities and Local Government
DEFRA	Department for Environment, Food and Rural Affairs
EA	Environment Agency
CRAAP	Currency, relevance, authority, accuracy, and purpose
EU	European Union
GDHI	Gross disposable household income
GREEN-WIN	Greener Waterway Infrastructure
HA	Hazard avoidance
IPCC	Intergovernmental Panel on Climate Change
JRF	Joseph Rowntree Foundation
LCCP	London Climate Change Partnership
LWEC	Living With Environmental Change
NAP	National Adaptation Programme
NI	Northern Ireland
NISRA	Northern Ireland Statistics and Research Agency
ONS	Office for National Statistics
NRW	Natural Resources Wales

Acronym	Definition
PfR1	Preparedness for response
PLP	Property-level protection
PRA	Prudential Regulation Authority
RCP	Representative Concentration Pathway
SEPA	Scottish Environment Protection Agency
SFFS	Scottish Flood Forecasting Service
SME	Small and medium-sized enterprises
SWM	Sustainability West Midlands
SWELL	Shared Waters Enhancement and Loughs Legacy
TCFD	Task Force on Climate-related Financial Disclosures
TPB	Theory of planned behaviour
TTM	Transtheoretical Model
UK	United Kingdom
UKCIP	UK Climate Impacts Programme
USAID	United States Agency for International Development
VR	Vulnerability reduction
WRMP	Water resource management plan
WTP	Willingness to pay

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1. Introduction

The Committee on Climate Change (CCC) is an independent, statutory body established under the Climate Change Act 2008. The CCC is tasked with providing independent advice to the UK Government on risks and opportunities to the UK from climate change, in part through the statutory UK Climate Change Risk Assessment (CCRA) and reporting to Parliament on progress in adapting to climate change.

The third CCRA will be published by the UK Government in January 2022, and the Department for Environment, Food and Rural Affairs (Defra) and the Devolved Administrations have asked the CCC to produce an accompanying Evidence Report by summer 2021. The CCC identified several evidence gaps from the previous CCRA released in 2017, and has therefore commissioned six separate studies to address these perceived gaps.

The influence of human behavioural factors on climate change risks that affect people, businesses and the environment (e.g. flooding, water scarcity, hot weather), as well as the ways to enable behaviour change towards more climate-resilient behaviours, are not well-researched. Therefore, to address a perceived evidence gap, this research project has been commissioned with the following overarching objective:

> *To understand the effect of different behaviours on climate change risk – as well as how risk reducing behaviours can be incentivised – taking into account different hazards, target groups, landscape types, and socioeconomic circumstances.*

AECOM was commissioned by the CCC to deliver this project. Acknowledging the importance of capturing nuances from across the different nations comprising the UK, AECOM partnered with the following organisations to support with accessing stakeholders and identifying locally-specific challenges:

- **England and Wales (excluding London)**: Sustainability West Midlands (SWM)
- **Scotland**: Sniffer
- **Northern Ireland:** Climate Northern Ireland (CNI)
- **London:** London Climate Change Partnership (LCCP).

The project team would like to acknowledge the informal contribution of Natural Resources Wales (NRW) staff from several departments, who assisted with identifying and reaching stakeholders to be involved in the research.

1.1 Study objectives and limitations

This study responds to the following research questions:

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?
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?
3. 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)?
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?

- This report should be read in the context of the following limitations:
    - Certain statements made in this report are not historical facts – instead they may constitute estimates, projections or other forward-looking statements, and although they are based on reasonable assumptions as of the date of the report, such forward-looking statements by their nature involve risks and uncertainties that could cause actual results to differ materially from the results predicted.
    - It has not been possible to seek representative samples for surveys and follow-up interviews. The findings may be affected by selection bias, particularly a tendency for respondents to have an existing interest in climate change and environmental issues.

- As with all surveys, findings can be affected by self-reporting bias. Refer to Section 3.3.1 for information on the methods used to limit this.

1.2 How to read this report

The report is structured as follows:

- **Section 2** describes the key concepts and theoretical constructs that underpin the research and this report.
- **Section 3** outlines the approach to data collection and analysis in response to the research questions.
- **Section 4** provides a summary of insights obtained from the suite of peer reviewed and grey literature, as well as semi-structured interviews with relevant practitioners and academics.
- **Section 5** describes findings of the seven case studies used to explore how behaviours adopted in anticipation of, and in response to, climate events can vary in different local contexts. The case studies are based on a mix of surveys and semi-structured interviews, and explore the willingness of participants to change their behaviours under projected changes in climate.
- **Section 6** summarises the key overall findings for each research question, considering all sources of evidence. The Appendices are provided as a standalone document with the following content:
- **Appendix A** includes the literature review protocol.
- **Appendix B** outlines the literature review findings.
- **Appendix C** describes the thematic analysis criteria.
- **Appendix D** outlines iterations of the methodology used, including expert interviews.
- **Appendix E** provides maps of the case studies for Social Flood Risk and Social Heat Vulnerability Indices.
- **Appendix F** is included as a separate spreadsheet and includes a matrix of all behaviours identified in the study, including their current level of adoption and influence on risk. By cross-referencing each behaviour to relevant risk descriptors being used in the third CCRA, this appendix is intended to act as a ‘ready reckoner’ against which authors of the CCRA can incorporate relevant behavioural factors into their deliberations around risk urgency scores.
- **Appendix G** provides a headline summary of the case study interviews.
- **Appendix H** provides an example survey.
- **Appendix I** lists the full suite of behaviours identified.

2. Conceptual framework

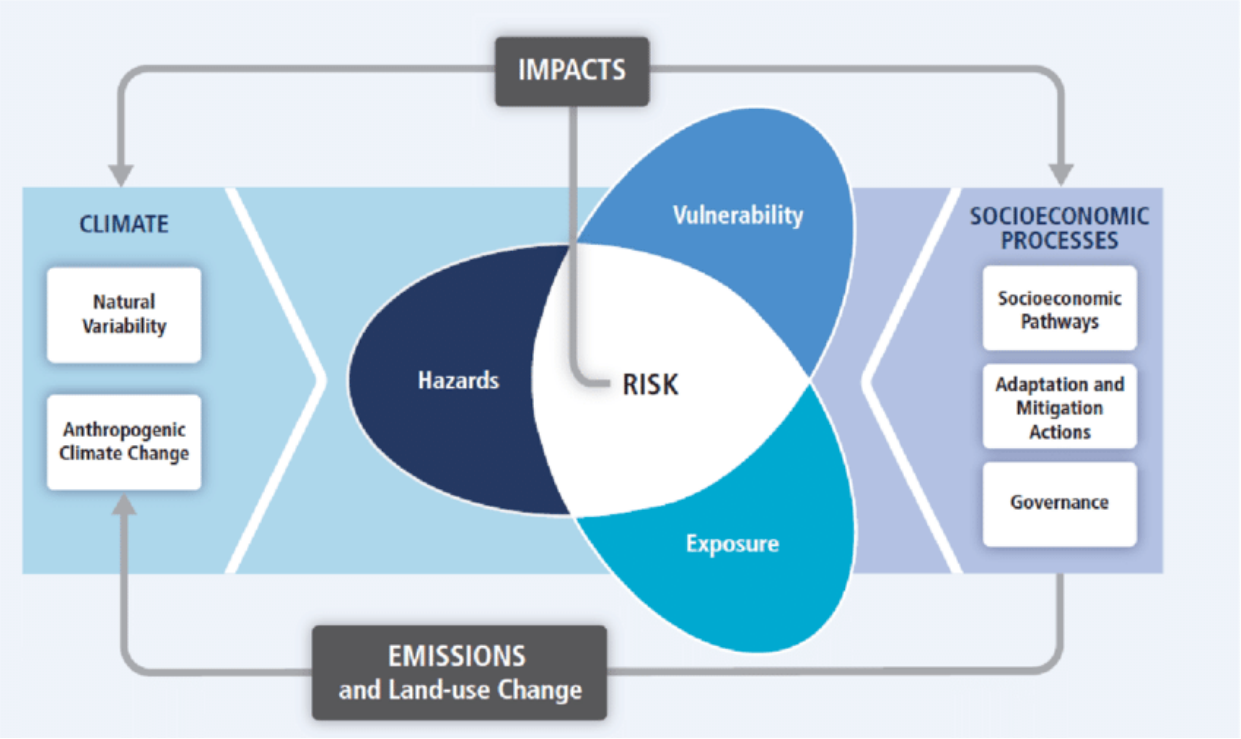
This section describes the key concepts and theoretical constructs that underpin the research and this report.

2.1 Climate change risk

This report uses the CCRA's definition of risk as 'the potential for consequences where something of value is at stake and where the outcome is uncertain' (Humphrey and Murphy, 2016). As 'adaptation projects' can vary widely (e.g. flood management schemes using physical interventions; training and awareness programmes), when evaluating case studies for their potential risk reduction impact, this study distinguishes between projects seeking to influence the different elements of risk as defined by the Intergovernmental Panel on Climate Change (IPCC) in its Fifth Assessment Report (AR5) (IPCC, 2014):

- **Exposure:** The presence of people, livelihoods, species or ecosystems, environmental functions, services, and resources, infrastructure, or economic, social, or cultural assets in places and settings that could be adversely affected.
- **Sensitivity:** Susceptibility to harm.
- **Adaptive capacity:** The ability of systems, institutions, humans and other organisms to adjust to potential damage, to take advantage of opportunities, or to respond to consequences.

Figure 2.1 How risk is conceptualised by the IPCC (2012)



Note that sensitivity and adaptive capacity are subsets of **vulnerability**, which is defined as 'the propensity or predisposition to be adversely affected'.

While this report focuses on climate change adaptation, there are strong synergies between climate change adaptation and disaster risk reduction (DRR) principles, particularly where adaptation is occurring to address risks associated with acute climate-related shocks such as floods. The United Nations Office for Disaster Risk Reduction (UNDRR) defines disaster risk reduction as:

> *'The concept and practice of reducing disaster risk through systematic efforts to analyse and manage the causal factors of disasters, including through reduced exposure to hazards, lessened vulnerability of people and property, wise management of land and the environment, and improved preparedness for adverse events.' (UNIDSR, 2009, p10 -11)*

Both climate change adaptation and disaster risk reduction seek to reduce the vulnerability of populations and assets to hazard impacts, and can use similar tools to achieve these goals. There are ongoing efforts in the UK and globally to integrate these frameworks (Dias et al. 2017).

2.2 Behaviours and adaptation

There is a significant body of evidence available around behaviour change for sustainability (e.g. resource efficiency; greenhouse gas mitigation). To date, a small number of academic papers have been identified that consider the cognitive factors underpinning individual scale climate adaptation (van der Linden, 2015; Osberghaus, Finkel & Pohl, 2010; Grothmann and Patt, 2005). In the grey literature, the United States Agency for International Development (USAID) guide entitled 'Integrating Social and Behavior Change in Climate Change Adaptation' (2019) represents the most comprehensive attempt so far at establishing a practical framework to support use of behaviour change principles to drive adaptation. However, 'behaviours' remain a relatively uncommon term in adaptation research. UK-based research by the Environment Agency (EA) around flood risk communication have considered factors that shape attitudes to risk and how flood risk communication can be improved, beginning from an underlying premise that certain actions are effective in reducing risk. A key difference for this report is the consideration of how and how much different behaviours affect the level of risk posed by different types of climate-related event.

In establishing this conceptual framework, numerous definitions of 'behaviour' and 'adaptation' were reviewed, including those shown in Table 2.1 below.

Table 2.1 Example definitions of behaviour and adaptation from the literature

Definitions of behaviour	Definitions of adaptation
An organism's external reactions to its environment (Shonkwiler & Herod, 2009) Observable activity of an organism; anything an organism does that involves action and/or response to stimulation (Wallace, 1991)	Adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities (IPCC, 2001) All changes an individual makes in order to adjust to a changing environment (Osberghaus, Finkel & Pohl, 2010)

Of particular relevance to this report is the construct of 'autonomous adaptation'. Distinct from 'planned adaptation', which UKCIP (2013) defines as "the result of a deliberate policy decision, based on an awareness that conditions have changed or are about to change, and that action is required to maintain, or achieve, a desired state." Autonomous adaptation occurs in response to experienced climate and its effects, and may not explicitly focus on addressing climate change. The CCRA3 draft methodology focuses on "what will happen in addition to Government planned adaptation". Specifically, the draft methodology refers to:

1. Planned non-governmental action, such as planned adaptation by the private sector.

2. Reactive, spontaneous adaptation which could arise from direct experience of a changing climate. These could involve, for example:

    a) *A natural response, for example, natural species shifts to changing agroclimatic zones, or acclimatisation, for example, the physiological and behavioural acclimatisation of people to experienced higher temperatures.*

    b) *An autonomic (unplanned) response in a system, e.g. reduced winter heating leading to reduced energy demand from automatic temperature control (noting these can be defined as impact or an adaptation).*

    c) *The reactive response of households or the private sector to experienced climate change, including behavioural change (focused on the response to changes experienced, not planned), without any Government intervention.*

    d) *The reactive market response, e.g. the changes in demand, trade, etc. as a result of changing prices from experienced climate change.*

Item 2c above is the focus of this report, which considers those behaviours taken by target groups either in anticipation of, or in response to, different types of climate-related events. This can include implementation of measures that may be commonly considered adaptation actions (e.g. elevating floor levels either in anticipation of, or following, a flood event), as well as more reactive actions that may have an influence on risk but may be considered more through the lens of DRR than climate adaptation (e.g. adhering to an evacuation order). Additionally, while 2c above focuses on responses 'to experienced climate change', it is also critical for the study to consider the influence of the social, political, governance/regulatory and environmental context in which behaviours are undertaken.

To provide more detail on how and how much each behaviour may influence the resultant level of risk, the project team determined that it would be valuable to identify a typology in which different behaviours could be grouped. The literature review revealed several different typologies that have been used to delineate groups of adaptation actions based on their intended outcome (Smit, 2000; Biagini et al. 2014). Of the typologies identified, the approach of Wamsler and Brink (2014, p.89-90) was found most suitable for use in this report. It aligns well with the IPCC's definition of risk but further delineates autonomous adaptation actions into the following categories:

- **Hazard reduction and avoidance:** to limit or avoid exposure to current and future hazards (e.g. managed retreat)
- **Vulnerability reduction:** to reduce current and future vulnerability to hazards (e.g. external solar shading to reduce overheating in buildings)
- **Preparedness for response:** to provide functional and flexible mechanisms and structures for disaster response (e.g. establish a Community Resilience Plan)
- **Coping during crisis:** to provide short-term solutions to mitigate harm during a hazard; solutions cannot be prepared for in advance (e.g. checking on neighbours during a heatwave)
- **Preparedness for recovery:** to provide functional and flexible mechanisms and structures for disaster recovery (e.g. purchasing flood insurance)

It is noted that autonomous behaviours identified in this study will not always be perceived as adaptation to the effects of climate change by those undertaking the behaviour. In many cases, behaviours may be aimed more broadly at building resilience to disruption caused by one or more hazards (which may or may not be climate-related). For example, ensuring flashlights are available can build resilience to power outages, which can have a range of different root causes. However, if someone elected to undertake this behaviour specifically because of a perception that a changing climate will cause more regular power outages, this may indeed be viewed as conscious climate adaptation response.

This issue of what motivates behaviours is highly relevant to research questions two and four in this study, as they relate to the factors influencing certain behaviours, as well as how desired behaviours can be encouraged. The issue of motivation is less relevant to research questions one and three, which seek to understand what behaviours are undertaken, as well as their effect on resultant risk.

3. Report methodology

This section describes the overall report methodology of the study, specifically:

- Variables considered,
- Process for data gathering (i.e. sources of evidence), and
- Process of analysis and reporting on findings.

3.1 Project variables

Table 3.1 describes the variables considered in this report. Refer to Appendix D for further information on how these were refined during the method development process.

Table 3.1 Variables considered in the study

Variable type	Considered in this report
Groups	- **Households** (owners and renters). - **Small and medium-sized enterprises** (SMEs), using the EU definition of a business with fewer than 250 employees and turnover of less than €50 million. Note that the vast majority of the UK's SMEs fall at the smaller end of this range, qualifying as 'micro-businesses' with 0-9 employees. - **Large businesses, which includes business with greater than 250 employees.** - **Communities**. This reflects behaviours that may be decided upon and adopted as a collective.[1] - **Land managers**, which encompasses agricultural land users, as well as individuals and groups managing large tracts of land for other purposes, such as The Land Trust, National Trust, and Historic Scotland. It is acknowledged that some land managers (e.g. smallholder farmers) may also be SMEs. Note that, during the initial development phase, it was agreed that larger corporate businesses would not be a major focus of this report. The focus on SMEs reflect that determinants of adaptation decision-making processes of such businesses (especially micro-businesses) more closely mimic those of decision-making by individuals, as opposed to large corporations that are driven by corporate governance processes and shareholder reporting. However, the literature review provided important points regarding the behaviour of large businesses, in particular how they are driven by different factors. Therefore, discussion around large businesses has been included as a result, noting that no large businesses were included in the case studies outside of water companies.
Climate events	- Flooding and coastal erosion. This encompasses fluvial (river), pluvial (rainfall), and coastal flooding and erosion. Behaviours have been documented under the overall banner of flooding; however, it is indicated where the relevance of a particular type of behaviour varies depending on the type of flooding (e.g. pluvial, fluvial, or coastal). - Extreme heat - Extreme cold - Storms - Droughts The research process has considered each of these event categories separately; however, where relevant it has been acknowledged where risks are a function of multiple interacting hazards, along with where behaviours may be relevant to several types of events. See Table 3.7 for full definitions.
Demographic variables	- Age - Income - Physical health - Gender

[1] The authors acknowledge the breadth of scholarship on the term 'communities.' For the purposes of this report, use of the term communities will specifically refer back to the definition provided above.

Variable type	Considered in this report
	The above variables were considered, where relevant, in the literature review, as well as through case study surveys. While the authors note the importance of mental health as a variable, this information was difficult to obtain, particularly among case study respondents and thus was not included of the demographic variables. As discussed in Section 4, the following composite vulnerability indices were also used in analysis of case studies: - Social Flood Risk Index (Sayers et al., 2017) - Social Heat Vulnerability Index (Lindley et al., 2011)
Nation	- England - Northern Ireland - Scotland - Wales
Land type	- Cities – for the purposes of this report, this has been interpreted more broadly as 'urban areas', as opposed to only those 69 UK settlements currently granted city status. Specific considerations for official cities and larger urban settlements have been noted where relevant. - Rural – using the official UK Rural Urban Classification definition of rural areas as those outside settlements with more than 10,000 resident population - Coastal – communities that are located on the interface or transition areas between land and sea, or large inland lakes. - Islands The distinction between behaviours adopted across different land use types was addressed both through existing literature and selection of case study locations.

3.2 Data gathering

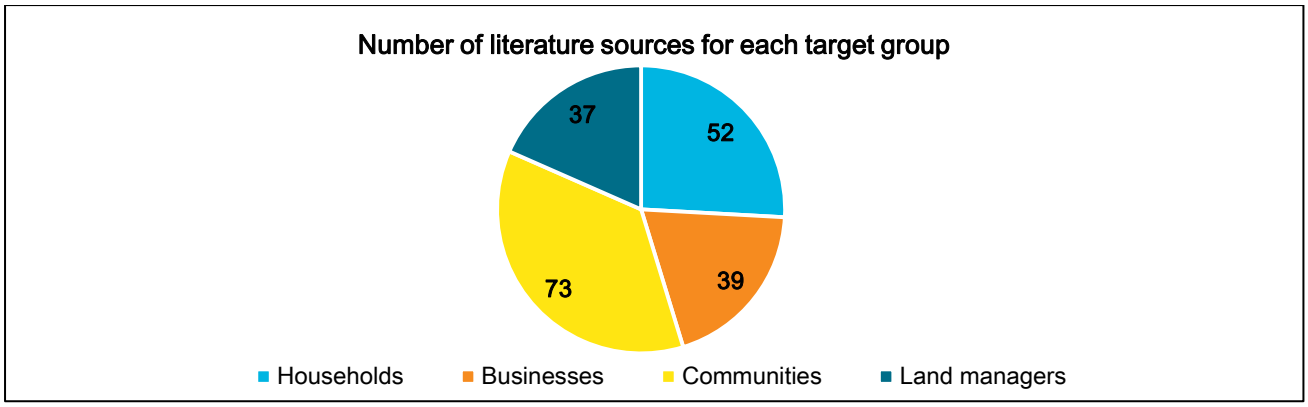
3.2.1 Literature review

An initial literature review was undertaken to assist with refining the project methodology. Considering both peer-reviewed and 'grey' literature, this focused on establishing a foundational understanding of:

- The extent to which 'behaviours' are a commonly used construct in the climate adaptation research and how the term should be treated for the purposes of this report.
- Existing examples of where typologies of behaviours or adaptation actions and their effect on risk have been created in order to assist risk assessment processes.
- Factors influencing decision-making and behaviours. This considered research specifically into decision-making in the context of risk and climate adaptation, as well as more general insights into behavioural determinants from sociological and behavioural economics research.
- Examples of past and current approaches to incentivising adaptation behaviours.
- Past climate-related events across all nations of the UK that could form suitable case studies (see Section 3.2.3).

Following confirmation of the final method, an additional period of literature review was undertaken, building on the initial review. A literature review protocol was developed to guide this process and is provided as Appendix A. Figure 3.1 identifies the breakdown of the literature by target group. The protocol 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) was used to evaluate pieces of grey literature and determine if they are suitable for inclusion in the report (Blakeslee, 2014). The formal literature search and review was supported by ad-hoc desktop research as required throughout the project. Approximately 92% of the sources covered in the literature review were peer-reviewed, and only 8% were classified as grey literature.

Figure 3.1 Breakdown of literature sources by target group



3.2.2 Expert interviews

In addition to the desk-based literature review, 37 expert interviews and nine semi-structured interviews were carried out with researchers and practitioners spanning the areas of climate adaptation, resilience and behavioural science. Conducted either in person or via telephone (depending on logistics), the aim of these interviews was to:

- Build on and test early literature review findings and identify further sources of evidence (including emerging literature or literature at the pre-publication stage).
- Identify factors influencing decision-making, examples of approaches to encouraging/incentivising adaptation behaviours, as well as evidence of the past effectiveness of different behaviours in influencing risk across different local contexts.
- Identify potential case study locations and communities.

Reflecting the need to canvass perspectives of professionals across the four nations of the UK, regional partner organisations (LCCP, CNI, SWM and Sniffer) assisted in developing the list of experts to be interviewed. A 'menu' of interview questions was then developed, with the most suitable questions for each interviewee then chosen depending on their area(s) of expertise, with responses captured in a consistent template. Refer to Appendix D for a high-level summary of the interviews conducted.

3.2.3 Case studies

Findings from the literature review and practitioner interviews, as well as from discussions with regional project partners were used to select seven specific case study locations for more focused research. Case studies reflect locations and target groups with heightened exposure and/or vulnerability to one or more types of climate events; some case studies focused on a specific past event, while others explored behaviours in response to climate-related events in general. The mixture of case studies was selected to cover, where possible, the following aspects:

- All four UK nations (England, Northern Ireland, Scotland and Wales)
- A range of climate-related events and landscape types
- A range of target groups
- Areas with varying socio-spatial vulnerability to climate-related events.

Regional partners played a key role in the selection of case study locations and recruitment of participants. A consistent overall process was adopted for recruitment:

- Engagement with regional partners, who provided a long-list of options in their devolved nation. These locations typically focused on locations or groups with which the partner organisation had some existing relationship, as this could provide a trusted conduit to households, businesses, communities or land managers willing to participate. This initial method of identification may have skewed the selection to locations with an above average level of existing engagement around natural hazards and climate change.

- Review of options for alignment with project research questions and the required mix of variables.
- Obtaining agreement from a trusted community conduit to approach potential participants either via proforma email or telephone call. A project Privacy Policy was distributed at this stage.
- Distribution of an initial survey to those who consented to participating in the process. An example survey is included as Appendix H; it included a question asking if the respondent consented to being contacted by a member of the project team to arrange a follow-up interview. Surveys were piloted by project partners prior to distributing the final survey to case study audiences.
- Scheduling and conducting follow-up semi-structured interviews either via telephone or in-person. Interviews were 30-60 minutes in duration. (see Figure 3.2 for the general structure of the case study interviews).

Due to the large number of variables that can affect adaptation behaviours, the research analysis of the case studies was largely qualitative, although counts were used from survey responses. Representative samples were not sought, and it was not the aim to establish causal links with high generalisability, nor was it the aim to draw direct comparisons between each case study. Rather, the study's case study approach aimed to conduct an in-depth, qualitative exploration of the research questions.

Figure 3.2 General structure of the case study interviews

Table 3.2 Case studies selected

Location	Event types	Target groups	Survey respondents (#)	Interviewees	How were participants identified and contacted?
Orkney Islands	Not specific to one event – storms, fluvial and coastal flooding, heatwaves.	Households, small and large businesses, land managers	105	6	Council advertisements and an interview discussing the project on BBC Radio Orkney.
Greater Manchester	Fluvial flooding (Boxing Day Floods of 2015) and reference to extreme heat.	Households	29	3	Survey issued through trusted community leaders and groups.
London Borough of Lewisham	Extreme heat.	Households	47	1	Survey was distributed to school parents via communications from the head teachers.
Peebles, Scottish Borders	Not specific to one event – storms, fluvial and coastal flooding.	Households and small to medium sized businesses	46	0	The survey was sent out to local organisations in Peebles, including the Peebles Community Trust and Peebles Bridge Community Group.
Llechryd, Ceredigion, Wales	Not specific to one event - fluvial and coastal flooding, storms and extreme heat.	Households	12	4	The survey was distributed to residents via the local village social media pages.

Location	Event types	Target groups	Survey respondents (#)	Interviewees	How were participants identified and contacted?
Northern Ireland	Not specific to one event - flooding, storms and extreme heat.	Households and small to medium sized businesses	32	6	Surveys were issued to all households and businesses that were registered to receive notifications from the Regional Community Resilience Group.
UK Water Companies	Heatwaves and drought	Households Businesses	6	4	The survey was sent out to relevant stakeholders within various water companies. Rather than considering behaviours of water companies, this survey used water companies at informants regarding the behaviours of households and businesses (their customers).

3.3 Analysis

Several types of analysis were used to inform the findings of this report, as described in the following sections. Where overall findings are drawn in Section 5, the sources of evidence are noted along with a confidence level using the approach in Table 3.3 below.

The guidance was derived from the confidence table in the CCRA3 method chapter; this table has been developed specifically for this report as the CCRA3 confidence table specifically relates to each stage of the urgency scoring method, whereas this table relates to the confidence in the analysis of specific behaviours and levels of impact.

Table 3.3 Approach for assigning confidence levels, based on sources of supporting evidence

Confidence level	Description
High	Supported by multiple, reliable and UK-based sources from literature review; or Supported by multiple expert interview sources.
Medium	Supported by at least one reliable UK-based source from literature review; or Supported by at least one expert interview; or Supported by case study analysis from multiple corroborating sources.
Low	Based on professional judgement only; or Based only on international source(s) from literature review; or Identified anecdotally through case study only.

3.3.1 Survey and interview analysis

Following the completion of the surveys, all responses to the multiple-choice, closed questions were input into a data collection spreadsheet. This collective spreadsheet enabled the findings to be summarised across all surveys and allowed key trends to be drawn out. The spreadsheet included all closed questions across the different surveys, allowing for responses between surveys to be compared where the same questions were asked. For clarity, responses were colour-coded according to the type of extreme weather event they related to. See Section 0 for key findings.

While analysing the closed survey responses, the following assumptions were made:

- All respondents understood the questions and interpreted them in a consistent way.
- Respondents were not influenced by external pressures and responses represented the true feelings of the individual or business.

It is understood that the respondents did not comprise representative samples of local residents at each case study location.

This report applied thematic analysis to the open-ended survey questions and to the case study interviews according to the principles set out by Braun & Clarke (2006) (see Appendix C). Thematic analysis was an applicable methodology, particularly to answer the question regarding the factors that drive behaviour because it is flexible and allows the researcher(s) the ability to more deeply interrogate the relevant material to identify key themes and illustrate a broader narrative to answer the research question(s).

This thematic analysis used a deductive approach. That is, the researchers generated an initial list of codes from the literature review and experience conducting the interviews. This frame was, however, flexible and is meant to be within thematic analysis. The analysis occurred as follows:

1. Generate 27 initial codes based on research question, transcribed interviews, and literature reviews.
2. Read through transcribed interviews, coding relevant responses, amending and adding codes where necessary. Once initial list generated, read through again to ensure agreement of findings.
3. Aggregate similar codes together into categories. Using these categories, search for themes.
4. Define, name, and review themes.

The analysis coded all 24 case study interviews. Analysis occurred 'by hand' as opposed to using computer-assisted qualitative data analysis software (CAQDAS). Analysis by hand used Excel software to separate data from the interviews by code. In total, 112 codes were derived and sorted into 12 categories. Section 5.2 describes the underlying themes in detail. This methodology provides additional anecdotal information; however, it is not statistically representative and does not imply causality between certain factors identified and the behaviours.

3.3.2 Evaluating the impact of behaviours on climate risk

Current day

Responding to the question **'How do…behaviours affect (positively or negatively) the impact of different types of climate event?**' required a clear and defensible method that – for each combination of climate-related event, group, and behaviour – considered:

- Current extent of adoption (using the guidance in Table 3.4 below). This considered both:
    - Distribution of adoption across land use and parts of the UK – an action that is applicable across the entire UK will receive a higher score than one adopted only in an isolated area.
    - The extent to which the behaviour is commonly adopted when the circumstances are suitable; for example, a no-cost action adopted by almost all people when conditions dictate will score more highly than a costly measure adopted only by those who can afford to invest in specialised equipment/infrastructure.
- How adopting the behaviour influences the **risk associated with the event** (using guidance in Table 3.5 below). This considered:
    - The type of adaptation action as per Wamsler and Brink's typology described in Section 2.2.
    - The element(s) of risk that is/are affected (exposure, sensitivity and/or adaptive capacity).
    - The relative strength of the effect.

Table 3.4 Guidance for assessing extent to which different adaptation behaviours are currently adopted

Extent of adoption	Description	Example(s)
Widespread (5)	The behaviour is applicable across all land use types and parts of the UK, and when circumstances are suitable, the behaviour is adopted by almost all members of the target group.	Householders seeking cool spaces during extreme heat.
Very common (4)	The behaviour is applicable across most land use types and parts of the UK, and when circumstances are suitable, the behaviour is adopted by most members of the target group.	Changing routines during extreme cold spells.
Moderately common (3)	• The behaviour is regularly adopted, but within a specific land use type or part of the UK, or • The behaviour is only sometimes adopted by members of the target group, though it is applicable across the UK.	a) Fastening down outbuildings with guy ropes on Orkney Islands. b) Small businesses using online data backup systems.
Uncommon (2)	• The behaviour is adopted by a minor proportion of the target group, but it is applicable across the UK, or • The behaviour is sometimes adopted by the target group and is only applicable in a specific land use type of part of the UK.	a) Preparing a household emergency kit b) Adopting climate-smart agricultural principles.
Extremely rare (1)	The behaviour is seldom adopted, even when circumstances may be suitable.	Permanently relocating from locations at risk of coastal flooding.

Table 3.5 Approach for assessing expected influence of each behaviour on risk, if adopted[2]

	Influence on risk	Description (using exposure/sensitivity)	Example(s)
Reduces risk	High (3)	a) Adopting this behaviour is expected to entirely remove exposure to relevant hazard(s), or b) Adopting this behaviour could significantly reduce sensitivity or increase adaptive capacity for relevant hazard(s).	a) Relocating from a flood zone. b) Applying tanking to all ground floor walls to reduce floodwaters entering the home.
	Medium (2)	a) Adopting this behaviour is expected to significantly reduce likelihood of exposure to relevant hazard(s), or b) Adopting this behaviour could partially reduce sensitivity or increase adaptive capacity for the relevant hazard(s).	a) Cleaning out drainage channels. b) Installing removable flood barriers at a property.
	Low (1)	Adopting this behaviour is expected to cause a minor improvement in sensitivity or adaptive capacity.	Keeping windows open at night during heatwaves.

[2] Note that the term 'significant' or 'significance' in this study does not refer to statistical significance.

	Influence on risk	Description (using exposure/sensitivity)	Example(s)
	Negligible (0)	The behaviour has a net negligible influence on the risk, or The behaviour is expected to reduce sensitivity for some but doing so may increase sensitivity or reduce the adaptive capacity of others in the same group.	Bulk-buying supplies in response to a forecast severe weather event.
	Uncertain N/A	There is no clear evidence on how this behaviour influences the risk as described.	NA
Increases risk	Low (-1)	Adopting this behaviour is expected to cause a minor adverse effect on sensitivity or adaptive capacity.	Opening blinds and/or windows during a heatwave day when the sun is out.
	Medium (-2)	a) Adopting this behaviour is expected to significantly increase the likelihood of exposure to relevant hazard(s), or b) Adopting this behaviour is expected to partially increase sensitivity or reduce adaptive capacity for the relevant hazard(s).	Playing sports in heatwave conditions.
	High (-3)	a) Adopting this behaviour is expected to cause exposure to hazard(s) for which there was no exposure previously, or b) Adopting this behaviour is expected to significantly increase sensitivity or reduce adaptive capacity for relevant hazard(s).	a) Building in a flood zone. b) Taking no action in response to a warning.

- This analysis is undertaken for a set of generalised events aligning with accepted definitions, as described in Section3.1. For example, in a generalised extreme heat event, how is risk affected:
    - For a small business owner who purchases air conditioning?
    - For a householder who takes additional cold showers?
- Any potential unintended consequences/maladaptation; for example:
    - Causing someone to underestimate the need to take additional actions (e.g. taking fewer preventative actions after purchasing flood insurance).
    - Behaviours that drive negative feedback loops and/or exacerbate risks experienced by others (e.g. taking additional cold showers places additional pressure on water supplies; installing air conditioning generates additional greenhouse gases or places pressure on peak energy supplies).

Based on this analysis, a set of **National Impact Scores** were calculated. These scores are intended to demonstrate, given the current level of adoption, to what extent each behaviour contributes to risk reduction across the UK. This was calculated as follows using the matrix in

Table 3.6.

Extent of adoption x **Influence on risk**

- It is acknowledged that a broad range of behaviours are covered in this study like (e.g. ‘Keeping windows open at night during heatwaves’ versus ‘Relocating from a flood zone’), and that the efficacy of most behaviours will vary widely depending on the specific circumstances within which it is deployed. **As such, the scoring approach is intended as a high level decision-support tool only – it does not seek to indicate those behaviours that are most desirable or effective in any circumstance, but it may be useful for distinguishing between behaviours that may be adopted in future at sufficient scale in future to have a tangible effect on future risk to the UK, versus those for which the effect may be marginal.**

- The described approach considered each behaviour individually. In other words, it did not specifically assess the influence on risk of *packages of behaviours* (e.g. leaving windows open at night, using personal fan, changing routines). However, it was noted where behaviours could indeed be adopted in a package alongside other complementary behaviours.

Table 3.6 Matrix for scoring influence of each behaviour on risk nationally, considering level of adoption

			Extent of adoption				
Confidence that the behaviour influences risk			Extremely rare (1)	Uncommon (2)	Moderately common (3)	Very common (4)	Widespread (5)
	Reduces risk	High (3)	+3	+6	+9	+12	+15
		Moderate (2)	+2	+4	+6	+8	+10
		Low (1)	+1	+2	+3	+4	+5
		Neutral (0)	0	0	0	0	0
		Uncertain (NA)	NA	NA	NA	NA	NA
	Increases risk	Low (-1)	-1	-2	-3	-4	-5
		Moderate (-2)	-2	-4	-6	-8	-10
		High (-3)	-3	-6	-9	-12	-15

Table 3.7 Generalised events used for analysis of behaviours and their effect on risk

Event type	Definition
Flood (riverine and coastal)	Due to the complex range of factors influencing the severity of a flood event (e.g. velocity of floodwaters; depth; local topography), analysis was not conducted with specific average recurrence interval (ARI) event in mind. However, it was noted during the analysis where certain behaviours may only be effective for flood events up to a certain magnitude.
Flood (pluvial)	See above.
Drought	This report has considered what the EA defines as an environmental drought: 'when a shortage of rainfall is having a detrimental impact on the environment. It is likely that there will be reduced river flows, exceptionally low groundwater levels and insufficient moisture within soils' (Environment Agency, 2017).
Extreme heat	An event that exceeds the threshold for the relevant Met Office National Severe Weather Warning Service (NSWWS) region (°C), (Public Health England, 2018; Met Office, n.d.): - London (32°C day / 18°C night) - South East (31°C / 16°C) - South West (30°C / 15°C) - Eastern (30°C / 15°C) - West Midlands (30°C / 15°C) - East Midlands (30°C / 15°C)

Event type	Definition
	- North West (30°C / 15°C) - Yorkshire and Humber (29°C / 15°C) - North East (28°C / 15°C) - Scotland, Northern Ireland and Wales – (25°C / 15°C).
Extreme cold	This report has used the threshold for a Level 3 cold weather alert ('severe weather action'): mean temperatures of 2°C and/or widespread ice and heavy snow (Public Health England, 2019).
Storm	This report has used the Association of British Insurers Definition; a period of violent weather with (ABI, 2019): - Wind speeds with gusts of at least 48 knots (55mph); or - Torrential rainfall at a rate of at least 25mm per hour; or - Snow to a depth of at least one foot (30 cm) in 24 hours; or - Hail of such intensity that it causes damage to hard surfaces or breaks glass.

4. Case studies

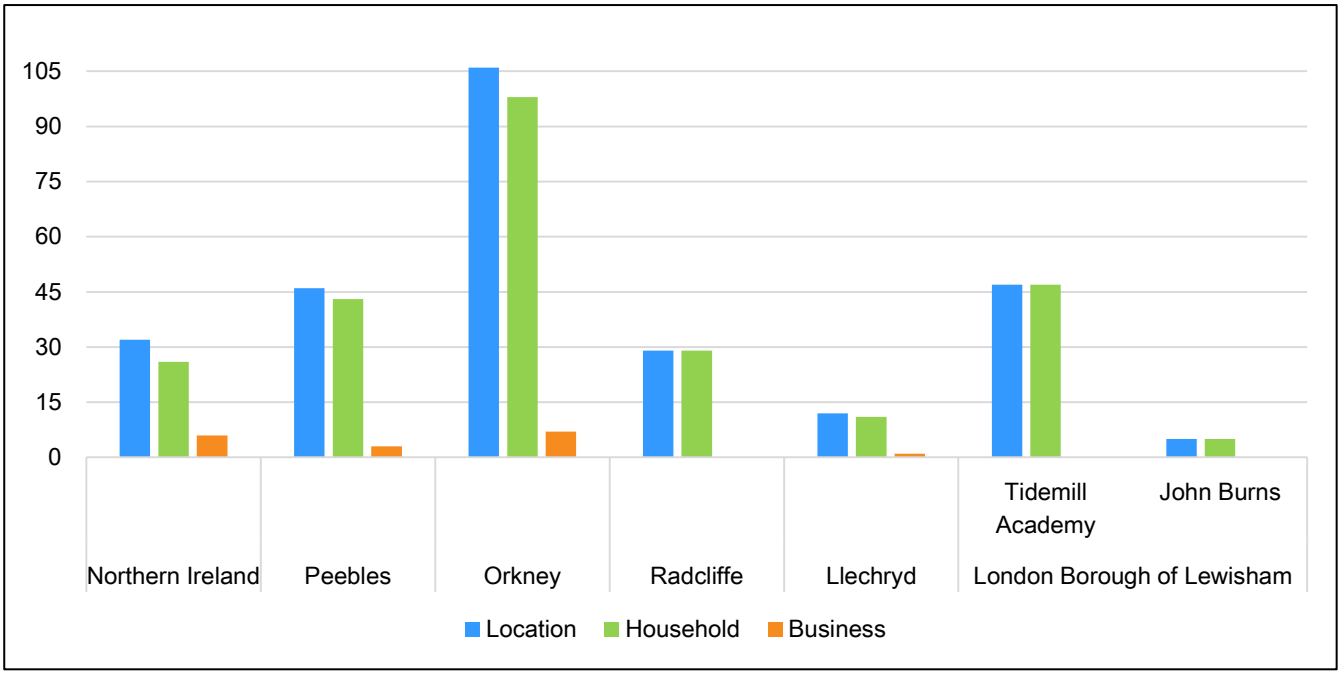
This section discusses the findings of the seven case studies. These case studies focused on the full range of the climate impacts of interest and included both surveys and semi-structured interviews (Figure 3.2 outlines the structure of these interviews). Four case studies – Orkney, Llechryd, Northern Ireland and Peebles – covered target groups' experience of general extreme weather events, while the remaining three covered a specific extreme weather event that the location experienced: Boxing Day Floods in Radcliffe Greater Manchester (2015), extreme heat in the London Borough of Lewisham – which focused on John Burns School and Tidemill Academy - (2018), and 2018 heatwave and meteorological drought experienced across the UK (using UK water companies as informants). As evidenced in Figure 4.1, Orkney received by far the greatest number of survey responses due to strong local support, such as local radio publicity. This skew in the distribution has been acknowledged through the case study analysis. Table 4.1 presents the legend for behaviour typologies which will appear throughout the case studies for clarity.

Each case study section begins with an overview of the type of engagement that occurred, the number of respondents, and background information on the geographic, climate, and social context of the case study. This is then followed by an analysis of the case study findings.

Table 4.1 Legend for behaviour typologies of the interviews

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

Figure 4.1 Number of responses per case study



4.1 Orkney Islands – non-event specific

Case Study Overview

Type of engagement		n
Survey	X	106
Semi-structured interview	X	6
Workshop	X	12

Target groups	
Households	X
SMEs	X
Communities	X
Land managers	X

Event types	
Flooding	
Extreme heat	
Drought	
Extreme cold	
Storms	
Non-specific	X

Typology of behaviour	
Hazard reduction	X
Vulnerability reduction	X
Preparedness for response	X
Coping during crisis	X
Preparedness for recovery	

Context			
Geographic	The Orkney Islands are situated 10 miles off the northeast coast of Scotland. Orkney comprises 70 isles, 20 of which are inhabited. The islands are typically formed of low-lying rock, with the exception of rugged stretches of coastline on Hoy and the western coastlines of some of the islands. Ward Hill on Hoy is Orkney's highest point at 481m.		
Climate	Orkney has a cool temperate climate, influenced by the North Atlantic Drift. It is characterised by mild summers ranging between 14°C and 16°C and cool winters averaging around 2°C. Wind is a common feature of Orkney in all seasons, but winter gales are especially common, typically around Force 7 or 8 (50 – 74 km/h respectively). Winter thunderstorms are also a feature of Orkney with associated lightning strikes. For properties that are vulnerable to flooding in Orkney, coastal flooding is the major risk (97%) (SEPA, 2019). Past examples of major events include: - The Great Storm of 1953 - January 2005 – coastal flooding in Kirkwall, St Mary's and Finstown - October 2006 – fluvial flooding in Finstown and Kirkwall		
Demographic*	**Population**	22,190. Increasing 13.3% since 1998 compared to Scotland's average population increase of 7.1%	
	Distribution by sex	**Female:**	50.3%
		Male:	49.7%
	Age distribution	**≤15:**	16%
		16 – 64	4%
		65 and over	23.6%
	Employment rate	83.7% (HIE, 2019)	
	GDHI**	£18,579 (2016), above UK average. Highest in Scotland.	
Social Flood Risk Index	**Sayers et al. (2017)**	Sayers et al. 2017 identify social flood risk for Kirkwall, the largest settlement on the Orkney Islands, which has the highest risk. The islands of Stronsay, Sanday and North Ronaldsay also have a 'Moderate' Social Flood Risk Index score in the current day, increasing to 'High' in the 2050s under 2°C and 4°C warming scenarios (see Appendix E).	

**Source: National Records of Scotland, 2018*

***GDHI*: The amount of disposal income left over after bills etc., which could theoretically be spent on adaptation measures.

Engagement overview

This survey asked questions about **floods** and **storm** events. Table 4.2 notes the reported current and future behaviours identified through the case study. The Orkney survey was publicised by Sniffer on Orkney Radio. As a result, the survey

had 105 responses, 93% of which were households. 91% lived in freestanding homes. Nearly 70% of respondents were between the ages of 50 and 69, with approximately 15% between the ages of 36 and 49.

In Orkney, the project team conducted a workshop with businesses, land managers, and local government officials to gain further insight into the behavioural practices of Orcadians and the adaptation approaches that businesses were undertaking. Despite the large number of survey responses, only 18 respondents selected that they would be interested in any follow-ups, and of those 18, only 6 responded in the affirmative to an interview request.

Legend:

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

Key findings

Table 4.2 Reported current and future behaviours

Current behaviours			
S	**F**	**PRes**	Stockpiling sandbags
S	**F**	**PRes**	Prepare or purchase a household emergency kit
	F	**PRes**	Move items to higher floors
	F	**PRes**	Listen to radio for information
	F	**PRes**	Have removable flood barriers handy
	F	**PRes**	Install flood doors
	F	**PRes**	Have flashlights handy
	S	**VR**	Park cars in the direction of the wind
	S	**VR**	Tie down potentially loose objects
	S	**VR**	Install surge protector
	S	**VR**	Trim trees and branches near buildings
	M	**VR**	Install generators
	S	**CC**	Turn off power mains
F	S	**CC**	Follow evacuation orders

Reported future change in behaviour			
	F	**HR**	Move to higher ground
S	**F**	**PRes**	Change insurance providers or increase insurance coverage

As the only island case study, Orkney has specific considerations for climate-related events. Transport between the islands occurs via ferry, small aircraft, helicopter (typically in instances of emergency) or car (particularly via the Churchill causeways linking the four islands that make up mainland Orkney). The transport links are a critical component that make up vulnerability in Orkney.

Orkney is unique among the six case studies in that the major extreme weather events are high winds and storms, which have been typical of Orkney for centuries. As a result, the Orcadian mindset has been shaped in part by these conditions, that preparing for bad weather is just a way of life, and it is necessary to maintain a certain amount of flexibility and calm in the face of disruption. A common thread in the surveys was that people felt they took all necessary precautions. Even in the event of severe storm conditions, few suggested that they would do anything significantly different in future. Indeed, there was an element of humour involved. In response to a question about what, if anything, a respondent would do to prepare for a future event given past experience. Their response was "*Nothing. Or maybe remember which of the neighbours has the best chain saw."*

Respondents revealed that the most common actions that they might take in response to storms were preparedness for response actions, including having a flashlight handy (46%) and putting together a household emergency kit (25%). As Figure 4.2 shows, other vulnerability reduction behaviours were less common, specifically turning of main power or gas lines, shuttering windows and having removable flood barriers ready.

Behaviour responses to flood events seemed to be less common than behaviour responses to storm events among Orkney households and businesses (see

Figure 4.3). However, survey responses highlighted the following actions that are most likely to be taken in response to a flood event: putting together a household emergency kit, having stores of sandbags and moving items to higher floors.

Figure 4.2 Behaviours Orkney respondents indicated they might take in response to storms

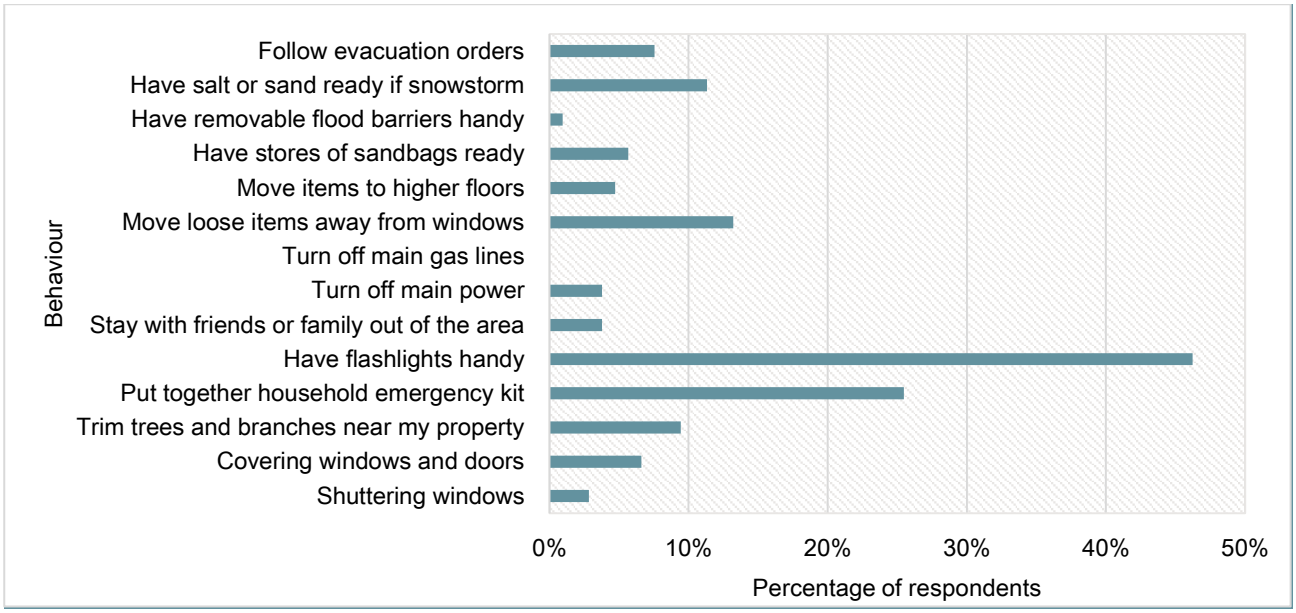
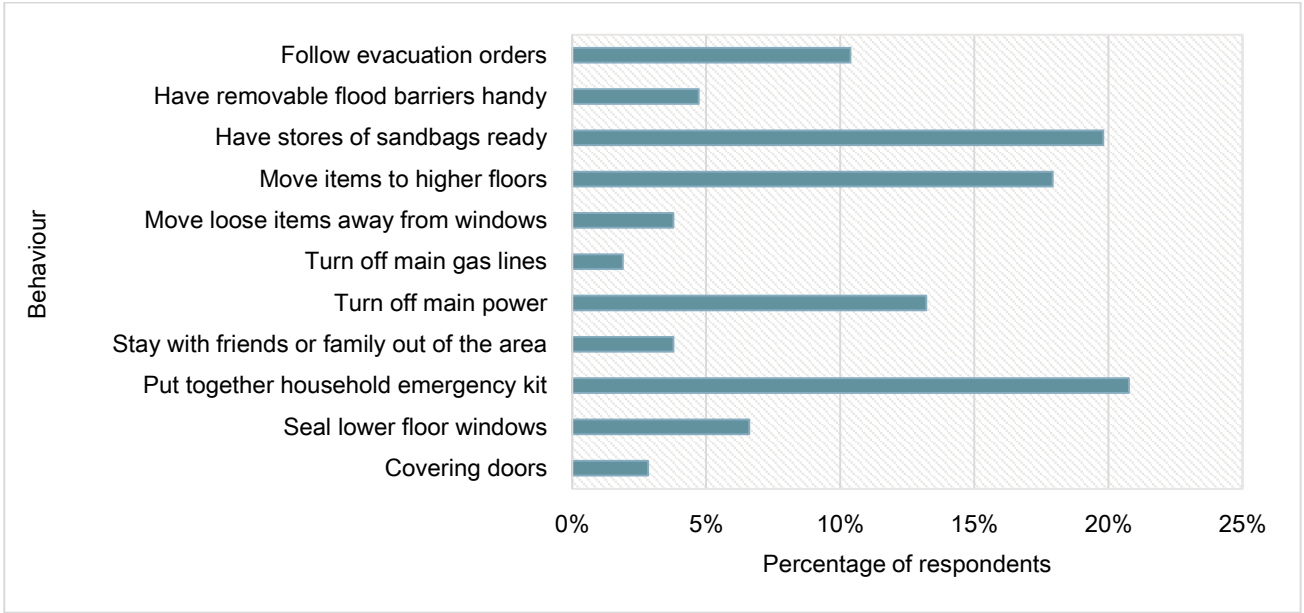


Figure 4.3 Behaviours Orkney respondents indicated they might take in response to flooding



Sea level rise was more of a concern in Orkney, particularly for lower-lying islands like Sanday. Coastal flooding is relatively common in Kirkwall, St Margaret's Hope, and St Mary on mainland Orkney, and many of the outlying islands similarly face coastal flooding. One interviewee explained that "*the community will be mostly impacted by sea level rise and not the heat events…the sea level rise is a bit of a bigger problem than the heat*". Many respondents and case study interviewees noted that Sanday is particularly at risk of being split in half by rising sea levels. Similarly, respondents consistently noted flooding as a concern in St Margaret's Hope, a coastal community directly on the shore. Two case study interviews provided anecdotal evidence of Stromness residents using their ground floors as storage space and placing belongings on pallets that could float in the event of a storm.

In Orkney, learning from neighbours – whether through speaking directly or through observing patterns of behaviour – was noted as a crucial means by which new residents learned the necessary practices to reduce risk of damage or disruption.

There is a difference between native Orcadians and incomers, although the term 'incomers' is not pejorative, many did note that they were either unaware of appropriate risk-reducing behaviours upon moving to Orkney. There was also anecdotal discussion about some incomers who had bought property on the shorefront at Stromness who did not install any flood mitigation technologies despite neighbours expressing concern, that were then flooded and left Orkney. One interviewee stated, "*I can think of only one person who sold their house and said, "I can't do this again*," *and they were incomers and hadn't been there very long…people had said to them, "You do realise that this is going to happen?" But no, they didn't take it, they didn't put in storm doors and they could have afforded to."*

Mechanisms used to incentivise certain behaviours

SEPA has implemented various methods to incentivise Orcadians to reduce their risk, specifically to flooding. This includes a new flood warning system that includes an updated flood forecasting model. Floodline and SEPA's Resilient Communities Initiatives also promote 'self-help' measures to encourage property-owners to take their own measures to protect against flooding. As of 2016, SEPA has also partnered with Neighbourhood Watch Scotland to raise awareness about flooding.

Limitations of case study

Orkney Islands represent a very specific environment in the UK. Therefore, the findings from this case study are extremely context specific and are less applicable to other extreme events in other regions in the UK (although findings may resonate with some other island communities, chiefly in Scotland). Additionally, despite the large sample size of the survey for this case study, respondents tended to be biased towards people aged 50 and over, and those in freestanding homes. Therefore, respondents did not accurately reflect the whole population of Orkney, and therefore insights from other groups within the community may be missing from the findings.

Box 4.1 Summary of key findings in Orkney

- A common thread in the surveys was that people felt they took all necessary precautions to storm events. Even in the event of severe storm conditions, few suggested that they would do anything significantly different in future. This is likely in part because Orcadians, by virtue of the culture on the islands as described by respondents, feel like have high social capital and, therefore, many of the behaviours they undertake focus on increasing their adaptive capacity.
- Typically, the low-cost methods employed by Orcadians decreased their sensitivity to the impacts of high winds and storms (e.g. surge protectors, back-up generators) or decreased exposure (e.g. securing objects with guy ropes to reduce changes of damage to or from windblown objects).
- Sea level rise was more of a concern in Orkney than pluvial flooding.
- Learning from neighbours was noted as a crucial means by which new residents learned the necessary practices to reduce risk of damage or disruption.
- Given the projected future of more climate extremes, Orkney evidences the need for integrating flexibility and redundancy into systems which could be drawn out in other locations(e.g. hotels taking last-minute reservations for Orcadians stuck on different parts of the islands if ferries or roads close due to poor weather; installing backup generators in case main power goes out).

Relevant CCRA Risk Descriptors: People and the Built Environment (41, 42, 43, 45) Business (52, 53, 56, 57)

4.2 Peebles, Scottish Borders – non-event specific

Case study overview

Type of engagement		n
Survey	X	46
Semi-structured interview		
Workshop		

Target groups	
Households	X
SMEs	X
Communities	X
Land managers	

Event types	
Flooding	X
Extreme heat	
Drought	
Extreme cold	
Storms	X
Non-specific	

Typology of behaviour	
Hazard reduction	X
Vulnerability reduction	X
Preparedness for response	X
Coping during crisis	X
Preparedness for recovery	

Context			
Geographic	Peebles is the county town of Peeblesshire, in the Scottish Borders, approximately 22 miles south of Edinburgh. Peebles is located at the confluence of Eddleston Water and the River Tweed.		
Climate	Peebles has a temperate maritime climate, with July as the hottest month and January as the coldest. Rainfall varies seasonally, with most precipitation falling in December. The winter temperature is typically around 5°C. Peebles experiences fluvial flooding due to its location on the River Tweed. Significant historical floods include: • December 2013 – Tweed Green was inundated by riverine floodwaters. • December 2015: Storm Frank contributed to the largest flood event in Peebles (1 in 55 year), with property inundation • 2018 – High flow event • February 2020 – High flow event Peebles has also experienced intense snow events, including during the 2018 Beast from the East event.		
Demographic**	**Population***	8,376 (Our Scottish Borders, 2011).	
	Distribution by sex	**Female:**	51.4%
		Male:	48.6%
	Age distribution	**≤15:**	16.5%
		16 – 64	59.1%
		65 and over	23.6%
	Employment rate	73.1% (Scottish Borders Council, 2013)	
	GDHI	N/A	
Social Flood Risk Index	**Sayers et al. (2017)**	Overall, Peebles has low to high flood vulnerability, coinciding with the course of the river. Vulnerability remains consistent under both 2°C and 4°C warming scenarios in 2050 (Sayers et al. 2017; see Appendix E).	

*__Source__: *Our Scottish Borders, 2011*

**__Source:__ *National Records of Scotland, 2019.*

Engagement overview

This case study targeted households (93.1% of respondents) and businesses (6.9%). Table 4.3 notes the reported current and future behaviours identified through the case study. The survey was sent out via Sniffer to local organisations

in Peebles – Peebles Community Trust and Peebles Bridge Community Group. Peebles Community Trust provided 29 responses and Peebles Bridge Community Group provided 17 responses. Most respondents lived in free-standing homes (45%), had lived in their homes between 5 and 20 years (50%), and were between the ages of 50–69 (60%). No follow-up interviews were conducted in Peebles due to lack of responses among survey respondents.

Legend:

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

Key findings

Table 4.3 Reported current behaviours and potential future behaviours

Current behaviours			
S	C	PRes	Have stockpile of non-perishable food
S	F	PRes	Prepare or purchase a household emergency kit
F	CC	PRes	Move items to higher floors
	M	PRes	Have flashlights on hand
		VR	Have salt or sand ready if snow/ice storm
	F	VR	Have removable flood barriers handy
	S	VR	Move loose items away from windows
	S	VR	Turn off power mains
	S	VR	Cover doors and windows
	S	VR	Turnoff gas connections
	C	CC	Seal lower-flood doors
S	F	CC	Stay with family or friends outside of the area

Reported behaviour change in future		
S	VR	Prearrange flexible working

Half of the survey respondents stated that their property had been adversely affected by severe weather events in the past, with 36% of respondents experiencing a financial cost because of these events. The most commonly reported types of severe weather experiences were heavy snow (68.8%), high winds (43.8%), heavy rain, and flooding (18.8%).

The survey results suggested that the most common method of finding out whether a severe storm was predicted to occur was social media and then mobile alerts. Social media was also the most commonly used method for finding out whether a flood was predicted to occur; neighbourhood groups were found to be the next more common ahead of mobile alerts. However, this finding is likely to have been biased by the method of survey distribution via community groups.

The most common behaviours cited in preparation for a storm or flood event fell under vulnerability reduction or preparedness for response. As shown in Figure 4.4, survey respondents revealed that the most likely actions they would take in response to a storm event would be having flashlights ready (50%) and having salt or sand ready (41%). In regard to flooding, Figure 4.5 demonstrates that having stores of sandbags ready (37%) and moving items to higher floors (37%) were the most commonly reported behaviours taken in response to a flood event. Specifically, there was higher than average proportion of people that noted they would have a store of sandbags ready in advance of a flood. This may in part be due to the size of the town and its location directly on the River Tweed, which is prone to flooding.

Only 11% of respondents noted that they had taken permanent protective measures to prepare their property for extreme events. Despite this, 48% of respondents felt that it was their responsibility to protect their properties from flooding, although 43% felt that this should be a government responsibility.

Figure 4.4 Behaviours that would be undertaken by Peebles survey respondents in response to storms (n = 46)

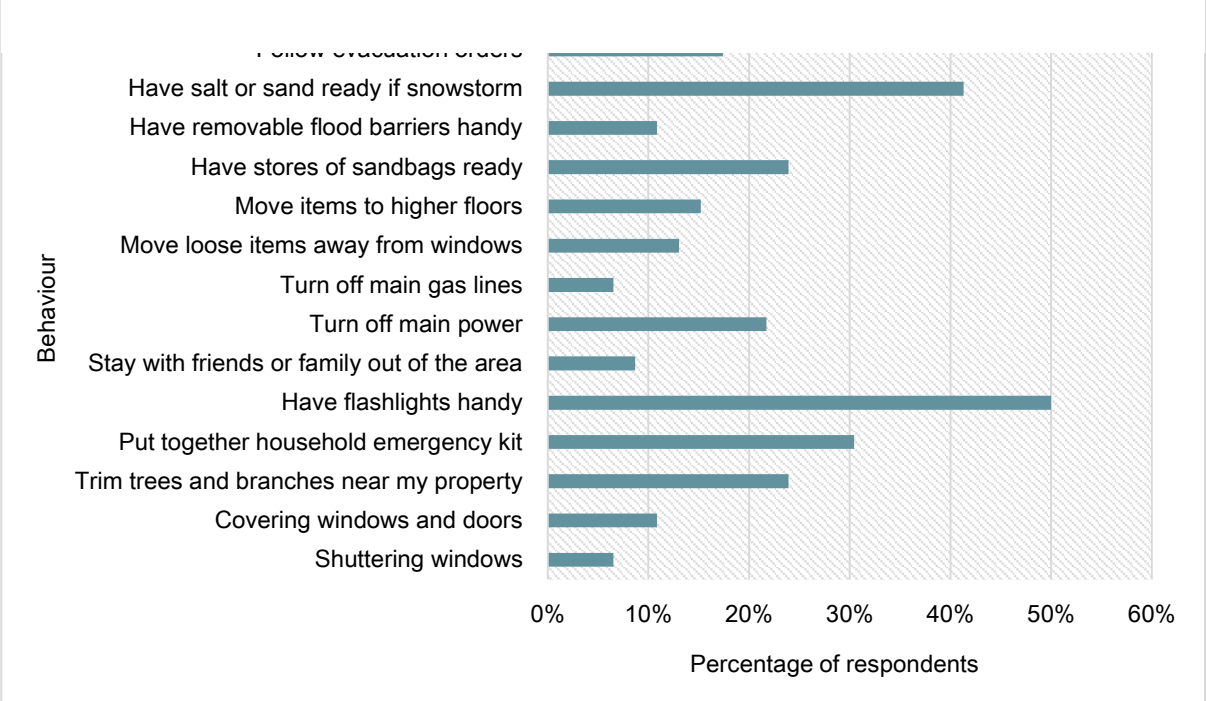
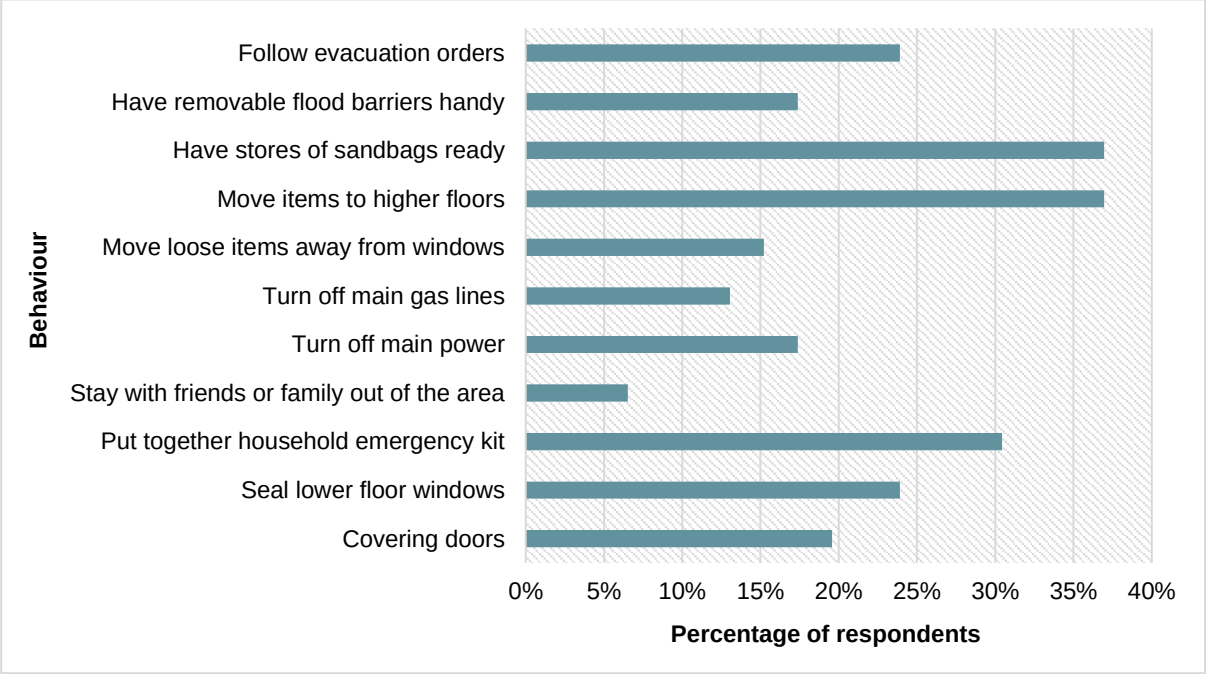


Figure 4.5 Behaviours that would be undertaken by Peebles survey respondents in response to flooding (n = 46)



Mechanisms used to incentivise certain behaviours

The most commonly reported factor that would encourage respondents to take actions to protect their properties from extreme weather was having more information regarding what they could do. In addition to the need for greater communication and knowledge transfer, the survey highlighted a desire for financial support, as just under a third of respondents agreed that they could not afford to spend money on measures to protect their homes or businesses from severe weather events. Moreover, around a third of the survey respondents stated that they would be more likely to install flood resilience measures in their properties if their neighbours did it too. This is an example of how descriptive norms can influence decision-making around climate adaptation.

SEPA's Tweed Flood Risk Management Strategy includes various interventions for areas along the Tweed River, including Peebles. This includes flood forecasting, self-help measures, and awareness raising to incentivise protective

behaviour generally (SEPA, 2013). SEPA operates the Scottish Flood Forecasting Service (SFFS), which is a free service in partnership with the Met Office. Through the SFFS, regional flood alerts (Floodline) are issued to the public. A daily assessment provides a projection of the five-day flood forecast to allow time for people and organisations to prepare (Scottish Borders Council, 2019). For SEPA's self-help scheme, Peebles residents have access to a Property Level Protection Scheme via Scottish Borders Council Flood Product Scheme. This scheme has been implemented by Scottish Borders Council in Peebles, protecting 39 homes (Scottish Borders Council, 2019).

SEPA's awareness-raising activities pertinent to Peebles include direct and digital engagement campaigns to raise awareness of Floodline. Additionally, they produce a quarterly email newsletter – Flooding Gateway. They have also partnered with Education Scotland and Scottish Government Resilience to integrate flood literacy in the Curriculum for Excellence. Residents can also contribute local flood conditions to SEPA's online tool (Scottish Borders Council, 2019). Scottish Borders Council operates resilient community schemes which, in part include promoting the FloodRe Insurance Scheme, to which residents at flood risk can apply for affordable insurance (Scottish Borders Council, 2019).

Limitations of case study

The survey had a relatively small sample size of 46 participants. Additionally, due to a lack of interest among participants, there were no follow up interviews conducted for this case study. Surveys were therefore the only data collection methods used, and hence there was a lack of qualitative interview data to support the survey findings.

While this case study covered both businesses and households, respondents were contacted via the Peebles Community Trust and Peebles Bridge Community Group. Therefore, residents and businesses within Peebles that are not members of these groups, were excluded from the sample population. Finally, the sample population was found to be biased to older individuals, who live in free-standing homes. This is not fully representative of the Peebles community, and therefore findings cannot be generalised for the whole area.

Box 4. 2 Summary of key findings in Peebles

- Most respondents had been impacted by heavy snow, high winds, heavy rain and flooding events, which commonly resulted in a financial cost.
- The most common behaviours cited in preparation for a storm or flood event are either typed as vulnerability reduction or preparedness for response.
- A higher than average number of participants noted they would have a store of sandbags ready in advance of a flood.
- About 1 out of 10 respondents noted that they had taken permanent protective measures to prepare their property for extreme events and only one third felt a high degree of responsibility for protecting their own property from flooding.
- Most respondents noted they would be more likely to take action if they had the information required to make changes.
- Financial support and seeing their neighbours act, were also found to be key factors for encouraging adaptation behaviours to protect their properties from severe weather events.

Relevant CCRA Risk Descriptors: People and Built Environment (32, 35, 37, 38, 39, 41, 44, 45) Businesses (52, 56)

4.3 Northern Ireland – non-event specific

Case study overview

Type of engagement		n
Survey	X	32
Semi-structured interview	X	6
Workshop		

Target groups	
Households	X
SMEs	X
Communities	
Land managers	

Event types	
Flooding	
Extreme heat	
Drought	
Extreme cold	
Storms	
Non-specific	X

Typology of behaviour	
Hazard reduction	
Vulnerability reduction	X
Preparedness for response	X
Coping during crisis	X
Preparedness for recovery	

Context			
Geographic	Northern Ireland occupies 17% of total UK land, and has a coastline of 334 miles (World Atlas, n.d).		
Climate	Northern Ireland has a temperate oceanic climate, with cold, rainy winters and mild, somewhat rainy summers. Atlantic frontal systems largely drive precipitation in Northern Ireland, with an average of 750 to 1000mm of annual rainfall. Headline projections for Northern Ireland include increased winter rainfall leading to more severe and frequent flooding, decreased summer rainfall leading to increased pressure on water availability, and more frequent extreme heat events (NI Direct, 2019). Net sea level rise on the Irish coast is approximately 3 mm per year. The sea level in the north of Northern Ireland is, in fact, rising at about 0.4 mm per year from isostatic rebound; thus, rates of sea level rise will occur more rapidly in the south than in the north (Garbutt, 2018).		
Demographic*	**Population****	1.88 million	
	Distribution by sex***	**Female:**	51%
		Male:	49%
	Age distribution	**≤15:**	20.9%
		16 – 64	30.8%
		65 and over	31.9%
	Employment rate	72.3%	
	GDHI	£15,813	

**Source: Nisra, 2018*

***Source: Woodland Trust, 2019*

Source: ***Northern Ireland Statistics and Research Agency, 2012

Note that Social Flood Risk Indices are not available for Northern Ireland.

Engagement overview

This survey was non-event specific and focused on severe storms and flooding affecting households and businesses in Northern Ireland. Surveys were issued to all those registered to receive notifications from the Regional Community Resilience Group. Table 4.4 notes the reported current and future behaviours identified through the case study.

The survey was completed by 32 respondents (26 households, 6 businesses). Approximately 80% of respondents lived in a freestanding (40%) or semi-detached (40%) house. Respondents were mostly between 50-69 years old (62%) and married (60%). Nearly all were property owners (95%). Around 75% of respondents had been living at their current residence for over 5 years. Six respondents who agreed to be contacted after the survey subsequently participated in a semi-structured interview, conducted by Climate NI.

Legend:

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

Key findings

Table 4.4 Reported current and future behaviours

Current behaviours		
F	CC	Asked for pump from emergency services
M	CC	Follow evacuation orders
M	PRes	Have stores of sandbags ready
M	PRes	Put together household emergency kit
S	VR	Have flashlight handy
S	VR	Have salt or sand ready if snowstorm
S	VR	Move loose items away from windows
S	VR	Trim trees and branches near my property
S	VR	Covering windows and doors
M	VR	Stay with family or friends out of the area
M	VR	Turn of main power
M	VR	Turn off main gas lines
S	VR	Install shuttering windows
S	VR	Check for loose tiles
F	VR	Covering doors
F	VR	Have removable flood barriers handy
F	VR	Move items to higher floods
F	VR	Seal lower floor windows
F	VR	Build boundary wall around perimeter of property
F	VR	Purchased water pump

Reported behaviour change in future		
S	VR	Get more information on where to get sandbags
F	VR	Moving valuable possessions upstairs permanently
S	PRes	Seek more information on what measures should be taken
F	VR	Purchase water pumps
S	VR	Install electricity generators

Approximately 68% of the survey respondents noted that their property had been adversely affected by an extreme weather event, with 86% of these respondents being impacted by flooding. Of those respondents impacted by severe weather, over half noted that there was a financial cost to repair the damages. Case study interviews also highlighted the

toll on mental health (e.g. loss of sleep, anxiety, stress on relationships, constant checking of weather forecast) both during the event and in the aftermath.

Given the means of distributing the survey, it is not surprising that nearly all respondents indicated using mobile alerts to find out about predicted severe storms. This was followed by television (64%), radio (55%), and online news sites (45%). To find out about flooding, in addition to mobile alerts (81%), television (55%), and radio (45%), respondents also turned to government websites (55%).

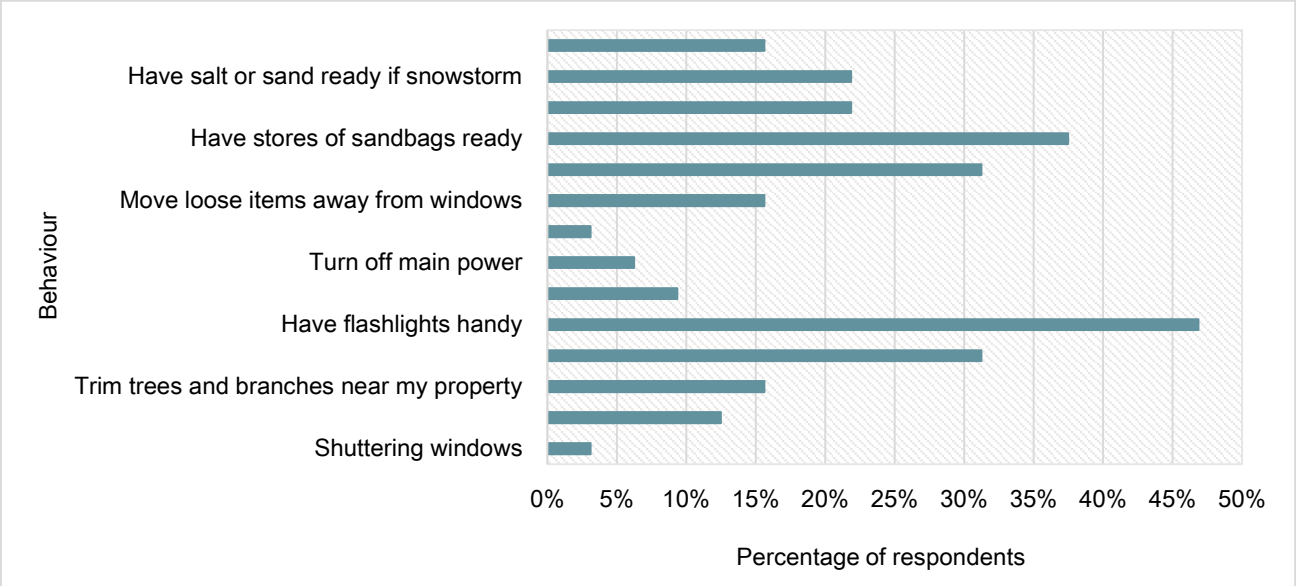
This case study focused on both storms and flood events. According to the survey findings, having flashlights handy was the most common preparatory measures households would be likely to take (47%) (see Figure 4.6). Similarly, having stores of sandbags ready (44%) is the most likely behaviour to be undertaken in response to flooding. Respondents also revealed that they would be likely to cover doors (38%) and have removable flood barriers handy (38%), in response to a flood event (see Figure 4.7).

Only 28% of respondents stated that they have taken permanent protective measures to prepare their properties for severe weather events. However, nearly all respondents agreed (90%) that their neighbourhood would pull together and help each other in case of an extreme weather event.

85% of survey respondents noted never having received any kind of Government grant to support with storm or flood protection. The 15% that did receive support used it for removing trees close to their property, installing impact-resistant windows, and replacing wooden floors or carpets with concrete or tile.

Several interviewees also noted that even if they wanted to move to a non-flood prone area, it would be unlikely they are able to sell their current property.

Figure 4.6 Behaviours that would be undertaken by the Northern Ireland survey respondents in response to storms (n=32)



Mechanisms used to incentivise certain behaviours

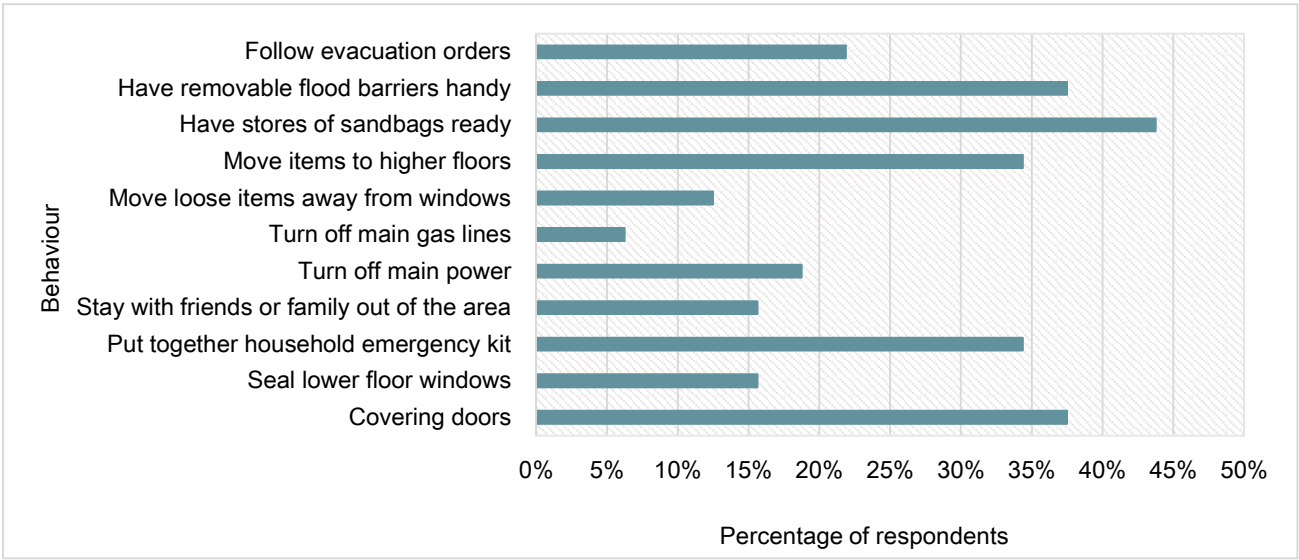
Approximately three quarters of respondents agreed with the statement that it is the Government's responsibility to protect people's homes and businesses from flooding, and around 67% of respondents strongly agreed that they would likely take more actions to protect their property if there was financial support available from Government. When one interviewee was asked whether they would undertake more flood protection measures, they responded saying "*if there was more financial assistance from the Government*", explaining that there is currently "*no assistance …[the] protection grant doesn't even include us because we've only been flooded once*." This highlights how decisions about the design of planned adaptation measures (e.g. eligibility for grants) can influence adaptation decision-making on the ground.

Interviewees also noted that despite willingness to act, there is only so much within the remit of households and communities, and government support is needed for wider infrastructure upgrades as well as setting guidelines for not

building in flood zones. One interviewee stated that they had "*no idea really about what local government or the Government is doing about the bigger picture*."

In addition to government action and financial support, nearly all the respondents (97%) agreed that they were more likely to take property protection measures if they had more information on what they could do.

Figure 4.7 Behaviours that would be undertaken by the Northern Ireland survey respondents in response to flooding (n=32)



Box 4.3 Summary of key findings in Northern Ireland

- Case study interviews also highlighted the toll on mental health and the emotional both during severe weather events and in the aftermath.
- Nearly all respondents indicated using mobile alerts to find out about predicted severe storms, followed by television, radio, and online news sites. To find out about flooding, in addition to mobile alerts, television, and radio, respondents also turned to Government websites.
- Interviewees noted that even if they wanted to move to a non-flood prone area, it would be unlikely they are able to sell their current property.
- There is consensus among survey respondents that it is the Government's responsibility to protect people's homes and businesses from flooding, with just under 70% of respondents stating that they would be more likely to take action if they received financial support from the Government.
- Nearly all the respondents agreed that they were more likely to take property protection measures if they had more information on what they could do.

Relevant CCRA Risk Descriptors: People and the Built Environment (41, 44, 45) and Business (52, 56)

4.4 Greater Manchester – Boxing Day floods

Case study overview

Type of engagement		n
Survey	X	32
Semi-structured interview	X	9
Workshop		

Target groups	
Households	X
SMEs	
Communities	
Land managers	

Event types	
Flooding	X
Extreme heat	X
Drought	
Extreme cold	
Storms	
Non-specific	

Typology of behaviour	
Hazard reduction	X
Vulnerability reduction	X
Preparedness for response	X
Coping during crisis	X
Preparedness for recovery	

Context			
Geographic	Radcliffe is a town located in the Metropolitan Borough of Bury, which is situated within Greater Manchester. The town lies in the Irwell Valley on the course of the River Irwell. The town centre of Radcliffe is predominantly surrounded by open space and rural land.		
Climate	Fluvial and surface water flooding is common in Radcliffe and the surrounding areas of the Irwell Valley. The three most recently documented floods occurred in 2010, 2012 and 2015. The latter, which occurred on Boxing Day, was the most severe, involving flooding of 600 houses and displacement of residents for up to 12 months. Headline climate change projections for Greater Manchester include increased winter rainfall leading to more severe and frequent flooding, decreased summer rainfall leading to increased pressure on water availability, and more frequent extreme heat events. Past examples of major events include: • The Boxing Day Floods of 2015 • Main River flooding at Castle Irwell in 2008 • Second hottest summer temperatures in Greater Manchester, 2018		
Demographic*	**Population**	**33,609.** Decreasing by 7.2% since 2001 compared to England's average population increase of 7.9%.	
	Distribution by sex	**Female:**	51.1%
		Male:	48.9%
	Age distribution	**≤15:**	20.5%
		16 – 64	65.8%
		65 and over	13.7%
	Employment rate	70.5%	
	GDHI	£15,794 (2017), below UK average	
Social Heat Vulnerability Index	**Lindley et al. (2011)**	Social heat vulnerability Index for Radcliffe ranges from relatively high to average.	
Social Flood Risk Index	**Sayers et al. (2017)**	For surface water flooding and river and coastal flooding, the current day Social Flood Index scores for Radcliffe ranges from low to very high. The Social Flood Risk Index scores for surface water flooding and river and coastal flooding are shown to increase in the 2050s under 2°C and 4°C warming scenario (See Appendix E).	

**Source:* *Nomis. 2011*

Engagement overview

The case study focused on residents of Radcliffe in Greater Manchester that were affected by the 2015 Boxing Day **flood** event. The questions were targeted towards behaviour regarding flooding, but behaviour in relation to extreme heat was also covered in the interviews. Table 4.5 notes the reported current and future behaviours identified through the case study.

There was a total of 29 survey respondents, all of which were from households affected by the 2015 Boxing Day flood event. Over 70% of the households were owned by the occupier, with the majority being freestanding houses or terrace townhouses. Nearly 50% of respondents were over 50 years of age, with approximately 24% of respondents between the ages of 36 and 49.

Of the 29 survey responses, nine of the respondents selected that they would be interested in participating in a follow-up interview. These individuals were contacted, and three survey respondents subsequently agreed to participate in a semi-structured interview via a 30-40-minute telephone call.

Key findings

Since this case study focused on residents impacted by the 2015 Boxing Day floods, flooding was found to be the most common type of severe weather that has been experienced in Radcliffe. Over half of all respondents were severely affected by the 2015 Boxing Day flood event and over three quarters of respondents experienced adverse financial impacts.

Importantly, prior to the 2015 Boxing Day flood, approximately 60% of respondents indicated that they did not receive advance warning. As a result, just under half of the households stated that they undertook temporary actions to prepare for the flooding. The most common temporary actions taken to prepare for the floods include the following:

- Moving items to higher floors (42% respondents)
- Turning off mains power (29%)
- Checking on safety/preparedness of relatives, friends and/or vulnerable neighbour (26%)
- Coordinating with neighbours (26%)
- Securing loose objects around the property (19%)
- Having a flashlight on hand (19%)
- Covering windows and doors (16%)
- Staying with friends or family out of the area (16%)
- Turning off main gas lines (16%)
- Following evacuation orders (16%)

Only 6% of respondents indicated that they took any permanent protective measures to protect their properties, prior to the flooding. Of the few permanent
More specifically, several residents indicated that they had moved or were planning to move in the future due to flooding. One concerned interviewee said "*I know that some of the houses in this village have not sold because of flooding. Me, personally, I will have to move eventually*", while another confirmed that they "*wanted to move to a new house since we were flooded*".

Interviewees raised concerns that even with household efforts to reduce the risks of flooding, development was still occurring on areas of high flood risk in Radcliffe. Consequently, there seemed to be a general call from residents for more robust planning of new developments on flood plains within the surrounding area.

In terms of extreme heat, interviewees suggested that they would be likely to purchase air conditioning in the future. One respondent suggested that "*they've now put air conditioning as standard in all cars so I can see it happening as standard in all new builds in the next five years*". Their answers suggested a belief that older households were more likely to purchase mobile air conditioning units to keep cool, while new builds would increasingly have air conditioning built into them.

Legend:

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

Table 4.5: Reported current and future behaviours

Current behaviours		
F	CC	Check on safety/preparedness of relatives, friends and/or vulnerable neighbours
F	CC	Changing plans to be home during the event
F	CC	Follow evacuation orders
F	HR	Move to a new location
F	PRes	Seek advice from others
F	PRes	Put together household emergency kit
F	PRes	Written flood disaster plan
F	VR	Coordinate with neighbours
F	VR	Covering windows and doors
F	VR	Secure loose objects around property
F	VR	Have flashlights handy
F	VR	Stay with friends or family out of the area
F	VR	Turn off main power
F	VR	Turn off main gas lines
F	VR	Move loose items away from windows
F	VR	Move items to higher floors
F	VR	Have store of sandbags ready
F	VR	Have removable flood barriers handy
F	VR	Raise appliances
F	VR	Move electrical sockets higher up the wall
F	VR	Install puddle pump
F	VR	Remove or do not plant large trees close to property
F	VR	Install impact-resistant windows
F	VR	Install water-resistant skirting boards
F	VR	Replace floors or carpets with concrete or tile
F	VR	Covert garage
F	VR	Flood doors / walls
F	VR	Brick up unneeded air stones
F	VR	Tanking to all ground floor walls
F	VR	Water proof paint
F	VR	Closable air bricks
F	VR	Plastic between the brickwork and plaster
F	VR	Flood protection barriers for doors
F	VR	Encourage the council to clear the drains from debris
F	VR	River / bank maintenance

Reported behaviour change in future		
F	CC	Earlier evacuation
F	HR	Move property
F	VR	Move cars
F	VR	Move valuables upstairs
F	VR	Improved flood insurance cover
H	VR	Purchase air conditioning

H	VR	More frequent showers
H	VR	Seek shade
H	VR	Wear a hat

Mechanisms used to incentivise certain behaviours

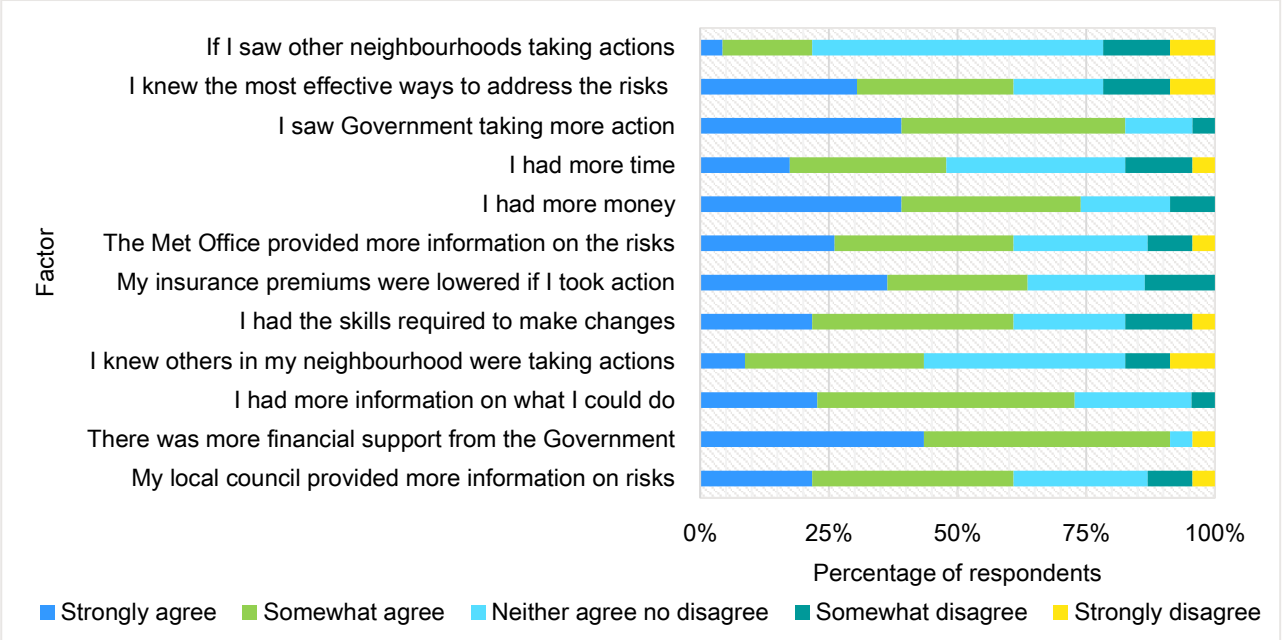
The EA is the lead organisation in helping residents understand and manage flood risk in Greater Manchester. This involves providing resilience and event response advice in person, online and in print. Additionally, Bury Council provides information on flooding and adaptation measures on the council's website. The EA also holds about three events per year briefing residents on the measures that they can take to reduce their flood risk or prepare for flood events (Bury Council, 2018) Finally, the Greater Manchester Resilience Forum, in partnership with the EA and Bury Council, provides educational materials on how to respond to coastal change and flooding.

Figure 4.8 shows the key factors that may incentivise survey respondents to take more action in response to severe weather events. According to the survey results from this case study, just under three quarters of respondents agreed that they would be more likely to take actions to protect their properties from flooding if there was more financial support or information from the Government. Similarly, over 65% of respondents stated that they would be more likely to take actions to protect their properties from flooding if they saw the Government taking more action. Only 17% of respondents agreed that seeing their neighbours taking actions encouraged them to have actions to prepare their properties for future flooding.

Limitations of case study

This case study is subject to several limitations. First, the survey had a relatively small sample size of 29 participants, and only three of these respondents participated in a follow-up interview. Additionally, the sample group was not fully representative of the Radcliffe community, with a bias towards households that are owned by the occupier and individuals who are over 50 years old. Finally, the 2015 Boxing Day floods were an example of a rare and extreme flood event, and therefore the findings may not be applicable to other smaller, less severe flooding events across the UK.

Figure 4.8 Factors that would encourage Radcliffe respondents to undertake actions to prepare for future events (n = 23)



Box 4.4 Summary of key findings for Radcliffe

- Flooding was the most common type of severe weather that has been experienced in Radcliffe.
- Over half of all respondents were severely affected by the 2015 Boxing Day flood event and over three quarters of respondents were financially impacted by the flooding.
- Prior to the 2015 Boxing Day flood, approximately 60% of respondents indicated that they did not receive advance warning.
- Around half of the survey respondents stated that they would be more likely to take actions to protect their house from flooding if they had more information on what they could do.
- The most commonly adopted behaviours during this flood event were moving items to higher floors, turning off the main power and gas power, and coordinating with neighbours.
- Since the flood event, the most common permanent protective measures taken by residents were moving electrical sockets up the wall, replacing floors or carpets with concrete or tile and raising household appliances.
- Several residents indicated that they had moved to a new house or were planning to move in the future due to flooding.
- Following the floods, grants of £5,000 were offered to support residents protect their homes from future flooding. Some residents used this money to purchase flood walls or doors.
- There was strong agreement from survey respondents that they would be more likely to take actions to protect their properties from flooding if there was more financial support from the Government.
- In terms of extreme heat, interviewees suggested that they would be likely to purchase air conditioning in the future.

Relevant CCRA Risk Descriptors: People and the Built Environment (41, 44, 45) and Business (52, 56)

4.5 Llechryd, Ceredigion, Wales - flooding

Case study overview

Type of engagement		n
Survey	X	12
Semi-structured interview	X	5
Workshop		

Target groups	
Households	X
SMEs	X
Communities	
Land managers	

Event types	
Flooding	
Extreme heat	
Drought	
Extreme cold	
Storms	
Non-specific	X

Typology of behaviour	
Hazard reduction	
Vulnerability reduction	X
Preparedness for response	X
Coping during crisis	X
Preparedness for recovery	

Context			
Geographic	Llechryd is a rural village located within the principle area of Ceredigion in Wales. The village is situated on the bank of the tidal River Teifi and lies less than 10 miles away from the Welsh coast.		
Climate	Besides riverine flooding, Llechryd's location on the western coast of Wales also exposes the village to the impacts of coastal storms, which are predicted to increase in intensity as a result of climate change. As the climate changes, Llechryd and the surrounding area of Ceredigion will be at higher risk of more frequent and intense flood events. Additionally, being located on the floodplain of the River Teifi which is susceptible to flooding, exposes the surrounding community to fluvial flooding. Moreover, given the area's close proximity to the coast, flooding from the sea is likely to become more frequent with sea level rise. Ceredigion and the remainder of Wales will likely see average summer temperature increase by 4°C to 7°C under RCP8.5. Additionally, summer heatwaves will occur 50% of the time by 2050 and are likely to be more prolonged (UKCP, 2018). Past examples of major events include: • Storm Callum in 2018 • Warm and dry summer of 2018 • North Ceredigion floods of 2012 • Coastal flooding of early 2014		
Demographic*	**Population**	**75,922** (Ceredigion) Increasing 1% since 2001 compared to average population increase of 5.5% in Wales.	
	Distribution by sex	**Female:**	50.2%
		Male:	49.8%
	Age distribution	**≤15:**	14.9%
		16 – 64	64.5%
		65 and over	20.8%
	Employment rate	61%	
	GDHI**	£17,835 (2017), above Wales average, below UK average.	
Social Flood Risk Index	**Sayers (2017)**	Llechyrd is exposed to both surface water flooding, with its Social Flood Risk Index scores increasing under 2°C and 4°C warming scenarios (see Appendix E).	

****Source: Nomis, 2011***

***GDHI**: The amount of disposal income left over after bills etc., which could theoretically be spent on adaptation measures.

Engagement overview

The case study focused on local residents and small businesses within Llechryd and the wider area of Ceredigion. The questions were targeted towards behaviour regarding extreme weather in general, but specifically looked at flooding and storms. Table 4.6 notes the reported current and future behaviours identified through the case study.

The survey was distributed via social media, by posting on the Facebook pages of the local village. There was a total of 12 survey responses, 11 of which came from households and one of which came from a local business. All the respondents were over 35 years of age, with 40% being in the 50-69 age category. Approximately half of the households were freestanding homes and around 60% of households were owned by the occupier.

Of the 12 survey responses, five of the respondents selected that they would be interested in participating in a follow-up interview. All of these individuals were contacted, and four respondents agreed to participate in a 20-30 minute semi-structured telephone interview.

Legend:

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

Key findings

Table 4.6 Reported current and future behaviours

Current behaviours		
F	CC	Follow evacuation orders
F	PRes	Put together household emergency kit
F	VR	Remove or do not plant large trees close to property
F	VR	Covering doors
F	VR	Seal lower floor covers
F	VR	Stay with friends and family outside of the area
F	VR	Turn off main power
F	VR	Turn off main gas lines
F	VR	Move loose items away from windows
F	VR	Move items to higher floors
F	VR	Have stores of sandbags ready
F	VR	Have removable flood barriers
F	VR	Landscape the surrounding area
F	VR	Water capture mechanisms
F	VR	Community resilience group

Reported behaviour change in future		
F	VR	Ensure that electricity is self-generated
F	VR	Increase house insulation
F	VR	Flexible working
F	VR	More community engagement
F	VR	Changing transportation methods
H	VR	Purchase air conditioning

Approximately half of the survey respondents' properties have been adversely affected by extreme weather events. Of these respondents, most commonly reported events that have been experienced in Llechryd were flooding, high winds and heavy rain.

The most common way that respondents find out if a flood was predicted to hit their community was social media (50%), following by news websites (42%), and Government websites (33%). Interestingly, none of the respondents stated that they used or would use mobile alerts of automated voice messaging services to find out about flood events.

The majority of Llechyrd case study respondents had undertaken vulnerability reduction actions, including structural modifications on their properties and through community activities that strengthened their adaptive capacity (e.g. developing a local Community Resilience Group). Aside from property modifications, interviews revealed that some of the respondents took other permanent actions to reduce their vulnerability to multiple hazards, including flooding and droughts. For example, one interviewee discussed how they had "*created a swale…and we've got various water run offs and ponds etc. so that we can capture that water on site and then use it obviously during the drought of the summer*".

Finally, there was frustration among respondents that large-scale developments were still being approved on floodplains and agreement that Government institutions needed to make adaptation a priority issue, with a joined-up approach among all different departments and agencies. The following quote from an interviewee summarises these concerns: "*we're still getting large scale developments happening … in flood plains etc. or not properly taking into account what is actually going to be happen in the next 50 to 100 years …. [we need] an overall joining of the dots across all of the various Governmental institutes whether at local or national level, and at a business level, particularly commercially where business wants to make business*".

Mechanisms used to incentivise certain behaviours

Natural Resources Wales (NRW) provides information online and in print on preparing for and responding to a flooding event. Approximately half of the survey respondents agreed that they would be more likely to take actions to protect their properties from extreme weather events if they had more time, money and information to support them. Around half of the survey respondents stated that they would be more likely to take actions to protect their homes from flooding if they received financial support from Government. While local community resilience groups set up within the local area seem to have been received very positively by local residents, only 25% of respondents agreed that seeing their neighbours taking actions would encourage them to take actions to prepare their properties for future flooding.

Limitations of case study

The survey had a particularly small sample size of 12 participants, and only four of these respondents participated in a follow-up interview. Additionally, the sample group was not fully representative of the Llechryd community, with a bias towards freestanding households that are owned by the occupier and individuals who are over 35 years old. Finally, the survey was distributed via social media, therefore residents and businesses that are not users of social media would have been excluded from this study. Analysing the frequency of survey responses for sample of this type is unlikely to provide usable insights, and hence the findings of this case study focus on the descriptive information provided in semi-structured interviews.

Box 4.5 Summary of key findings in Llechryd

- The majority of extreme weather that has been experienced in Llechryd was flooding, high winds and heavy rain.
- Government websites, news websites and social media were the most common ways that residents and businesses would find out if a flood was predicted to occur.
- The most common behaviour that residents indicated that they would take to prepare for a flood was putting together a household emergency plan.
- Only 25% of survey respondents indicated that they have taken measures to prepare their properties for severe weather events, and these tended to involve minor changes such as removing or not planting large trees close by their houses.
- There was a general agreement that people would be more likely to take actions if they had more information, more time and more money to support them to do so.
- Local community resilience groups have been set up within the local area and these are very positively received by local residents.
- There was frustration among respondents that large-scale developments were still being approved on floodplains.

Relevant CCRA Risk Descriptors: People and the Built Environment (41, 44, 45) and Business (52, 56)

4.6 London Borough of Lewisham – extreme heat

Type of engagement		n
Survey	X	52
Semi-structured interview	X	1
Workshop		

Target groups	
Households	X
SMEs	
Communities	X
Land managers	

Event types	
Flooding	
Extreme heat	X
Drought	
Extreme cold	
Storms	
Non-specific	

Typology of behaviour	
Hazard reduction	X
Vulnerability reduction	X
Preparedness for response	X
Coping during crisis	X
Preparedness for recovery	

Context			
Geographic	The Borough of Lewisham is situated in south London. The River Ravensbourne and its tributaries (River Quaggy, River Pool, and Honor Oak Stream) pass through the borough. The River Thames forms a small stretch of the borough's northern boundary with the Isle of Dogs.		
Climate	**Heat** Despite the many green spaces in the Borough, Lewisham, as most inner London boroughs, suffers during heatwaves. London also generates the UK's strongest urban heat island effect. This can result in inner city areas (including Lewisham) being up to 10°C warmer than the rural areas around London, as observed during past heatwaves (EPA, 2014). London has already seen mean summer temperature increase by 1.9°C between 1961 and early 2000s (City Hall Greens & JCSC, 2019). The mean daily maximum temperature in London is projected to be 3.7°C by 2050, under a medium emissions scenario and 50% probability level. Additionally, heatwaves as experienced in 2003 and 2018 are projected to be normal summers by the 2040s (City Hall Greens & JCSC, 2019). **Flooding** Flooding from the River Ravensbourne has been recorded in the area since 1809, with major incidents in 1968, less severe incidents in 1977, 1992 and 1993 (Environment Agency, 2018), and minor events as recently as October 2019. There are approximately 4,000 homes and businesses located within the floodplain between Catford and Lewisham, with 420 homes and 90 businesses classified at high or medium risk of floodwater entering their property (Environment Agency, 2018).		
Demographic*	**Population**	275,900 (GLA Intelligence, 2012).	
	Distribution by sex	**Female:**	50%
		Male:	50%
	Age distribution	**≤15:**	20.6%
		16 – 64	70%
		65 and over	9.4%
	Employment rate	84%	
	GDHI	NA	
Social Heat Vulnerability Index	**Lindley et al. (2011)**	Lewisham's social heat vulnerability is relatively to extremely high. Most residential areas of Lewisham have a social heat vulnerability of relatively to extremely high (See Appendix E).	

****Source: Nomis, 2011***

Engagement overview

The case study focused on school parents from two schools. Parents were chosen because they could speak of their experience of adapting in their own homes and in preparing their children for dealing with heatwaves at school. The questions were targeted to behaviour regarding **extreme heat.**

The survey was distributed via the school's head teacher. There were 52 responses recorded, all of which were households, and half of which had been living in the borough between five and 20 years. The split between renters and owners was fairly even. The majority of respondents were between 36–49 years old, followed by 18–35 years old. Half of the respondents were married. Despite initial positive indications of willingness for a follow-up interview, after multiple attempts by the researchers only one respondent was able to commit time for a follow-up interview.

Legend:

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

Key findings

Table 4.7 Reported current behaviours and potential future behaviours

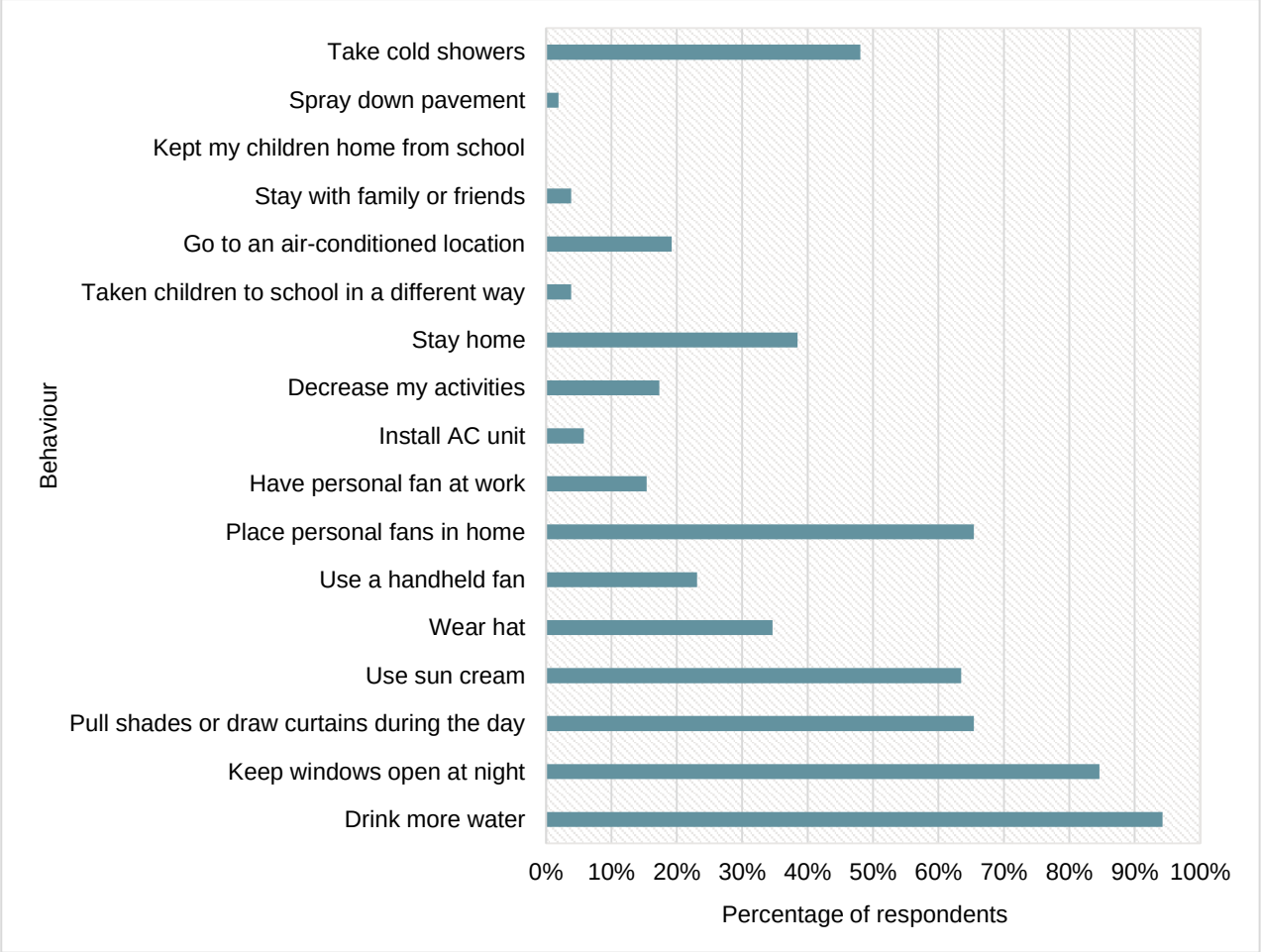
Current behaviours		
H	HR	Seek cooling on the coast
H	VR	Drink water to stay hydrated
H	VR	Keep windows open at night
H	VR	Draw curtains
H	VR	Use sunscreen
H	VR	Install air conditioning unit
H	VR	Place personal fans in home
H	VR	Spray down pavement
H	CC	Take cold showers
H	CC	Stay at home
H	CC	Check on elderly neighbours
H	CC	Wear hats when outdoors
H	CC	Use handheld fan
H	CC	Use personal fans at work
H	CC	Change transport patterns
H	CC	Go to a public air-conditioned location
M	CC	Stay with family or friends outside of the area

Reported behaviour change in future		
H	HR	Install air conditioning units

Approximately half of the survey respondents revealed that their household is uncomfortable during hot weather, yet only one household was found to have air conditioning installed. All other households took alternative action to cope with hot weather, with the most common behaviours including drinking more water, keeping windows open at night, drawing curtains during the day, using sun cream, placing personal fans at home and taking cold showers. Interestingly, none of the respondents indicated that they would keep their children off from school, and few had indicated that they had taken their child or children to school in a different way due to warm weather.

Figure 4.9 below shows the occurrence of each of the extreme heat behaviours among the survey respondents.

Figure 4.9 Behaviours undertaken by Lewisham survey respondents in response to extreme heat (n=52)



Some respondents considered purchasing air conditioning if heatwaves were to become more frequent but indicated they would need more information on how effective this measure would be before making the investment. One interviewee stated that "*if it were to become a regular thing that we have sort of heat waves every summer, it might possible to think about air conditioning one room, but honestly, the fans seem to work really well*".

Approximately 40% of respondents agreed that there was nothing they could to stop their home from overheating, and 15% of respondents do not have a specific plan for coping with hot weather. Aside from household modifications, over 80% of respondents felt that they know exactly what to do to cope with hot weather.

Mechanisms used to incentivise certain behaviours

London City Hall provides information about responding to heatwaves. The Refill London scheme and app also provides information on where Londoners can access water refill stations throughout the city.

Approximately half of the survey respondents revealed that they cannot afford to spend money on measures that protect their home from overheating. Additionally, 40% of households did not agree that they know where to go to find advice on coping for heat. The interviewee felt that "*if the local borough is doing anything to combat heat…I don't know about it, so they should be shouting about it if that's what they're doing*".

If the responses in this case study are reflective of mindsets more widely, this may suggest that, in the absence of investment in physical measures to reduce vulnerability, better communication and behavioural nudges will be needed to encourage coping behaviours during periods of warm weather.

Limitations in the Case Study

The survey had a relatively small sample size of 52 participants, and only one of these respondents participated in a follow-up interview. Additionally, the sample group was made up of middle-aged parents of children who attend primary school in Lewisham. Data sourced from these respondents are hence not representative of more vulnerable cohorts, such as such as the elderly. The findings from this case study cannot be generalised for the whole of the Borough or London more broadly.

Box 4.6 Summary of key findings for Lewisham

- Of the respondents, 62% lived in a flat or apartment. Only one respondent currently had an air conditioning unit. Half of the total respondents considered their home uncomfortable during hot weather.
- The most frequent reported negative consequence of extreme heat was having difficulty sleeping. Further frequently reported knock-on effects from extreme heat outside the home included overheating of the workplace, feeling unwell while travelling, and disruption of daily routine.
- Drinking more water, keeping windows open at night, using fans at home, drawing the curtains, and using sun cream were the top five most frequently reported actions taken to cope with hot weather.
- No respondents indicated keeping their children from school, and few had taken their child(ren) to school in a different way.
- Some respondents considered purchasing air conditioning if heatwaves were to become more frequent, but indicated they would need more information on how effective this measure would be before making the investment.

Relevant CCRA Risk Descriptors: People and the Built Environment (32, 33, 34, 35, 37, 38, 39, 45, 46) and Business (56)

4.7 UK water companies – 2018 drought

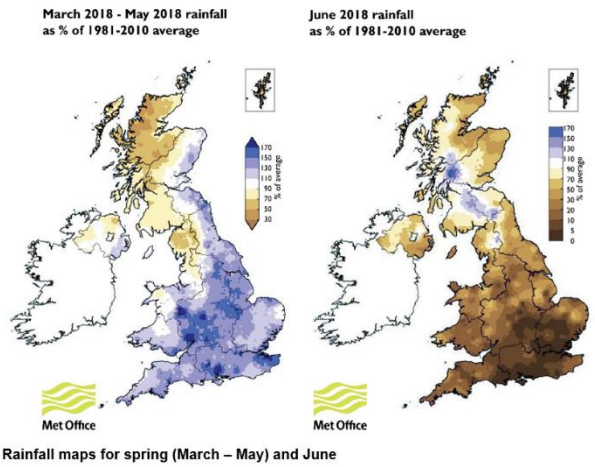
Case study overview

Type of engagement		n
Survey	X	6
Semi-structured interview	X	5
Workshop		

Target groups	
Households	X
SMEs	X
Communities	X
Land managers	X
Large business	X

Event types	
Flooding	
Extreme heat	X
Drought	X
Extreme cold	
Storms	
Non-specific	

Typology of behaviour	
Hazard reduction	
Vulnerability reduction	X
Preparedness for response	X
Coping during crisis	X
Preparedness for recovery	

Context	
Geographic	The UK has 25 water suppliers across its devolved administrations. OfWat (Water Services Regulation Authority) regulates water and sewage management in England and Wales, and Welsh Water (Dwr Cymru) is operated as a non-profit corporation which services most of Wales and part of Western England. Scotland and Northern Ireland are both supplied by state-owned corporations/entities – Scottish Water and Northern Ireland Water respectively.
Climate	While Scotland and Northern Ireland are supplied by one institution in each nation, England's water companies operate within different locations that have different sources and levels of water availability. This highly localised context has implications for how these water companies respond to climate events such as the summer 2018 heatwave. Some companies source their water largely from aquifers that rapidly recharge; others abstract from rivers and store water in reservoirs. These differing operational realities mean that different companies have different risk of drought conditions. Most of the UK was affected by a summer heatwave and associated meteorological drought from June – August 2018 (UK Centre for Ecology & Hydrology, 2018).  Figure 4.10 Met Office maps of the 2018 meteorological drought Source: *UK Centre for Ecology & Hydrology, 2018.*

Note: Demographic, social flood risk index and social heat vulnerability index information have not been added to this table as they are not applicable to the case study on UK water companies, given the whole-country coverage of the case study.

Engagement overview

This case study targeted officials from water companies, using them as informants on the behaviours of their customers (households, small businesses, large businesses, and land managers). The case study focused on heatwaves and droughts. Table 4.8 notes the reported current and future behaviours identified through the case study.

The survey was sent out to relevant stakeholders within various water companies via project partners including Sniffer, NIEL's Climate Northern Ireland programme's network, and Sustainability West Midlands in July 2019. Representatives of six water companies agreed to participate. Five respondents subsequently indicated they would be willing to be interviewed, and ultimately four respondents took part in an interview in November 2019.

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		

Table 4.8 Reported current and future behaviours

Current behaviours			Reported behaviour change in future
D	CC	Water consumption increased across the board (customers)	NA
D	CC	Anecdotal evidence that customers washed cars less frequently	

Key findings

In response to the 2018 heatwave, three of the six of the water companies surveyed stated that they had to enact drought response measures, specifically relating to hosepipe bans. All water companies surveyed noted that their customers' water use increased. However, there were regional differences, as one interviewee stated that "*between April and almost October, we saw an average of 20% increase in demand for water from our domestic customers in the south, and we also saw not quite as great, but probably about a 12% increase in demand for water in the north-east*". Some companies said that increased consumption water use was within their expected range. One noted that "*2018 was exceptional in the length of time demand remained high",* although the increase was still within dry year planning. Another stated that they witnessed a 29% increase in demand, which was "*in excess of the peak demands modelled for a 1-in-40 drought*". Importantly, all the water companies confirmed that there had not been any discernible lasting changes to water consumption patterns since the heatwave.

Three of the four interviewed participants noted that elderly people are more likely to exhibit water-saving behaviours. Two of the four interviewees noted that rural households were more likely to exhibit water-saving behaviours because of the perception that their water is locally-sourced – that is, if they can see a river level is lower than normal, they may assume that their water supply is similarly low, even if this is not actually the case.

All the water company employees surveyed agreed that households, followed by agricultural users were the most important customers to target to improve the resilience of the UK's water supply. These were based on their professional opinion.

Mechanisms used to incentivise certain behaviours

According to the survey results the following factors were highlighted as the biggest barriers to water-saving behaviour generally:

- Income to undertake changes
- Information on behavioural changes people can make to decrease water consumption
- Information on future water availability and impacts
- Belief that it is the responsibility of water companies.

Water companies have a whole range of activities to encourage customers to use less water. These activities are company specific, but include: working with schools, water efficiency home visits (to install water saving gadgets, give advice, fixing leaking toilets), use data generated by smart meters (where these are installed) to identify and fix leaks inside customers' homes, using community incentives (for example Green Redeem, or Southern Water's River Itchen water saving project). Companies can and do make use of behavioural science when implementing water-saving initiatives. For example, some studies have shown that feedback on how a household's consumption compares to that of neighbours can result in lower water use.

One mechanism currently being used to incentivise behaviours is annual water saving communications, such as SaveWater South East and the Love Water campaign (a national multi-stakeholder campaign led by the EA). This mechanism targets response efficacy and self-efficacy, in that it seeks to strengthen the perspective that effective interventions are both available and achievable for end users. In-school education was one of the most effective methods noted during the interviews and through external research. There was a generational component where anecdotal evidence suggests that schoolchildren who learn to be 'water wise' often bring this knowledge back home to their parents, sharing knowledge.

Additionally, customer metering was highlighted as another mechanism to incentivise behaviour, specifically targeting descriptive norms and compliance. One interview noted that on average customer metering did reduce water consumption. However, it was noted that it could present perverse incentives during heatwaves, whereby households felt they had the right to use more water since they were paying for it. A step tariff payment system could help to minimise this type of behaviour.

Limitations of case study

Due to the small number of interviewees, this case study provides limited insights into responses to the 2018 drought. Survey responses were only received from six of the UK water companies, and only four of these companies participated in a follow-up interview. Drought vulnerability and response from both water companies and water consumers is extremely context specific and varies from region to region. Therefore, although this represents 16% of water companies, the findings cannot be generalised across the country. Furthermore, this case study extrapolated consumer behaviour based on the expert opinion of practitioners; a more detailed, dedicated exercise with consumers would be required to expand understanding of patterns of water use behaviour.

Box 4.7 Summary of key findings from UK water companies

- In response to the 2018 heatwave, around half of the water companies surveyed stated that they had to enact drought response measures.
- All water companies surveyed noted that their customers' water use increased; however, there were regional differences.
- All participating water companies confirmed that there had not been any discernible lasting changes to water consumption patterns since the heatwave.
- Most companies surveyed noted that the elderly and rural households are more likely to exhibit water-saving behaviours.
- All participating water companies surveyed agreed that households are the most important customers to target in order to improve the resilience of the UK's water supply.
- **The** biggest reported barriers to water-saving behaviour include income to undertake changes; information on behavioural changes people can make to decrease water consumption; information on future water availability and impacts, and belief that it is the responsibility of water companies.
- Water companies have a whole range of activities to encourage customers to use less water, which are context specific, but include communication initiatives and metering.

Relevant CCRA Risk Descriptors: People and the Built Environment (38, 39, 40, 45, 50) and Business (51, 54)

5. Key Findings

This section summarises overall findings by research question drawing on the various sources of evidence outlined in the preceding sections, as well as the literature review in Appendix A. Table 5.1 provides a high-level summary of the key findings.

Table 5.1 Key findings by 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? (See Section 5.1).	
General	• This study identified 86 unique behaviours (see Appendix I), which are taken in advance of, during, or in response to an extreme weather event. Vulnerability reduction, coping during crisis and preparedness for response behaviours made up the bulk of actions that all target groups have taken or are likely to take. Throughout these actions, low-cost and flexible solutions dominated. • The types of behaviours taken vary according to several different factors, including the type of climate event being experienced. • Extreme cold and heat events tend to elicit reactive coping responses rather than proactive strategies before the event due to the widespread nature and avoidance difficulties associated with these hazards. • Conversely, adaptation to flooding includes more proactive vulnerability reduction and preparedness for response mechanisms, in part because flooding has historically been a common occurrence and is arguably the most well-known climate impact in the UK, with flood-risk zones being clearly defined.
Households	• The evidence reviewed suggests that few households take permanent protective measures to prepare their homes for severe weather events. However, the most common permanent proactive actions taken included removing or not planting large trees close by (in response to risks from high winds), installing water tanks (to adapt to drought risk), and raising appliances (to adapt to flood risk).
SMEs and large businesses	• Drawn largely from the literature review, adaptation from large businesses tended to also be more proactive than individuals or households, seemingly due to the wider range of skills, capital, and understanding of operational risk posed by climate hazards.
Land managers	• Conversely, agricultural land managers were more likely to proactively manage climate risk due to placing a greater importance on variations in climate and weather in relation to protecting their livelihoods, and therefore also having a greater awareness of these variations.
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? (See Section 5.2)	
General	Some of the most impactful behaviours by hazard were: • **Flooding**: applying tanking (a process in which a liquid coating bonds to damp masonry to form a waterproof barrier when it dries) to all ground floor walls; routine clearance of drains; online data back-up; moving vulnerable items within the house as well as static items like sockets up walls; and purchasing flood insurance. • **Extreme heat**: Seeking shady areas; drinking more water to stay hydrated; installing air conditioning (for businesses, though to note this can be maladaptive); keeping windows open at night; changing clothing, and reducing physical activity. • **Drought**: planning for longer periods of peak water demand; water-efficient landscaping; implementing water saving practices; and climate-smart agriculture. • **Extreme cold**: Changing clothing; insulating buildings; changing work practices to avoid coldest parts of the day. • **Storms**: Installing surge protectors; turn off mains power; unplug electronic devices; tie down potentially loose objects; have salt or sand ready if snowstorm Some of the least impactful behaviours (due to limited effectiveness, expense, and/or limited uptake) by hazard were:

	• **Flooding**: Stockpiling sandbags (limited effectiveness); and increasing floor elevation (difficult and expensive) • **Extreme heat**: spraying down pavements (maladaptive); changing how children are taken to school (no respondents indicated they had undertaken this behaviour); and keeping children home from school (limited uptake) • **Drought**: installing greywater harvesting systems (difficult and expensive), applying more water to lawns/landscaping (maladaptive) • **Extreme cold**: attend community warming centres (limited uptake on average across the UK) • **Storms**: Implement backup plan for building access (maladaptive), generate own electricity independent from grid (higher upfront costs)
Implications for maladaptation	• It was found that not all behaviours in response to climate events are inherently positive, and some are likely to carry the risk of being maladaptive, whereby they increase the vulnerability and/or exposure of the individual, collective, or organisation, or create trade-offs with other objectives such as climate change mitigation. This is particularly common for behaviours in response to drought and extreme heat, for example some respondents were observed to be applying more water to their lawns during periods of drought (which has little impact and uses up scarce water resources) or increasing use of air conditioning during extreme heat events (which has negative trade-offs for energy use and expels waste heat into the environment). These maladaptive behaviours may decrease in the future due to improved information and awareness. However, the evidence reviewed and collected suggests that air conditioning use could continue to increase as heatwaves become more intense and frequent in the future.
Considerations for future research	• Following this broad study, it may be valuable to commission more in-depth, quantitative research targeted on a smaller number of priority behaviours and their effect on climate risk and on packages of expected behaviours and their impact on risk (e.g. using agent-based modelling) could provide useful insight into combinations that most effectively reduce risk.
3. 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)? (See Section 5.3).	
Key factors	• The key factors identified from this study that influence behaviours, included: – Perceived response-efficacy: The belief that the behaviour will be effective. – Perceived self-efficacy: The belief that one has the capability to undertake a behaviour. – Direct past experience: Previous experience of a climate event impacts negative affect and learning, driving future adaptive behaviour. – Social norms/capital: The norms of the local context and the actions of neighbours; social ties and links; sense of community. – Socio-demographic factors: age, marital status, gender, income, political orientation and value orientation.
Key considerations	• Direct past experience was one of the most significant drivers of adopting some adaptation behaviours, particularly permanent proactive ones. This may mean that some behaviours will become more widely adopted as the frequency and severity of climate impacts increase. • For example, many flood risk-reducing behaviours may increase in the UK as more areas became flood prone and those areas that are currently flood prone experience more frequent and intense flooding. Drought-risk reducing actions could become more common, particularly among agricultural land managers, and the ecological and economic co-benefits of climate-resilient agriculture and land management become more well-known and widely referenced in the policy environment (e.g. through the implementation of the government's 25-Year Environment Plan). • This study also found that there are various barriers which mean adaptation behaviours are not being adopted now and may not be adopted in the future even with greater experience of climate events. The study points towards the issue that the automatic connection between increasing extreme weather events and climate change is not often made. Moreover, the case study evidence suggests that people tend to associate adaptive measures with 'hard' adaptation actions, while low-cost, flexible solutions, which can increase adaptive capacity and reduce

	sensitivity, are typically the most easily accessible. Therefore, educating communities and individual stakeholders on what adaptation could look like (e.g. beyond obvious structural modifications) could likely have benefits in reducing the negative impacts of climate events, potentially through innovative measures like integrating information into in-school education. For example, many case study respondents did not realize that a behaviour they had undertaken likely reduced their risk despite the fact that it was not a structural modification. This misconception that adaptation only includes structural or property adjustments could be deterring greater action. • In addition to these factors, the case studies demonstrated that behaviours and the factors affecting behaviours vary according to local context, as different communities have collective mindsets shaped in part by their historical and cultural backgrounds, which therefore influence their behaviours.
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? (See Section 5.4)**	
General	• Adaptation responses are extremely context specific and therefore future incentives to encourage uptake of behaviours will need to be designed considering the specific characteristics of the location and community. Generally, this study found that adaptation measures that require significant upfront capital are unlikely to occur without provision of public or private sector support. Additionally, more effective climate and risk communication is required, with the evidence highlighting the need for more information on which measures are most effective.
Households and SMEs	• Financial incentives and support • Information about most effective mechanisms • Locally-relevant communication using locally-appropriate sources of communication, aided by methodologies that improve data availability and accessibility • Role of insurance providers
Businesses and land managers	• Regulation, standards and policies • Stakeholder and shareholder pressure • Continuing role of data, particularly AI, for forecasting and real-time risk modelling

5.1 Behaviours identified

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?

This section summarises the suite of behaviours identified as relevant to one or more climate-related events. Appendix I provides the full list of behaviours identified, denoted by type and matched against the relevant climate-related events.

The literature review, surveys and case studies evidenced 86 behaviours that target groups take in advance of, during or in response to a climate-related event. Table 5.2 delineates the breakdown of behaviours by the typology (Wamsler and Brink, 2014) identified in Section 3

Table 5.2 Summary of behaviours by typology

#	Behaviour type
1	Hazard reduction
50	Vulnerability reduction
11	Preparedness for response
21	Coping during crisis
2	Preparedness for recovery
86	**Total number of behaviours**

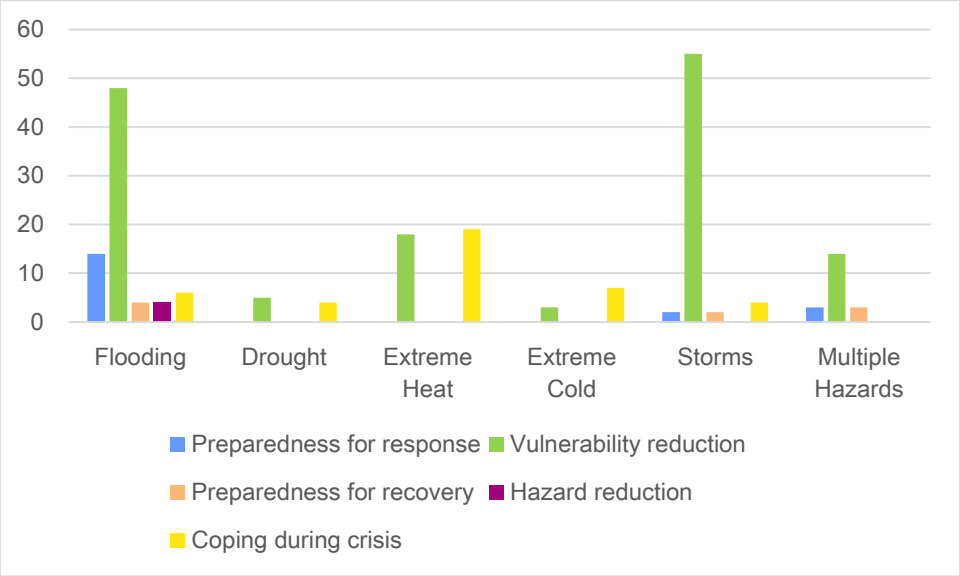
Figure 5.1 delineates the type and number of behaviours mapped against the relevant event(s) that were identified through the literature review and case studies. Flooding and storms dominated the case studies, which in part reflects the skew of behaviours to those two climate events. Equally, though, these are the two climate events that have historically affected the UK the most and are relatively well-understood in the public consciousness. This has implications around encouraging necessary behaviour change to accommodate an increase in frequency and magnitude of extreme heat and drought, which the UK public has historically less experience.

Regarding target groups, households were the most represented within the survey and case study data. According to the surveys, less than 20% of households have taken any permanent protective measures to prepare their homes for severe weather events. In households that had taken protective measures, the most common actions included removing or not planting large trees close by, installing water tanks, and raising appliances. Other actions such as moving electrical sockets higher up the wall, replacing wooden floors or carpets with concrete or tiles, installing storm shutters, installing impact-resistant windows, changing roof pitch to minimise wind damage, and installing water-resistant skirting boards were found to be rare among households. Similarly, less than 20% of small and medium-sized businesses surveyed had taken any permanent protective measures. Removing or not planting large trees close by to structures was the only permanent protective measure case study respondents identified as having undertaken. In SMEs that had taken protective measures, the most common actions included removing or not planting large trees close by, installing water tanks, and raising appliances. Other actions such as moving electrical sockets higher up the wall, replacing wooden floors or carpets with concrete or tile, installing storm shutters, installing impact-resistant windows, changing roof pitch to minimise wind damage, and install water-resistant skirting boards were found to be rare among households. It was also noted in surveys that those with disability may not be able to implement certain actions.

While few land managers took part in the case studies and no large businesses, the literature indicates that common proactive measures include business resilience planning to ensure that redundancies are in-built into their processes (Welsh Government, 2019; Surminski et al. 2018; Agrawala et al. 2011). This was also evidenced during the workshop with small business owners and service providers on the Orkney Islands.

Factors influencing these behaviours are identified in Section 5.3.

Figure 5.1 Summary of behaviour typologies per climate-related event



5.1.1 Flooding

Climate change projections indicate that, on average, the UK will experience greater pluvial and fluvial flooding due to wetter winters and more intense rainfall events. Similarly, sea level rise will contribute to increased coastal flooding and coastal erosion.

Typically, reactive adaptation to flooding falls under the categories of vulnerability reduction and preparedness for response (Kinoshita et al. 2018), although this varies between target groups. Vulnerability reduction and preparedness for response measures tend to be easier to undertake and lower cost than hazard reduction measures, thereby can be more accessible to those undertaking autonomous adaptation.

The surveys supported the findings of the literature review, with 62% of flood-related measures typed as vulnerability reduction followed by 18% typed as preparedness for response.[3]

The case studies provided insight into instances of building back better following a flooding event. In Orkney, coastal flooding – a combination of tides, wind direction, and sea level rise – is a continual problem in the towns of Stromness and St Margaret's Hope. Following a particularly severe flood event in 2005, one interviewee whose home had been flooded discussed how they and their neighbours had recovered: *'… after that, you know where our house was, everybody, when they were getting the stuff redone, everybody put in underfloor heating, stone floors, the electrics coming down from the top, not up from the bottom, and things like that. So, if they to, you know, replace. And the other thing was storm doors.*'

Target group variation

Across all target groups, vulnerability reduction was the most common typology of behaviour (Figure 5.2). Among target groups, 25% of **household respondents** experienced floods. Figure 5.3 shows the most common behaviours that households suggested that they would take to prepare for a flood event. The most frequently reported behaviours were having stores of sandbags ready (28%), putting together household emergency kits (27%), and moving items to higher floors (25%).

[3] Note that the case studies largely covered pluvial and fluvial flooding, with Orkney providing the main insight for coastal flooding.

Figure 5.2 Number of behaviours per typology in response to flooding by target group

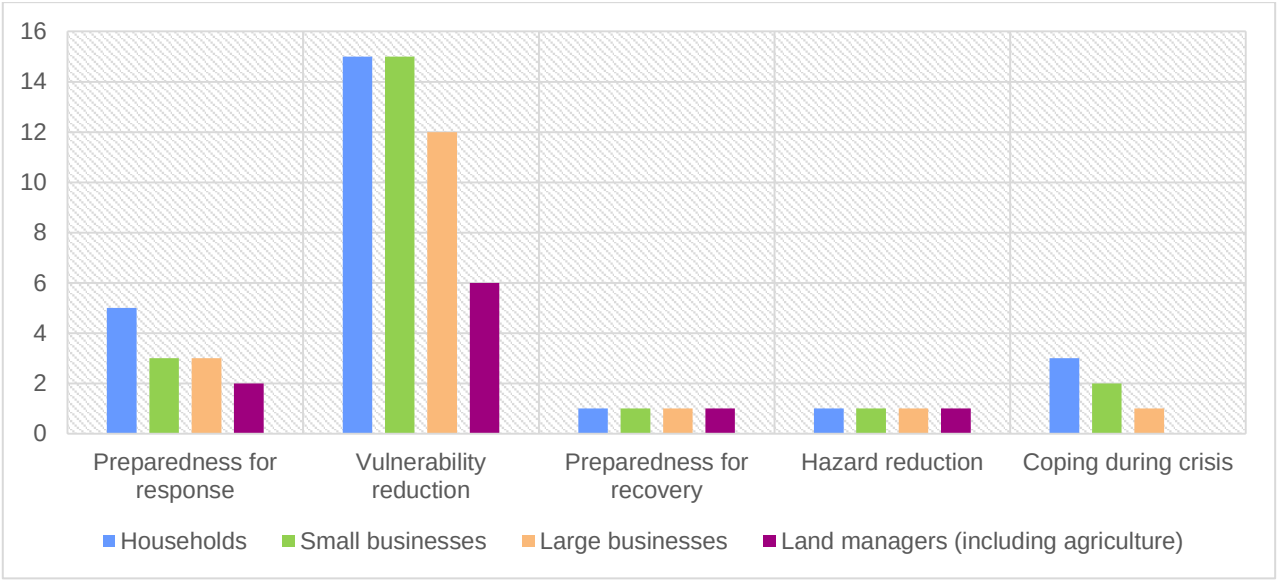
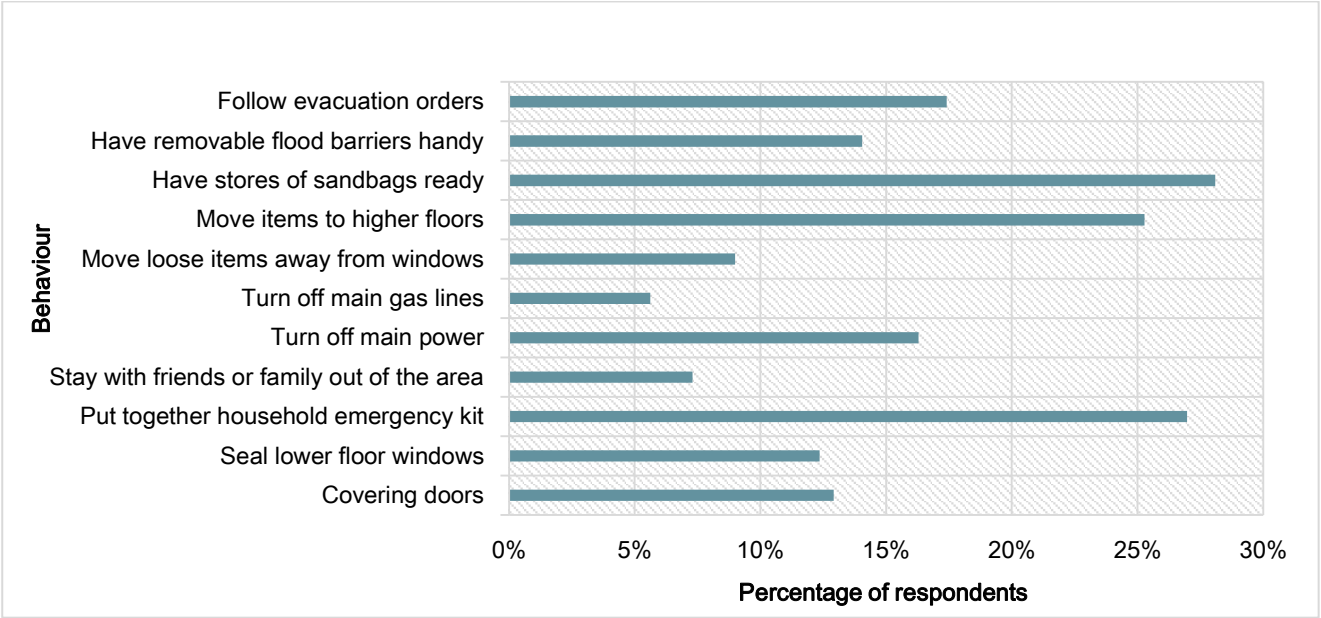


Figure 5.3 Household behaviours most likely to be taken to prepare for a flood event, according to the survey respondents (n = 178)

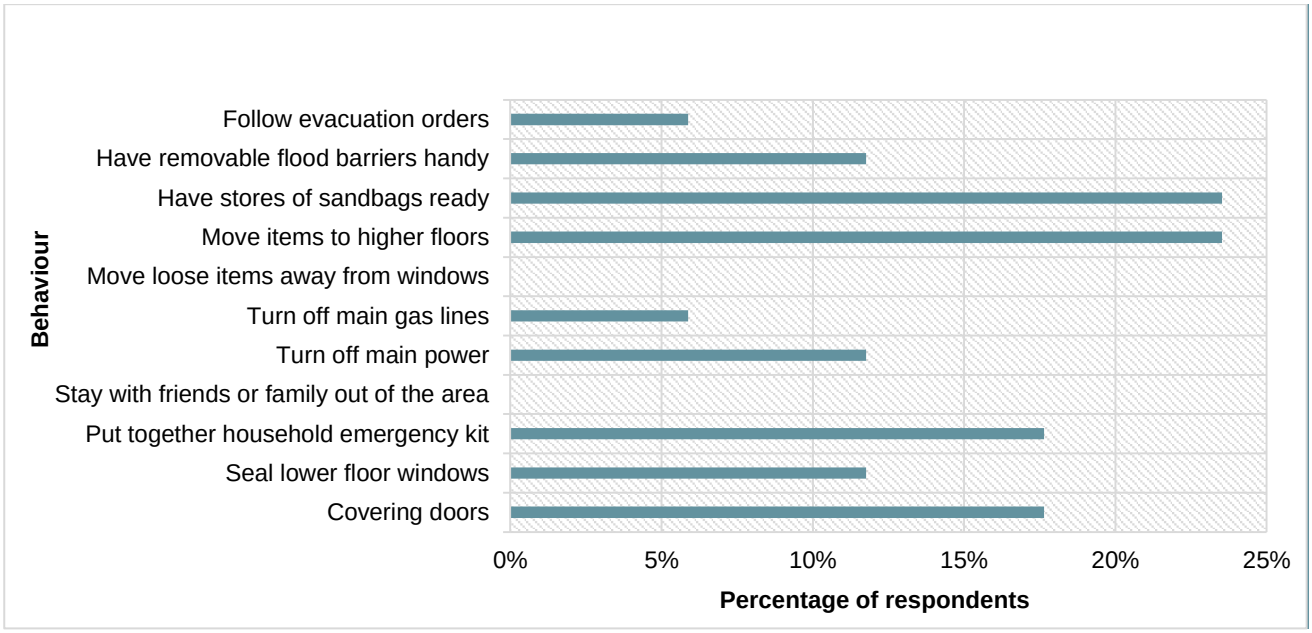


The CCRA2 notes two specific risks to businesses: (1) Bu1 – risks to business sites from flooding and (2) Bu2 – risks to businesses from loss of coastal locations and infrastructure.

The case study surveys indicate that just under one-quarter of the **small and medium-sized businesses** surveyed had experienced flooding events. For those that had, Figure 5.4shows the most common behaviours that small to medium sized businesses suggested that they would take to prepare for a flood event. The most frequently reported behaviours were having stores of sandbags ready (24%) and moving items to higher floors (24%). Automated voice messaging systems, text alerts and government websites were shown to be the most commonly used sources of information about flooding events by small to medium sized businesses.

Similar to households, anecdotal evidence indicates that some SMEs had built back better following disruptive events. For example, a coastal restaurant in Orkney installed storm doors during its renovation process (Interview 13).

Figure 5.4: Behaviours most likely to be taken by small to medium sized businesses to prepare for a flood event, according to the survey respondents (n = 17)



One of the unique behaviours adopted by **land managers** in response to flooding was changing irrigation practices or infrastructure in line with rainfall trends. Additionally, the literature highlighted land managers' increased dependence on the natural environment, and therefore more natural vulnerability reduction behaviours (e.g. routine clearance of drainage systems; landscaping for drainage) are suggested to be more common among land managers, compared to the other target groups.

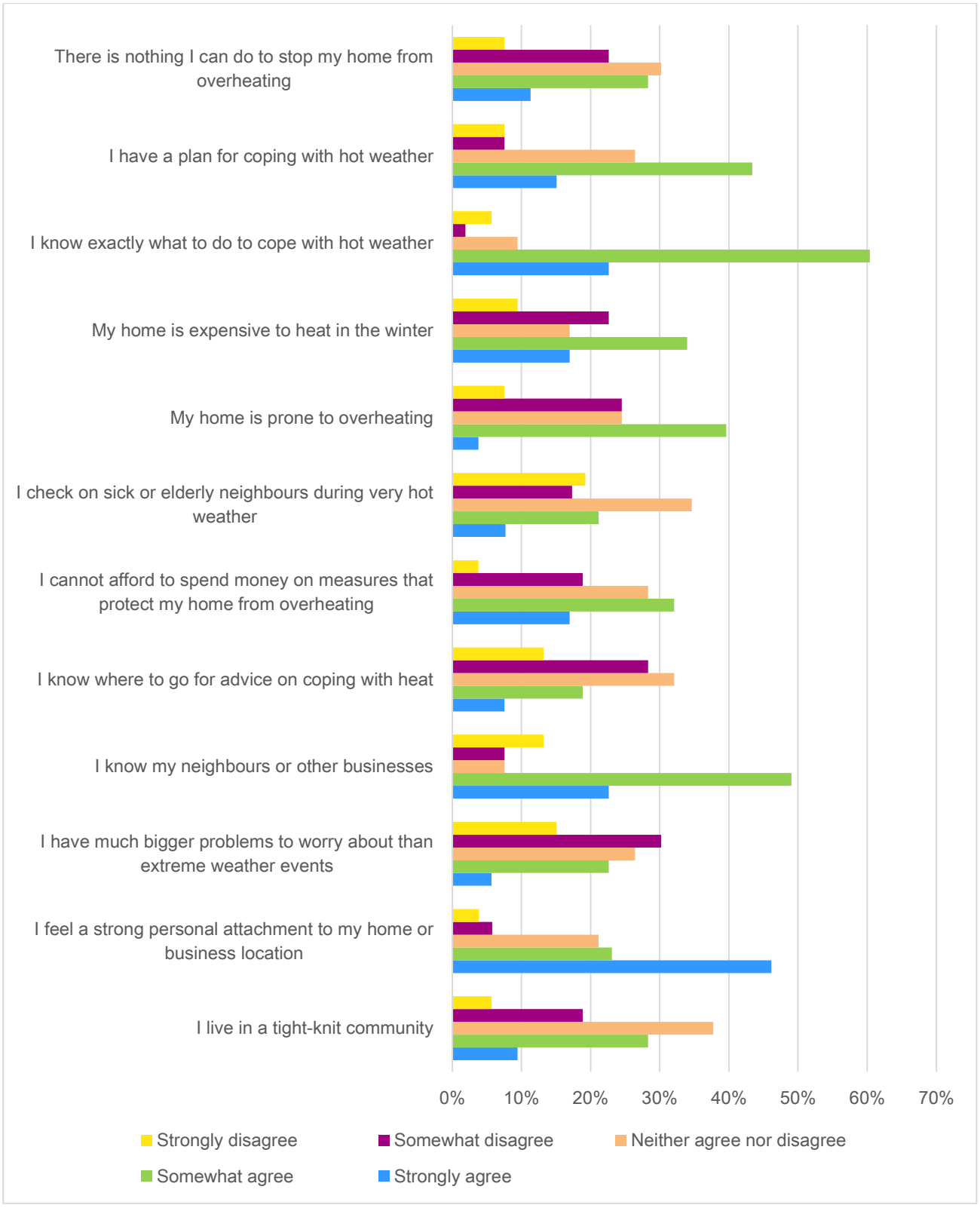
5.1.2 Extreme heat

Extreme heat events are an increasing challenge in the UK. They are compounded by poor ventilation within buildings and, in urban and suburban areas, the urban heat island effects. The impacts of extreme heat differ from other climate hazards because the effects are mediated by the length and intensity of the event (CDC, n.d.). By definition, heatwaves last several days, and population vulnerability increases over time from the accumulated effects of heat stress. Heatwaves can be an insidious public health threat because research indicates individuals may not realise the effect of heat stress until it becomes critical (WHO, n.d.). Additionally, for example, the UK saw a spike in deaths following high July temperatures in 2019 (Roberts, 2019). Elderly and other vulnerable populations are especially susceptible.

Generally, extreme heat events elicit coping responses due to their widespread nature (Porter, Dessai, and Tompkins 2014). Therefore, it is less likely that individuals can physically remove themselves from the affected area in the same way that they could in the event of an acute flood or storm. Zografos et al. (2016) identify that local level response to heatwaves almost exclusively involves short-term coping behaviours. Similarly, in their study on heatwaves responses in London and Norwich, Wolf et al. (2010) note that coping responses are more frequent among this group.

Beyond the literature, the surveys and case studies supported coping responses as the most common type of behaviour taken by households and SMEs. Of the 37 behaviours identified for extreme heat, 19 were typed as coping behaviours and 18 were categorised as vulnerability reduction measures. The majority of respondents in the Lewisham heat survey indicated they felt they knew how to cope with hot weather; however, respondents either somewhat disagreed or neither agreed nor disagreed with the statement that they knew where to go for advice on coping with heat). This presents an interesting dichotomy in that people feel well-prepared to cope with heat; however, they may not have the most up-to-date advice or know where to seek it out. It is unclear if this reported confidence in the ability to cope with heat is justified and hence more information on effective responses is not needed, or if the confidence is unfounded and presents a barrier to respondents accessing valuable advice (Burchell et al 2017; Lefervre et al 2015; Abrahamson et al. 2009).

Figure 5.5 Survey responses around coping with extreme heat (n=52)



Target group variations

All target groups cited behaviours considered to be vulnerability reduction and coping during crisis (Figure 5.6). Approximately half of the survey respondents revealed that their **households** were not comfortable and 'too hot' during periods of extreme heat. Households took a range of different behaviours in response. As Figure 5.7 summarises, the most common behaviours were drinking more water (94%), keeping windows open at night (85%), using a personal fan at home (65%), pulling the shades or drawing the curtains during the day (65%), and using sun cream (63%).

Figure 5.6 Number of behaviours in response to extreme heat by target groups

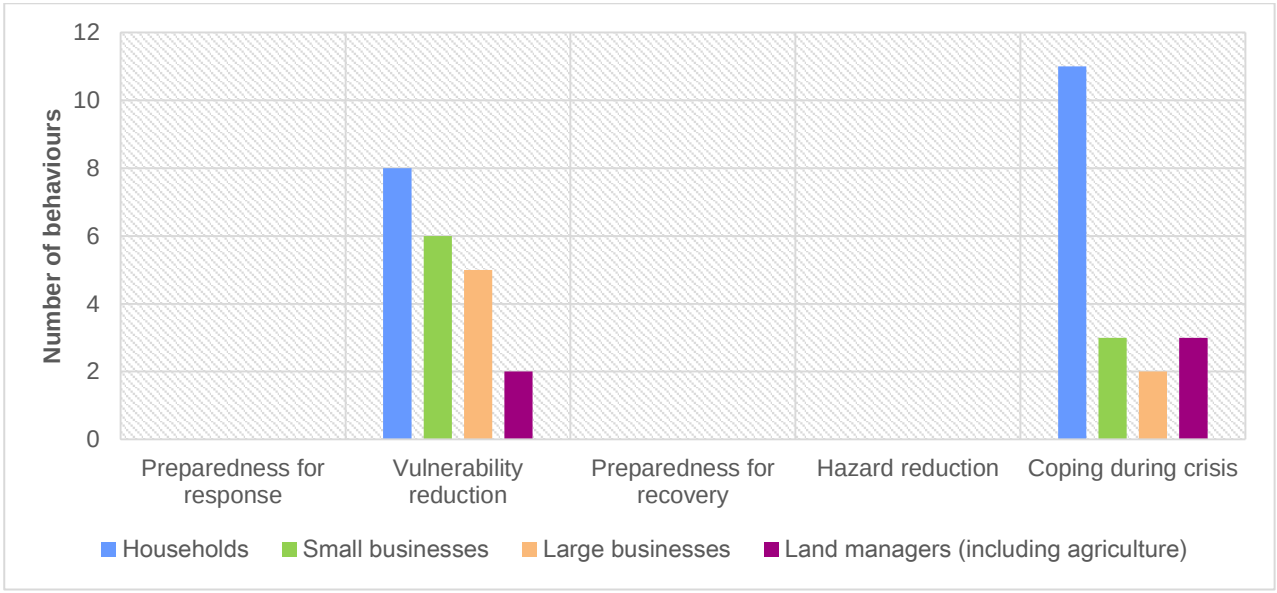
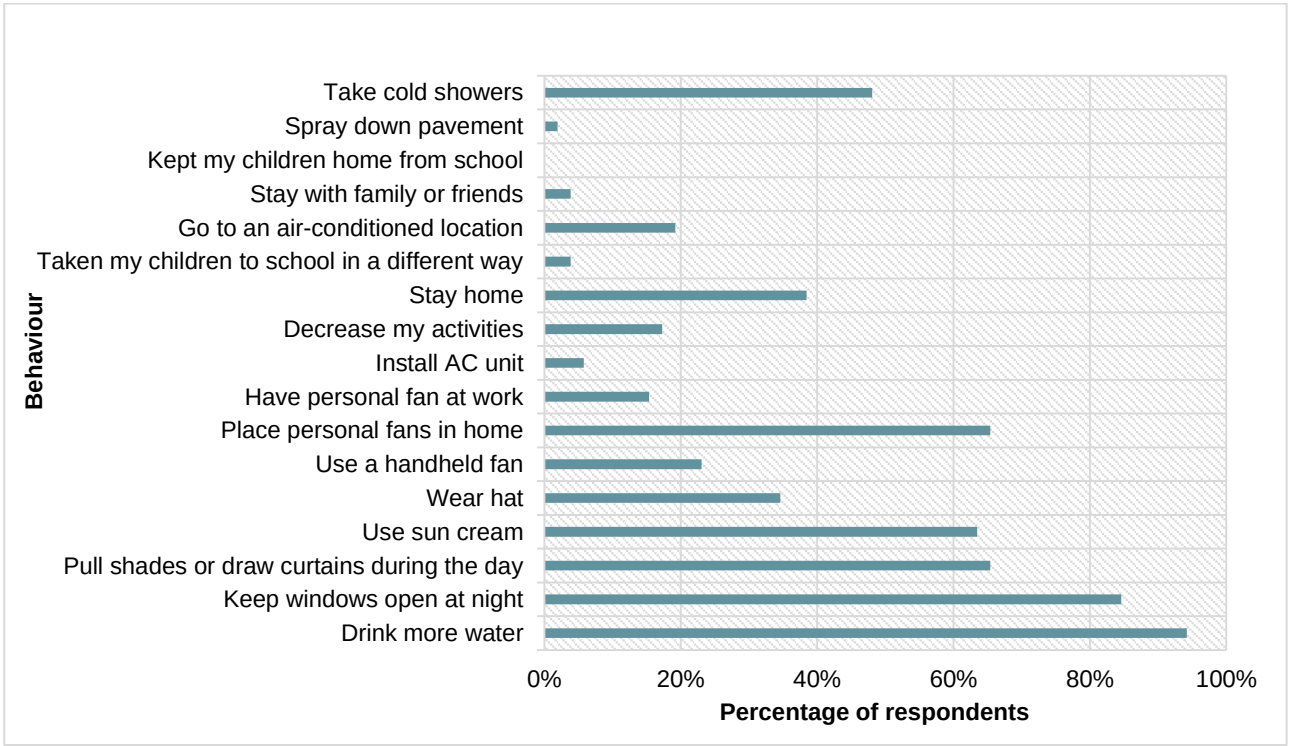


Figure 5.7: Household behaviours taken to cope with hot weather, according to the survey respondents (n = 52)



5.1.3 Drought

While the common perception is that the UK has regular and significant rainfall, rainfall varies widely between regions, seasons and years (CIWEM, 2019). Additionally, droughts are longer-term events derived from complex hydrometeorological conditions (e.g. lack of precipitation, conditions that increase evaporation, etc.) as opposed to only extreme heat events. The nine behaviours identified in the literature review and case studies were delineated into five behaviours which were typed as vulnerability reduction and four behaviours that were typed as coping responses.

At present, only **large businesses, SMEs and land managers** reported taking any measures to reduce their vulnerability to drought. Possible drivers for this include a perception among many UK households that drought is not a risk that requires behavioural change, or that action to address droughts is not seen as the responsibility of private households. Indeed, study indicated that 76% perceived a low to very low likelihood of drought impacting local areas (Bryan, 2019). However, it is also likely that property level measures (e.g. low-flow fittings, greywater recycling systems) were not captured within the case studies, as few focused specifically on drought events.

Water companies have a whole range of activities to encourage customers to use less water. These activities are company specific, but include: working with schools, water efficiency home visits (to install water saving gadgets, give advice, fixing leaking toilets), use data generated by smart meters (where these are installed) to identify and fix leaks inside customers' homes, using community incentives (for example Green Redeem, or Southern Water's River Itchen water saving project). Companies can and do make use of behavioural science when implementing water-saving initiatives. For example, some studies have shown that feedback on how a household's consumption compares to that of neighbours can result in lower water use. The literature around drought adaptation behaviours, was largely focused on agricultural land managers, where water-stress has a significant impact. Most of these behaviours were vulnerability reduction actions, including transitions to new agricultural practices. For example, climate-smart agriculture, which involves agricultural practices that increase the resilience of the agricultural system while still maintaining or increasing productivity. Examples of drought-specific practices include integrated water management, use of drought resistant seeds/crops and application of weather information systems. Importantly, high initial investment costs, additional labour requirements and management intensity were highlighted as key barriers preventing some land-managers from exploring climate-smart agricultural innovations. Other specific measures taken by land managers to reduce their vulnerability to drought include applying agroecology principles (an integrated approach applying ecological and social principles to the design and management of agricultural systems) and planning for longer period of peak water demand (including increased water efficiency, and assessing trends in quality and quantity of water supply).

5.1.4 Extreme cold

UK climate projections anticipate milder, albeit wetter winters, so a reduction in extreme cold snaps or heavy snowfall is expected. However, when cold snaps do occur, they can severely affect public health and infrastructure, as evidenced by the 'Beast from the East' in 2018 (Morris, Weaver & Halliday, 2018). The elderly and those with underlying risk factors, such as chronic obstructive pulmonary disease, are at heightened risk (Hajat et al. 2016). However, Hajat et al. 2016 reported that younger adults are at higher risk of fractures during heavy snow events.

Similar to heatwaves, extreme cold temperatures tend to elicit coping behaviours (e.g. changing clothing) as target groups cannot remove themselves from the impacted area (whereas they may be able to evacuate to higher ground in advance of a severe flooding event). A continuing challenge for the UK is the lack of insulation and poor energy efficiency in older buildings, particularly in the north-west (BEIS, 2017), contributing to fuel poverty. The UK government provides grants and subsidies to vulnerable groups to combat fuel poverty.

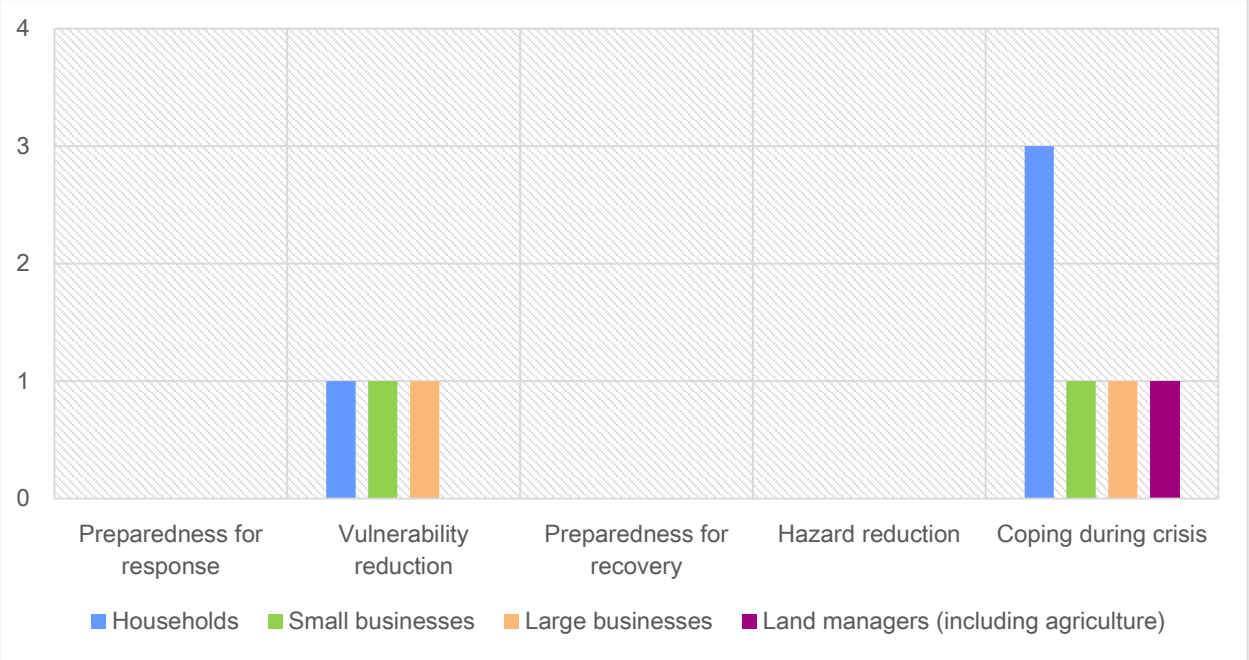
The Peebles case study provided the most insight into extreme cold events, with the town having been severely affected by the Beast from the East. Beyond insulation, measures that case study respondents noted included having appropriate clothing, including footwear and waterproof gloves (Peebles Survey 01, 1100513596). Others noted that they had installed backup generators, although it was unclear in these surveys whether this was in direct response to perceived risk (Survey 07, Survey 45, Survey 85, Survey 146).

Target group variation

The analysis indicated that **households** are more likely to adopt coping measures than vulnerability reduction measures, with all other target groups taking vulnerability reduction and coping measures equally (

Figure 5.8).

Figure 5.8 Number of behaviours by type identified in response to extreme cold by target groups



5.1.5 Storms

UK climate projections anticipate an increase in convective storms, and the interlinkages with storm surge and sea level rise are of particular concern around coastal flooding and erosion.[4] Storms are a common occurrence in certain regions of the UK, although can affect the whole of the UK on occasion, and the nature of these events provides insight into behaviour in response to uncertainty and unpredictable weather. Therefore, behaviour in response to storms has bearing on behaviour more broadly.

Target group variation

The analysis indicated that vulnerability reduction measures were the most common amongst all target groups (Figure 5.8). As shown in

Figure 5.10 according to the surveys, the most likely behaviours that **households** would take to prepare for a storm event were having flashlights handy (46%) and putting together a household emergency kit (27%). Among small to medium businesses that responded to the survey, just under half had experienced storm events (47%), As shown in Figure 5.11, according to the surveys, the most likely behaviours that **small- to medium- sized businesses** would take to prepare for a storm event, were having flashlights handy (31%), moving items to higher floors (25%), and having salt or sand ready (25%). Of those businesses who stated that they had experienced a severe weather event in the past, only 30% said that they were exposed to financial costs as a result. According to the surveys, the most common methods used by small to medium sized businesses to access information regarding storms were television, mobile alerts and social media.

[4] Storms refer to the following: wind speeds with gusts of at least 48 knots (55mph); or torrential rainfall at a rate of at least 25mm per hour; or snow to a depth of at least one foot (30 cm) in 24 hours; or hail of such intensity that it causes damage to hard surfaces or breaks glass (See Section 3.3 for definition).

Figure 5.9 Number of behaviours by type identified in response to storms

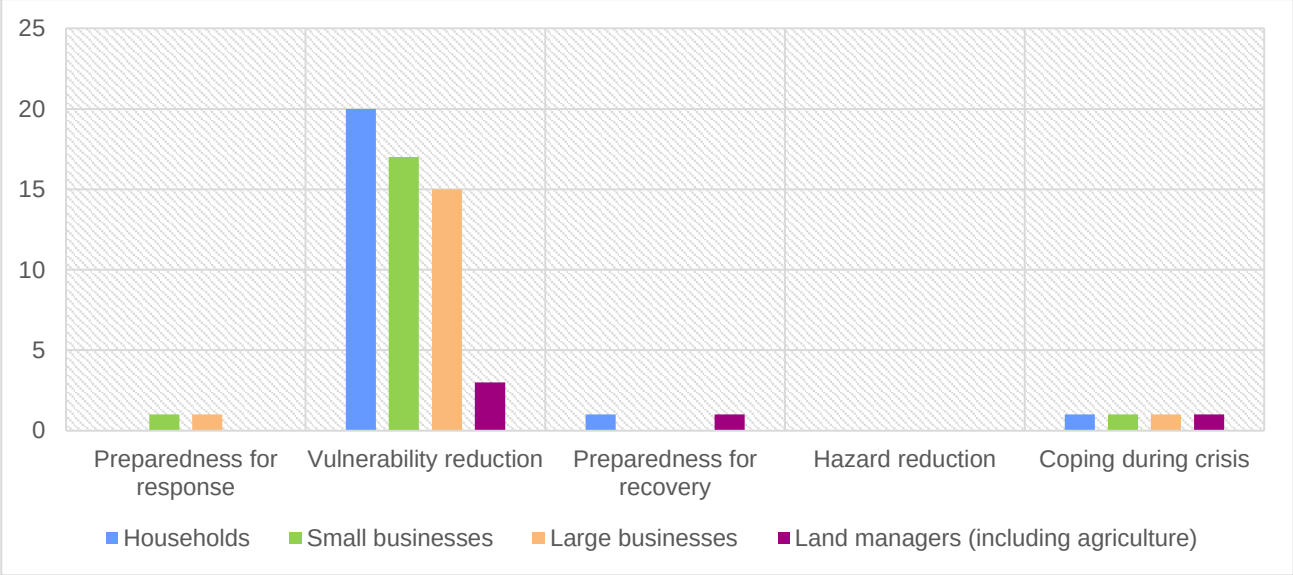


Figure 5.10 Household behaviours most likely to be taken to prepare for a storm event, according to the survey respondents (n = 167)

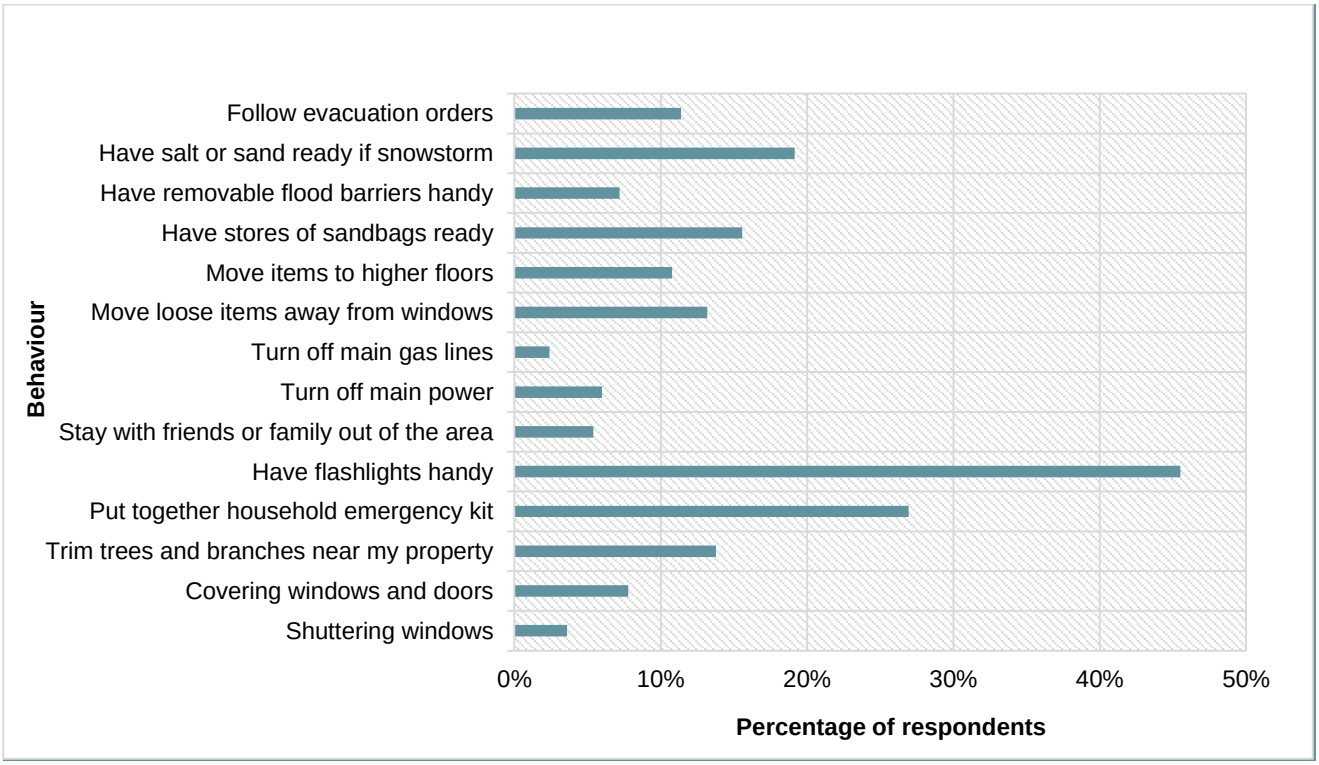
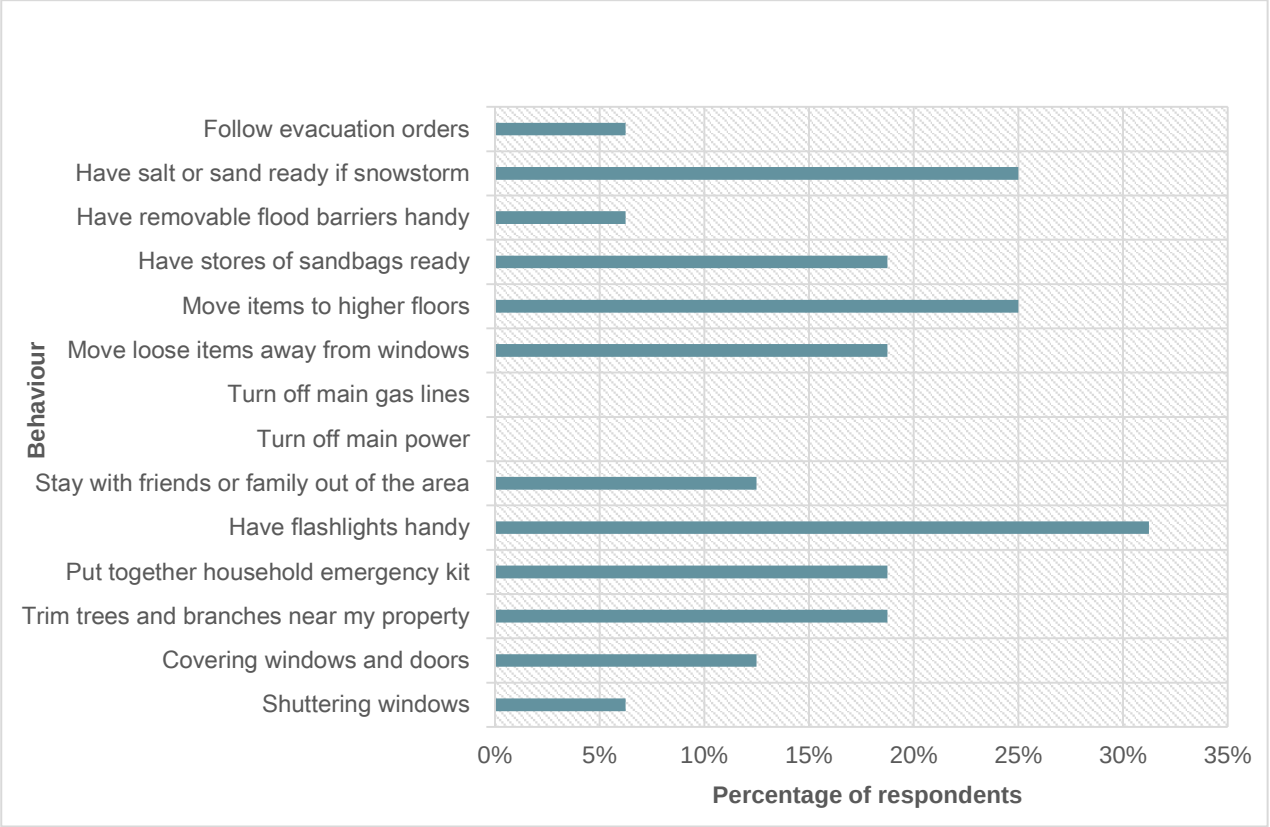


Figure 5.11 Behaviours most likely to be taken by small to medium sized businesses to prepare for a storm event, according to the survey respondents.(n = 16)



Another consideration is that of indoor fungi and mould. This was rarely mentioned in the literature and no case study respondents noted it, but storm events can contribute to the breakdown of physical barriers between indoor and outdoor space. Driving rain or humidity can lead to damp in homes – particularly older homes – and contribute to the growth of mould, which can negatively affect occupant health (EPA, 2014). Greater awareness around this issue is necessary, particularly for vulnerable populations (e.g. elderly, those with asthma etc.)

5.2 Current influence on risk

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?

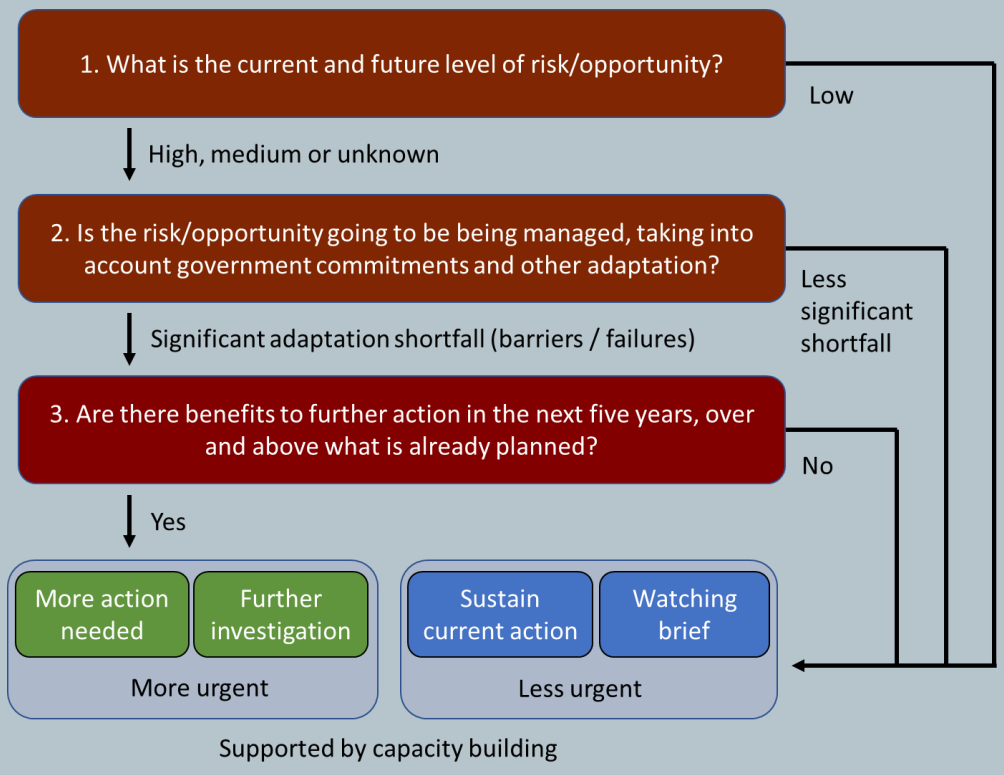
This section presents the findings of the risk scoring methodology, which was informed by the literature review and case studies. As described in Section 3.3.2, each combination of event, target group and behaviour were assessed in according to level of adoption and influence on risk. A confidence level was also assigned to each risk score, as established in Section 3. Discussion of the behaviours relating to each event type is structured as follows:

- Current day: (1) Table of behaviours and associated National Impact Scores; (2) Discussion of key findings around current day
- Potential for maladaptation
- Impact on risks being considered in the CCRA3 urgency scoring process.

Box 5.1: Background to CCRA3 urgency scoring

Development of the CCRA3 includes a consistent process to prioritise risks to focus on, which is captured through an analysis of urgency. The analysis of urgency of risks was advanced in CCRA2 through an urgency scoring framework, which has been carried over into CCRA3. This prioritises risks and opportunities using three questions:

1. What is the current and future level of risk/opportunity?
2. Is the risk/opportunity going to be managed, considering government commitments and autonomous adaptation?
3. Are there benefits to further action in the next five years, over and above what is already planned?



Source: CCRA3 Chapter 2 Methodology (Draft)

The remainder of this section includes commentary for CCRA3 authors about how potential future trends in adoption of autonomous adaptation behaviours could affect the resultant level of risk. It is noted where trends may be strong enough to be a material consideration when attributing an urgency score to a specific risk descriptor. Note, however, that instances where trends in adoption of behaviours could affect final scores are rare. This is due both to the relatively coarse urgency scoring approach, the primarily qualitative nature of this study, and the array of other considerations to be factored into the scores.

To inform the discussion, Figure 5.12 below outlines an example of national effectiveness scoring and the anticipated future direction of change for a flood-related behaviour (stockpiling sandbags). Stockpiling sandbags was an autonomous adaptation identified in both literature reviews and case studies that households, SMEs and land managers took to prepare for a flood event. The current extent of adoption was assessed as 'uncommon' because not all households within a flood-prone area are likely to undertake this action. Additionally, given that the EA estimates one in six properties are at risk of flooding, it is unlikely that non-flood prone properties will undertake this action. The influence on risk was assessed at 'medium' according to the framework outlined in Section 3.3.2. Sandbags can only partially reduce the likelihood of exposure to flooding (for example, property or crops) depending of the magnitude of the flood and are not particularly effective at reducing exposure. The ultimate National Impact Score ('NIS' in the below table) was calculated by multiplying the assessed current extent of adoption by the influence on risk.

. Figure 5.12 Worked example of the risk score for current day behaviour 'stockpiling sandbags'

Target Group	Relevant behaviour	Mechanism for influencing risk	Current extent of adoption	Influence on risk (for those adopting the behaviour)	NIS
Households	Stockpiling sandbags	Preparedness for response	Uncommon (2)	Medium (2)	**4**
Potential for maladaptation or unintended consequences?					
Could engender a false sense of preparedness for a major event. Additionally, sandbags are considered contaminated waste, and disposal is challenging.					
Confidence level and rationale					
Adoption nationally is uncommon as flood-prone areas are in the minority and not all households in such areas will adopt this measure when faced with a potential flood event. If implemented, the measure can reduce vulnerability for events up to a point, thus has a medium influence on risk. Supported by multiple reliable sources [91, 92, 101] from the literature review, one of which had a UK focus), and evidenced by case study surveys (NI), therefore confidence level is **high**.					

5.2.1 Flooding

Table 5.3 lists the ranking of flood-related behaviours by target group and National Impact Scores.

Table 5.3 Behaviours by target group and National Impact Scores identified in response to flooding

NIS	Households		Small businesses		Large businesses		Land managers (including agriculture)	
2	**PRes**	Develop household evacuation plan	**PRes**	Landscaping for drainage	**VR**	Increase floor elevation	**PRes**	Stockpiling sandbags
	VR	Install pumps	**VR**	Install pumps	**VR**	Install pumps		
	PRes	Stockpiling sandbags	**PRes**	Stockpiling sandbags	**HR**	Relocate	**VR**	Install pumps
	PRes	Document evidence for future preparedness	**PRes**	Document evidence for future preparedness	**PRes**	Document evidence for future preparedness		
	PRes	Prepare or purchase household emergency kit	**VR**	Subscribe to Automated Voice Messaging Service	**VR**	Subscribe to Automated Voice Messaging Service	**VR**	Change irrigation practices
	VR	Subscribe to Automated Voice Messaging Service						
3	**HR**	Relocate	**HR**	Relocate	**HR**	Relocate	**HR**	Relocate

NIS	Households		Small businesses		Large businesses		Land managers (including agriculture)	
4	**VR**	Structural changes or reinforcements	**VR**	Structural changes or reinforcements	**VR**	Landscaping for drainage		
	VR	Increase floor elevation	**VR**	Increase floor elevation	**VR**	Increase floor elevation		
			PRes	Stockpiling sandbags	**PRes**	Stockpiling sandbags		
	VR	Produce and enact written flood disaster plan	**VR**	Have removable flood barriers on hand	**VR**	Elevate electrical appliances	**PRec**	Dig water channels or build provisional channels
	PRes	Produce and enact written flood disaster plan	**PRes**	Produce and enact written flood disaster plan	**PRes**	Produce and enact written flood disaster plan	**PRes**	Produce and enact written flood disaster plan
	VR	Plastic lining membranes between brickwork and plaster	**VR**	Plastic lining membranes between brickwork and plaster	**VR**	Plastic lining membranes between brickwork and plaster		
	VR	Landscaping for drainage	**VR**	Install air brick covers	**VR**	Move electrical sockets up the wall		
	CdC	Put towels down	**VR**	Elevate electrical appliances				
			CdC	Put towels down				
			VR	Move furniture to higher floors in response to a forecast event				
			VR	Move electrical sockets up the wall				
6	**VR**	Follow evacuation orders	**CdC**	Follow evacuation orders	**CdC**	Follow evacuation orders	**VR**	Landscaping for drainage
	VR	Move furniture to higher floors in response to a forecast event	**VR**	Purchasing flood insurance	**VR**	Purchasing flood insurance	**VR**	Purchasing flood insurance
	CdC	Install air brick covers	**VR**	Routine clearance of drainage systems (gutters, ditches, etc.)	**VR**	Move furniture to higher floors in response to a forecast event	**VR**	Routine clearance of drainage systems (gutters, ditches, etc.)
	VR	Apply waterproof paint	**VR**	Apply waterproof paint	**VR**	Apply waterproof paint		
	VR	Stay with family or friends when flood warning is issued	**VR**	Online data back-up	**VR**	Online data back-up		

NIS	**Households**	**Small businesses**	**Large businesses**	**Land managers (including agriculture)**
8	**VR** Move furniture to higher floors in response to a forecast event **VR** Move electrical sockets up the wall **VR** Elevate electrical appliances **VR** Purchasing flood insurance		**VR** Structural changes or reinforcements	
	VR Routine clearance of drainage systems (gutters, ditches, etc.)		**VR** Routine clearance of drainage systems (gutters, ditches, etc.) **VR** Online data back-up	
9	**VR** Apply tanking to all ground floor walls	**VR** Apply tanking to all ground floor walls	**VR** Apply tanking to all ground floor walls	

Current Day

Flooding was proportionately the most common climate risk experienced by survey respondents and interviewees (storms were disproportionately represented due to the high volume of responses from Orkney). The extent of adoption of flood-related adaptive behaviours is currently uncommon to moderately common, largely because they apply to specific areas of the UK that are flood-prone and therefore are actions that households, businesses, or land managers in non-flood prone areas have not presently taken up (at least not to a comparable degree).

Most reported flood-related behaviours were vulnerability reduction measures (62%) (see Figure 5.2). Moreover, the behaviours respondents took generally had a 'medium' response to risk (51%) followed by a 'high' response (35%), indicating that the behaviours undertaken were either reducing exposure to flooding (e.g. relocating) or were reducing the sensitivity of the target group to the impacts of flooding (e.g. having store of sandbags ready). Of those who had experienced flooding, only 15% had installed any permanent protection measures on their homes. These included building protective outdoor walls, tanking ground floors, and installing plastic sheeting between brick and plasterwork. Only one instance of relocation following a flood was recorded (Interview 13).

The National Impact Scores ranged from 2 (low importance) to 9 (high importance), as shown in Figure 5.2. This analysis has bearing on the risk descriptors set out in Table 5.4. The same behaviour can have a different National Impact Score depending on the target group that adopts the behaviour. For example, online data back-ups have the highest national importance score for large businesses because such businesses have a much higher uptake of data backup services than a typical household. While SMEs also face significant risks to their businesses if they do not have data backup, certain small businesses (particularly self-employed or freelancers) may not implement data backups as regularly as large businesses, or if they do, they practice on-site back up. However, over three-quarters of SMEs are estimated to use cloud-based backups by 2020 (CIF, 2017), thereby reducing the risk of damage to on-site hardware.

Overall, the current behaviours identified can effectively reduce the exposure or vulnerability of target groups; however, the case study responses indicate that many people in flood-prone areas had infrequently undertaken the actions identified or had only undertaken actions following a flooding event. To this end, it is important that future policies encourage proactive measures, whether those focus on vulnerability reduction or increasing adaptive capacity in advance of impacts to reduce damages (physical, emotional, financial) should an impact occur.

Considerations for future adoption and impact

With regards to the future impact of flood-related measures that are currently identified

Survey respondents noted that they might consider taking in the future was relocating. All respondents who noted this had, however, previously experienced a severe flooding event. Several interviewees noted concerns around property values, indicating that even if they desired to move to avoid future flooding, they feared they may be unable because they would not be able to recapture the expected value of their property (Interview 11).

Alongside property values, case study respondents also noted the potential future cost of insurance as a concern (Interview 14). Flood insurance can play a valuable role in increasing adaptive capacity and encouraging all target groups to build back better. Insurance companies also have a vested business interest in people continuing to purchase their products. As a result, there is a clear opportunity for insurance companies to play a role in incentivising the uptake of behaviours that will reduce exposure and sensitivity, and increase adaptive capacity, particularly by instituting clear policies around building back better.

Potential for maladaptation

Overall, most reported behaviours identified carry a low risk of maladaptation as they are often short-term or flexible behaviours (e.g. moving items upstairs; using waterproof paint). However, there is possibility for maladaptation among some measures, whether that is because a pre-emptive action may provide a false sense of security, or if infrastructure is poorly designed. Additionally, the actions of one household, business, or land manager may reduce their vulnerability while increasing the vulnerability of neighbours not taking adequate or corrective actions. For example, a land manager that designs a drainage system to protect their own property may inadvertently increase runoff in the direction of another property or contribute to an increased volume of runoff in municipal systems that may not be able to cope.

Implications for CCRA3 urgency scoring

This analysis has bearing on the risk descriptors set out in Table 5.4:

Table 5.4 Risk descriptors related to flooding

Latest Risk Descriptor	Implications
(41) Risks to people, communities and buildings from flooding (42) Risks to people, communities and buildings from coastal change (45) Risks to health and social care delivery from extreme weather (54) Risks to business sites from flooding (53) Risks to business locations and infrastructure from coastal change	There exists significant potential for action in the next five years to bridge the gap between autonomous adaptation and governmental intervention around flooding. This in part can draw on incentivising behaviours that better prepare households, SMEs, large businesses and land managers to better respond to and bounce back from a flood event.

5.2.2 Extreme heat

Table 5.5 lists the ranking of heat-related behaviours by target group and National Impact Scores.

Table 5.5 Behaviours by target group and National Impact Scores identified in response to extreme heat – current day

NIS	Households	Small businesses	Large businesses	Land managers (including agriculture)
1	**VR** Spray down pavement **CdC** Change mode of taking children to school **CdC** Keep children from school			
2	**CdC** Go to a private air-conditioned location (e.g. relative or friend's house) **CdC** Wear hats when outdoors **CdC** Go to a public air-conditioned location **VR** Install external shutters	**VR** Install external shutters	**VR** Install external shutters	**CdC** Use personal fans at work **VR** Provide sunscreen to employees
3	**CdC** Changing routines (e.g. changing work hours to be out of the heat of the day) **VR** Place personal fans in home	**CdC** Changing routines (e.g. changing work hours to be out of the heat of the day) **VR** Provide protective clothing to employees (e.g. sun hats, long-sleeved clothes)	**CdC** Changing routines (e.g. changing work hours to be out of the heat of the day) **VR** Provide protective clothing to employees (e.g. sun hats, long-sleeved clothes)	**CdC** Changing routines (e.g. changing work hours to be out of the heat of the day) **VR** Provide protective clothing to employees (e.g. sun hats, long-sleeved clothes)

NIS	Households	Small businesses	Large businesses	Land managers (including agriculture)
	CdC Stay at home	**CdC** Use personal fans at work **CdC** Keeping windows open at night **CdC** Provide sunscreen to employees	**CdC** Provide sunscreen to employees	
4	**CdC** Take cold showers **VR** Drawing curtains **CdC** Use sunscreen	**VR** Drawing curtains	**VR** Drawing curtains	
5	**CdC** Temporarily decreasing activity **CdC** Changing clothing in response to high temperatures **VR** Keeping windows open at night	**CdC** Temporarily decreasing activity	**CdC** Temporarily decreasing activity	**CdC** Temporarily decreasing activity
6	**VR** Install AC units			
9		**VR** Install AC units	**VR** Install AC units	
10	**CdC** Seek protection in shady areas when outdoors **VR** Drinking water to stay hydrated			

Current day

Extreme heat reduction behaviours are moderately common (47%) to widespread (23%), as these are largely easy to adopt (except for installing air conditioning) and applicable across the UK. Most behaviours associated with extreme heat are low-cost and flexible solutions, excluding installation of air conditioning and installing external shutters. Except for air-conditioning (high, although maladaptive) and installing external shutters (medium), extreme heat responses typically have low influence on risk to individuals (86%), mildly decreasing the sensitivity of affected groups but typically not removing exposure. Still, the adoption of these behaviours collectively may contribute to greater risk reduction, and these behaviours – taken collectively or individually – are an important component of combatting the impacts of extreme heat.

While many actions identified can reduce exposure (e.g. drawing curtains, using personal fans in home), the challenge with extreme heat is that the effects are cumulative, building up over the length of the heatwave. The length and severity of the heatwave also decreases the effectiveness of behaviours that attempt to reduce exposure. For example, the indoor cooling effect of leaving windows open at night is entirely dependent on the night-time air temperature and the baseline indoor temperature, which is likely to be higher day-on-day as the effects of extreme heat build (WHO, 2018).

Implications for future adoption and effectiveness

Temperatures are projected to increase across the UK, with greater warming anticipated in the South and Southeast (Met Office, 2018). The 2017 CCRA Evidence Report also noted that newer buildings may be more prone to overheating than older buildings, and that quickly integrating design standards to combat this risk is crucial (CCC, 2017). Case study respondents specifically mentioned air-conditioning as the main behaviour they would adopt that they have not yet adopted (Interview 20).

Potential for maladaptation

Most of the behaviours identified carry have few maladaptive consequences; notable exceptions are actions related to water use, keeping windows open, and installing air conditioning. Water use will be described further in the following section on drought.

Keeping windows open can be maladaptive in certain cases if a householder is unaware that it is more effective to shut windows in the morning to lock in the cooler evening air throughout the day, rather than keeping windows open throughout the day and night. This is also dependent on location and structure of the property. It is possible that uptake of good practices in heatwaves will improve as these events become more common, reducing the level of maladaptation (Howarth et al. 2019). Additionally, noise and air pollution are side effects of keeping windows open.

Finally, use of air conditioning in businesses or households is highly maladaptive for several reasons. First, air conditioners place increased stress on electrical networks, which may already be experiencing stress due to high temperatures and peak demand. This is evidenced by past experiences of rolling blackouts in cities experiencing prolonged heatwaves (Sanchez, 2019; McEvoy, Iftekhar, & Mullett, 2012). Secondly, air conditioners contribute to greenhouse gas emissions through their use of electricity (when generated with fossil fuels), and therefore make achieving climate change mitigation targets more challenging (IEA, 2018). Finally, air conditioners generate waste heat during operation that compounds heatwave conditions (Salamanca et al. 2014). It is, however, possible that more energy-efficient AC technology will be developed in the coming years (IEA, 2018).

Implications for CCRA3 urgency scoring

This analysis has bearing on the risk descriptors set out in Table 5.6.

Table 5.6 Risk descriptors relevant to extreme heat

Latest Risk Descriptor	Implications
(35) Risks to energy from high and low temperatures, high winds, lightning (40) Risks to health and social care delivery from extreme weather (56) Risks to business from reduced employee productivity due to infrastructure disruption and higher temperatures in working environments	Respondents indicated that they felt they were undertaking all the behaviours available to them, aside from installing air-conditioning. The public appears to be less aware of ways to adapt to extreme heat than they are to flooding, as extreme heat has been historically less common, but will increase in frequency and severity by 2050s and 2080s.

5.2.3 Drought

Table 5.7 lists the ranking of drought-related behaviours by target group and National Impact Scores.

Table 5.7 Behaviours by target group and National Impact Scores identified in response to drought – current day

NIS	Households	Small businesses	Large businesses	Land managers (including agriculture)
3	**VR** Install greywater or rainwater systems **CdC** Apply more water to lawns/landscaping	**VR** Install greywater or rainwater systems **CdC** Apply more water to lawns/landscaping	**CdC** Apply more water to lawns/landscaping	**CdC** Apply more water to lawns/landscaping
4	**VR** Water-efficient landscaping **VR** Implement water-saving practices	**VR** Implement water-saving practices	**VR** Plan for longer period of peak water demand	**VR** Climate-smart agriculture **VR** Apply agroecology principles
6				**VR** Plan for longer period of peak water demand

Current day

A relatively common and maladaptive, practice noted throughout the case studies was that UK **householders** may actually increase their water use to maintain costly gardens in the event of drought (Interview 22). However, while no case study respondents explicitly noted this, water-efficient landscaping is becoming more common in areas affected by drought (Stoker et al. 2019) Additionally, the literature review indicated that installation of greywater or rainwater systems is an increasing practice in drought-prone areas although no case study respondents noted having undertaken these actions.

Implementing water-saving practices can entail a wide range of measures, including working with schools, water efficiency home visits (to install water saving gadgets, give advice, fixing leaking toilets), use data generated by smart meters (where these are installed) to identify and fix leaks inside customers' homes, using community incentives (for example Green Redeem, or Southern Water's River Itchen water saving project). Companies can and do make use of behavioural science when implementing water-saving initiatives. For example, some studies have shown that feedback on how a household's consumption compares to that of neighbours can result in lower water use.

For drought specifically, most of the current behaviours identified relate to **land managers and businesses**, who are highly dependent on water availability. This included agroecology practices for land managers and/or businesses involved in agriculture; for example, changing irrigation practices and using native plant types for regenerative agriculture. Actions were relatively common among these groups, because they are applicable across the UK and can result in multiple benefits (FAO, n.d.). Most actions had a low to medium effect on risk.

Maladaptation

During extreme heat events, residential and agricultural water use typically increases – during the 2018 heatwave, residential water consumption increased on average around 20% (Interview 21, Interview 23). It is possible that this consumption was driven in part by customers taking cool showers and baths based on NHS heatwave guidelines (NHS, 2019). Similarly, evidence indicates that household users increase water use to care for gardens. One interviewee noted the cost of garden plants outweigh the concerns or financial cost of increased water use: *'If you look at a very, very modest garden and all the plants in that garden, to replace them would cost you between £500 and £1000, if they all died and you went to a nursery'* (Interview 23). These actions are maladaptive as it places increased stress on water supply, which is compounded by temperature, especially for those water utilities that use surface storage.

Implications for CCRA3 urgency scoring

This analysis has bearing on the risk descriptors set out in Table 5.8.

Table 5.8 Risk descriptors relevant to drought

Latest Risk Descriptor	Implications
(50) Risk of household water supply interruptions (54) Risks to businesses for water scarcity.	The literature and case studies indicate that recognition of the risk of droughts among the UK public is low, or the risk seems abstract. Therefore, few substantive adaptive behaviours were noted in the case studies. Further work is required to provide clearer information on the risks and mechanisms that residents can undertake now to prepare for future changes. Businesses, particularly those dependent on water provision and availability, are more aware of the risks and incorporate better future planning.

5.2.4 Extreme cold

Table 5.9 lists the ranking of cold-related behaviours by target group and National Impact Scores.

Table 5.9 Behaviours by target group and National Impact Scores identified in response to extreme cold – current day

NIS	Households	Small businesses	Large businesses	Land managers (including agriculture)
2	**CdC** Attend community warming centres	-		
3	**VR** Insulating buildings	**VR** Insulating buildings **CdC** Changing work practices to avoid coldest/snowiest parts of day	**VR** Insulating buildings **CdC** Changing work practices to avoid coldest/snowiest parts of day	**VR** Insulating buildings **CdC** Changing work practices to avoid coldest/snowiest parts of day
5	**CdC** Changing clothes		**VR** Market water consumption data in city centre **VR** Plan for longer period of peak water demand	

Current day

While the incidence of extreme cold events will, on average, decrease across the UK, they will still occur on occasion.[5] Additionally, the perception of milder winters under a changing climate may engender a false sense of security when these events do occur. This is compounded by the fact that many vulnerable individuals may not be aware of the importance of keeping warm to overall health (Tod et al. 2013). A major adaptation behaviour undertaken in the UK is insulating homes to address fuel poverty, for which certain schemes are available to support low-income households. Similarly, households may apply for subsidies on energy bills if they cannot afford to pay.

While snow and ice storms are included under the 'storms' category, it is important to touch on how extreme cold can increase target groups' vulnerability during extreme cold events and vice versa. Presently, the National Impact Scores assigned to extreme cold behaviours ranged between 2 and 5. Structural modifications (e.g. insulation) have a high impact on risk but there are financial barriers to uptake without subsidies.

Within the case studies, few behaviours were identified, with only two case studies, Peebles and Orkney, noting experience with extreme cold events in the form of snowstorms. Actions identified were mostly 'coping during crisis' (70%) or 'vulnerability reduction' (30%). These actions also had primarily a low influence on risk. One case study respondent noted they had changed the design of their driveway to better accommodate heavy snowfall.

Maladaptation

The greatest potential for maladaptation to extreme cold is in fact making properties and residents more vulnerable to heat stress in extreme heat scenarios. Increasing insulation in buildings that have been poorly designed can increase overheating, although the opposite is seen for insulation in well-designed buildings (Fosas et al. 2018). This distinction is critical to note, as vulnerable populations are more likely to live in older homes or estates with poorer design. If these are insulated, this could potentially increase their risk for overheating in summer months.

Also relevant is the projected decrease in extreme cold events. Over time, this may cause members of all target groups to take fewer preparatory actions in advance of winter months (e.g. storing grit), resulting in more severe consequences should extreme cold snap occur.

[5] Specifically, research on the jet stream and its stability under climate change will continue and have further implications for occurrences of extreme cold snaps in the UK.

Implications for CCRA3 urgency scoring This analysis has bearing on the risk descriptors set out in Table 5.10.

Table 5.10 Risk descriptors relevant to extreme cold

Latest Risk Descriptor	Implications
(35) Risks to energy from high and low temperatures, high winds, lightning (40) Risks to health and social care delivery from extreme weather (56) Risks to business from reduced employee productivity due to infrastructure disruption and higher temperatures in working environments	Extreme cold snaps are likely to decrease under future climate conditions.

5.2.5 Storms

Table 5.11 lists the ranking of storms-related behaviours by target group and National Impact Scores.

Table 5.11 Behaviours by target group and National Impact Scores identified in response to storms

NIS	Households		Small businesses		Large businesses		Land managers (including agriculture)	
1	**VR**	Secure or remove items stored on roofs	**VR**	Secure or remove items stored on roofs	**VR**	Secure or remove items stored on roofs	**VR**	Secure or remove items stored on roofs
	PRec	Have chainsaw to move downed trees	**PRes**	Implement backup plan for building access	**PRes**	Implement backup plan for building access	**PRec**	Have chainsaw to move downed trees
	VR	Reduce driveway gradient						
2	**CdC**	Stay with family or friends out of the affected area	**VR**	Shuttering windows	**VR**	Shuttering windows		
	VR	Impact-rate windows and entry doors	**VR**	Impact-rate windows and entry doors	**VR**	Impact-rate windows and entry doors		
	VR	Generate own electricity independent from grid	**VR**	Generate own electricity independent from grid	**VR**	Generate own electricity independent from grid		
	VR	Install outward-opening doors	**VR**	Install outward-opening doors	**VR**	Install outward-opening doors		
	VR	Move loose items away from windows	**VR**	Move loose items away from windows	**VR**	Move loose items away from windows		
	VR	Turn off gas connection	**VR**	Turn off gas connection	**VR**	Turn off gas connection		
	VR	Shuttering windows						
3	**VR**	Have flashlights on hand	**VR**	Have flashlights on hand	**VR**	Have flashlights on hand		
	VR	Storm-proofing structural modifications	**VR**	Storm-proofing structural modifications	**VR**	Storm-proofing structural modifications		
	VR	Install sealed roof deck	**VR**	Install sealed roof deck	**VR**	Install sealed roof deck		
4	**VR**	Park cars into wind	**VR**	Trim trees and branches near buildings	**VR**	Trim trees and branches near buildings	**PRes**	Have salt or sand ready if snowstorm
	VR	Covering windows and doors	**VR**	Covering windows and doors	**VR**	Covering windows and doors	**VR**	Tie down potentially loose objects
	VR	Tie down potentially loose objects	**VR**	Tie down potentially loose objects	**VR**	Tie down potentially loose objects		
	VR	Install surge protector	**VR**	Install surge protector	**VR**	Install surge protector		
	PRes	Have salt or sand ready if snowstorm	**PRes**	Have salt or sand ready if snowstorm	**PRes**	Have salt or sand ready if snowstorm		
	VR	Turn off mains power	**VR**	Turn off mains power	**VR**	Turn off mains power		
	VR	Unplug router or electronic devices	**VR**	Unplug router or electronic devices				
	VR	Trim trees and branches near buildings						

NIS	Households	Small businesses	Large businesses	Land managers (including agriculture)
6	**CdC** Follow evacuation orders	**CdC** Follow evacuation orders	**CdC** Follow evacuation orders	**CdC** Follow evacuation orders

Current day

Many of the actions for flood-related events are also applicable in the context of storms; however, several actions diverge and are relevant to the experience of select regions of the UK, such as Orkney, which provided a wealth of case study evidence. Storms may include high winds, driving rain, lightning strikes and associated flooding (discussed in Section 5.2.1). The identified behaviours were either extremely rare (45%) or uncommonly adopted (52%). Most actions (62%) had a medium effect on risk, either increasing the adaptive capacity of impacted groups or reducing their sensitivity.

In addition to high winds and lightning storms, snow and ice storms (including drifting snow) have historically caused severe impacts throughout the UK (Centre for Ecology and Hydrology, 2016). These storms can disrupt all forms of transit along with electrical and connectivity (internet, phone) networks. This, in turn, can disrupt health (e.g. inability to access health centres or sheltering areas) and/or livelihoods (e.g. damage to assets or inability to get to work). Respondents in both Peebles and Orkney noted these impacts following snow or ice storms (Survey 90).

To address these impacts, respondents typically took vulnerability reduction, coping, and preparedness for response measures. Behaviours typically decreased the sensitivity to the impacts (e.g. turn off mains power; install surge protector; tie down loose objects) and, in some cases, increased adaptive capacity (e.g. unplugging routers decreases the chances of a resident being disconnected from the Internet due to a damaged router, making them more able to get updates after the event).

Maladaptation

Most identified actions are unlikely to be maladaptive. However, those that carry risk of maladaptation either give a false sense of preparedness (e.g. installing backup generators, surge protectors) or may encourage actions that could increase exposure (e.g. changing driveway gradient to be less prone to snow-in could encourage an individual to drive in unsafe conditions). Other actions may also increase vulnerability to other climate events; for example, sealing a roof could lead to heating of the building during extreme heat events and trimming trees could contribute to urban heat island effects.

Implications for CCRA3 urgency scoring: This analysis has bearing on the risk descriptors set out in Table 5.12 Risk descriptors relevant to storms

Table 5.12 Risk descriptors relevant to storms

Latest Risk Descriptor	Implications
(35) Risks to energy from high and low temperatures, high winds, lightning (40) Risks to health and social care delivery from extreme weather	While there remains uncertainty around storm activity under climate change, the impacts can still influence the identified risks, particularly as further research may be needed to understand how current autonomous adaptation impacts on broader systems like ICT and service delivery.

5.3 Factors influencing action

3. 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)?

The literature review identified several factors that influence decision-making by households, businesses, or land managers around reactive adaptation. These are summarised in Table 5.13 noting that multiple factors may be in operation simultaneously.

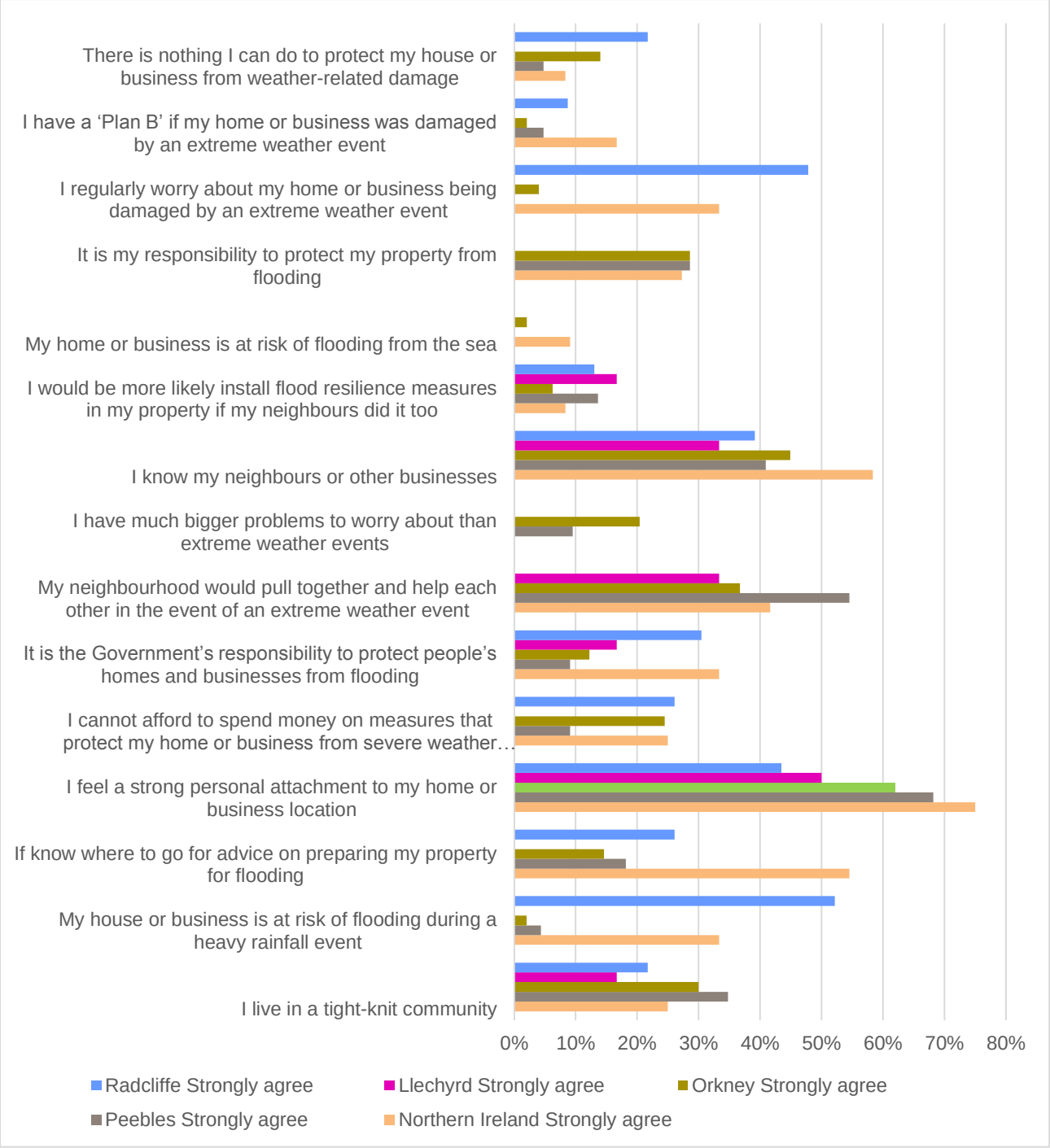
Table 5.13 Behavioural determinants identified in literature review

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.

The case studies affirmed many of the behavioural determinants identified by the literature review and provided further breadth around how these determinants mediate the target groups' decisions to undertake certain behaviours, including not taking any action. Most behaviours identified were not explicitly undertaken as adaptation to climate change, but rather in response to perceived or experienced acute risks.

Figure 5.13 provides a summary of survey responses to specific questions regarding underlying factors driving behaviours, noting overall respondents who strongly agreed with the statements, separated out by case study.

Figure 5.13 Survey responses noting 'strongly agree' to questions surrounding factors motivating behaviour (n = 225)



Demographic and socioeconomic factors

The literature review indicated that ownership, gender, age and marital status were often predictors of adaptive behaviour (Rapaport et al. 2018; Grothmann & Reusswig, 2006; Koerth, Vafeidis, & Hinkel, 2017; Brink & Wamsler, 2018). The case studies supported age and ownership as potential predictors and identified the type of dwelling as a possible predictor of undertaking permanent protective measures[6]. There were no clear trends in income or marital status and autonomous adaptation (Figure 5.14 and Figure 5.15).

Overall, the sample sizes in case studies mean that it is difficult to draw further conclusions around demographic factors driving adaptation behaviours. However, younger respondents did report having undertaken more permanent protective measures, decreasing as age increased (Figure 5.14).

A potential explanation is the greater level of understanding about climate risk and adaptation among younger generations (van der Linden, 2015), although both the correlation with age and the hypothesis would need to be tested in more detail.

Figure 5.14 Proportion of respondents in each age bracket who had taken protective measures (n = 117)

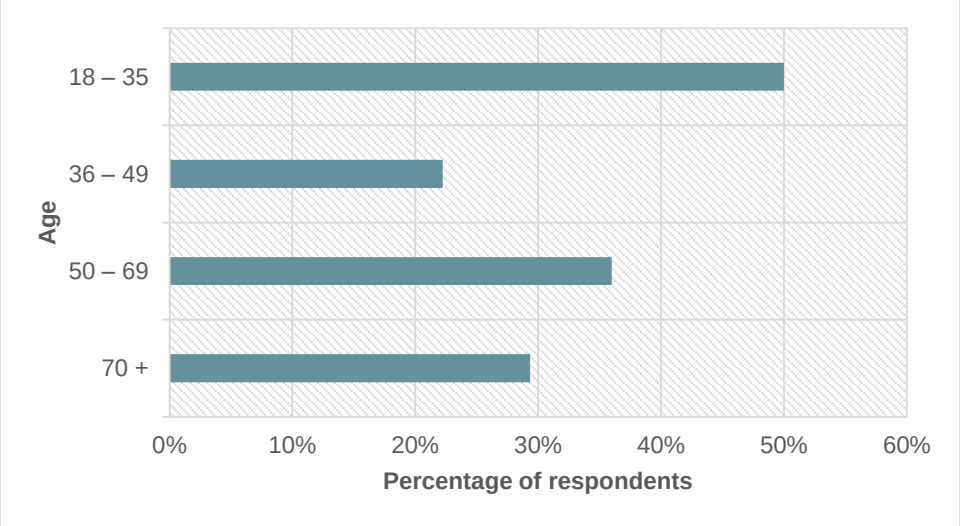
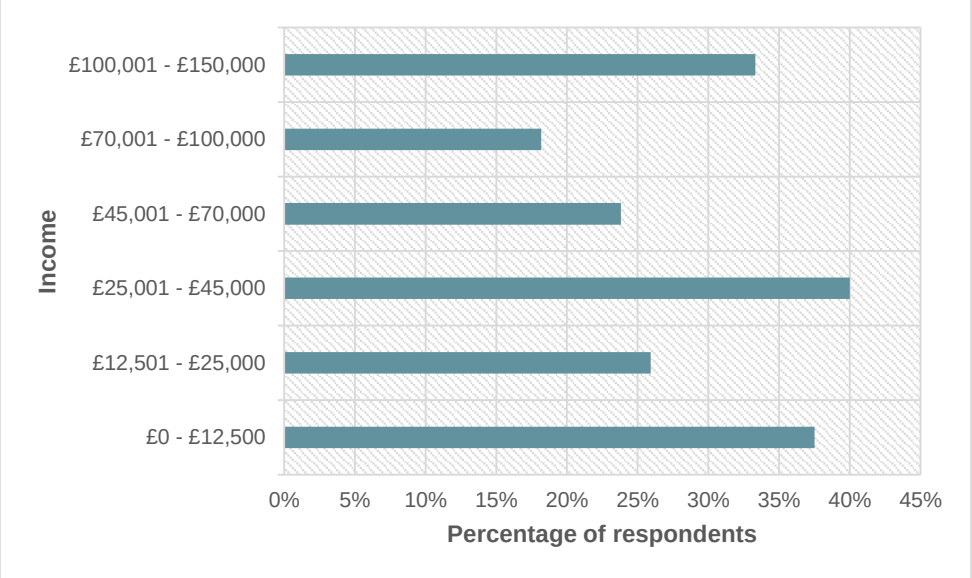


Figure 5.15 Proportion of respondents within income brackets who had taken protective measures (n = 98)



[6] Permanent protective measures are characterised as those that are not easily reversed (e.g. clear structural modifications).

5.3.1 Social norms and community knowledge-sharing

The case study findings indicated that local social norms mediated behaviour. Different communities were seen to have different collective mindsets shaped by the historical context and culture. For example, a specific theme that surfaced in Orkney was the idea that extreme weather was a way of life and had been for millennia. As a result, many case study respondents there noted the need for flexibility and patience in response to extreme weather. Power outages occur, roads may close for a time, but in their context, these are all part of life and residents and businesses alike just 'get through it' (Survey 42).

Furthermore, neighbours and communities can play a key role in influencing and encouraging adaptive behaviour. 43% of respondents indicated they would be more likely to act to protect their property from extreme weather events if they knew others in their neighbourhood were doing the same. This extends beyond protecting personal property to collective measures. In Wales, it was reported that several members of the community had developed a community resilience group in response to flooding (Interview 05).

The necessity of using local knowledge also surfaced in the interviews. Not only did respondents learn from direct experience of events, they also learned from proactive behaviours neighbours were taking, whether that was through knowledge-sharing or observation. On Orkney, 'incomers' – those non-native to the islands –commonly expressed their experience of learning common risk-reducing behaviours from neighbours: 'there's always a very helpful neighbour [that will say] "*Oh, ay, you know, that'll never last." No, people are helpful, but you observe what other people do"* (Interview 03). This interviewee went on to note: "*People parked their cars at the end of the tracks (...) I noticed people do that and I think that's probably why I did that. No-one actually told me to do that, but I had seen other people do that*" (Interview 2). In this case, parking cars at the end of tracks in Orkney allowed one to have their car on a ploughed road in case of a snowstorm, as opposed to having to shovel one's driveway out.

Another respondent explained: "*It's the community (…) if somebody found out something, they'd tell you*." (Interview 13). The respondent further elaborated on an example where a small business had recently refurbished their property with storm doors and sealed lower windows, which had successfully prevented water entering the premises. After hearing this, multiple people in the adjacent area also installed storm doors (Interview 13).

Another respondent noted that the they expect knowledge-sharing to increase in the future as people begin to proactively organise: "*People will be able to pool resources and basically pool their abilities. There are some people who will suffer more than others who will obviously be able to be bailed out there and then straight away. But also just to pool skills, to pool talents, so that when people are having problems there is a group of people that can find solutions*" (Interview 05).

5.3.2 Learning from past experience and associated negative affect

Interviewees noted that they had gained knowledge following past events, where direct experience of extreme weather had spurred learning about how to respond and further awareness of risks.

For one, experiencing a climate event makes those exposed acutely aware of the ways in which these events affect daily life. Following the 2015 Boxing Day flood, one respondent indicated that they were fearful of projections of increased incidence and severity of flooding in the future. They stated: 'Well, flooding is […] physical, financial and emotional distress to the community' (Interview 01), indicating that the negative feelings attributed to past events can spur action to avoid similar consequences. In this case, the community developed a resilience network as a starting point to share information.

One repeatedly reported behaviour, specifically in relation to flooding, was to build community information or support networks in response to a past event. This was explicitly noted in three separate case study interviews:

- *'Well, you see I wasn't aware of anything before the flood so, yes, there would be a difference now because we would be more aware, we have a system in place where we can contact each other but up to that there was nothing because there hadn't been [any flooding] before that."* (Interview 01).
- *'Well, yeah, we have a resilience group started up now. A network of people who can communicate with each other in the event of there being any events like that again."* (interview 11).
- 'Locally also there is, last year, basically as a consequence of the flooding there's been a community group developed in the…area that is specifically designed for community resilience.' (Interview 01, Interview 05).

Past experience also contributes to negative affect. This was reflected with Interviewee 11, who noted a social network that connects neighbours with information, but also contributes to a sense of elevated discomfort that the community could experience a similar flooding event. They note:

'…[W]e've also got an app where we can ring that or we text various bits of advice, there was lots of noise this morning about renewing insurance premiums, things like that. I think there's a much greater level of knowledge out there. But there's also that knowledge and with all these flood alerts, there is a greater amount of panic, I would, say, and concern and alarm that, "Oh, are we going to go through this again?'

In addition, respondents noted that their individual behaviour had changed in response to past experience. In addition to the examples of 'building back better' noted in Section 0, another interviewee who had experienced a lightning storm explained: '*You know, if you've had one satellite dish blow up, you learn from it. OK, it cost me in the pocket but it's not, I don't look upon it as a bad thing, it's learning"* (Interview 02). However, it should be noted that negative affect can either drive a decision to act or inhibit it.

5.3.3 Size of community

It is likely that many factors influencing adaptive behaviour are mediated by the size of the community (Paul et al. 2016). Many interviewees noted that their communities had developed resilience networks either in response to past events or in advance of anticipated impacts. These communities all have populations under 9,000 and most survey respondents noted that they agreed or strongly agreed with the statements 'I live in a tight-knit community,' 'I know my neighbours or local businesses,' and 'my neighbourhood would pull together and help each other in the event of an extreme weather event.' This indicates that smaller communities where residents and businesses know each other may have higher tendency to organise because of this social capital, and additionally because it is easier to coordinate amongst smaller populations (Babutsidze & Chait, 2018; Rapaport et al. 2018; Bamberg, 2017).

The observation that smaller communities are more likely to adopt adaptive behaviour was supported by surveys and interviewees with water industry experts, who noted that consumers in rural areas were more likely to adopt water-saving behaviour because of the often-incorrect assumption that their water was sourced locally. In dry periods, these customers could see a local river at lower levels and assume that their water supply was similarly depleted (Interview 22, Interview 23):

> *'And then, yeah, then we do find that local communities … smaller towns and villages, just because predominantly, they will be located on the South Downs and/or living in the countryside, and can see the direct impact of water abstraction, perhaps, on the river, and stuff like that, because they're … closer'* (Interview 22).

However, this pattern may also be replicated in larger towns or urban environments, where informal local or block-based community groups or networks arise in response to perceived risks.

5.3.4 Perceived level of government involvement

The case study surveys and interviews indicated that perception around government's action – particularly National government – influenced people's belief in the need for, or efficacy of, their own work (Kent et al. 2013). However, perception of or reaction to government action, or lack thereof, often led to contradictory outcomes. Indeed, government action can often decrease individual or community risk perceptions, known as the levee effect (Interview 11; Hutton et al. 2019). For example, public flood defence projects can often increase people's sense of security and therefore they will not undertake household- or community-level adaptation.

Throughout the case study data, a recurring theme was the role government action plays in incentivising adaptation (Expert Interview 33). Respondents noted hesitance around the efficacy of household or community level adaptation when they perceived that local or central government and politicians were not undertaking sufficient action. Respondents noted:

- *"Our community is perfectly capable of putting our shoulders to the wheel and working really hard to get everybody back into their homes (..) but there are serious infrastructure problems here which are not being addressed, and we as a community cannot address them. (..) The last time surface water flooding happened a few weeks ago we were all on our hands and knees cleaning out the drains manually and I just don't think that's acceptable"* (Interview 08).
- *"Individually we are doing as much as we can within the constraints of the current infrastructure and societal system. (..) There are limitations on what individuals can do within their means, and the frustration we have is that for all the talk of local authorities or whoever is declaring climate emergencies nothing changes"* (Interview 15).

- *"The term 'climate emergency' I do have problems with. Maybe I am overthinking it, but you can't tell someone it's an emergency unless you're going to actually take emergency action*" (Interview 02).

In some cases, it was perceived that political decisions even worked against adaptation objectives. A recurring example was local politicians approving planning permissions to develop housing in low-lying flood prone areas, or exploitation of conservation areas (Interview 08, Interview 17). A perceived or observed discrepancy between individual and government action caused frustration and disincentivised autonomous adaptation.

While there was a low number of responses to this question in the survey, multiple case study interviews discussed feelings of disappointment that either central and, to a lesser extent, local government were not taking climate change seriously. That is, many respondents noted that they felt the government – especially the central government – did not adequately communicate the urgency of the situation, nor was this urgency reflected in their policy (Interview 05).

Alternatively, the absence of perceived investments in infrastructure dis-incentivised reciprocal action in the form of autonomous adaptive behaviours (Interview 08). This indicates that many feel local or individual actions have a weak response efficacy weak compared to planned adaptation projects. This was compounded by respondents' confusion over new developments occurring in floodplains (Hart & Feldman, 2016). While new developments are regulated by the Town and Country Planning Act (2012) and statutory local plans and must meet specific criteria in order to pursue development in a flood-prone area and must reduce the risk of flooding of those developments through their design, it is clear that many residents are unaware of these rules. This can undermine the perceived risk (e.g. if the district council has approved a new development in this area, then the risk must not be significant) or trust in government (e.g. if the district council approved a new development in this area knowing it is at risk of flooding, they are not taking this issue seriously). Land constraints often force development in flood-risk areas and the need for more and affordable housing means that such development will likely continue; therefore, communicating these constraints more effectively to residents may help to mediate this effect.

5.3.5 Perceived self- and/or response-efficacy

The majority of survey respondents who had experienced an adverse weather event also noted that they did not feel they could have done anything differently to respond to the event better (Survey 47, 49, 119). As one interviewee put it, '[i]t's hard to defend against floods as water will find its way no matter what' (Interview 06). This indicates that respondents either did not have the information needed, did not feel they had the necessary skills, or did not believe any further action would have been useful enough to warrant undertaking it. However, the case study interviews illustrated that many people perceived adaptive behaviour to only comprise of 'hard' adaptations, or those more geared toward reducing vulnerability rather than increasing adaptive capacity. This has implications regarding awareness campaigns or incentive mechanisms to promote adaptation, which are discussed in the following section

.

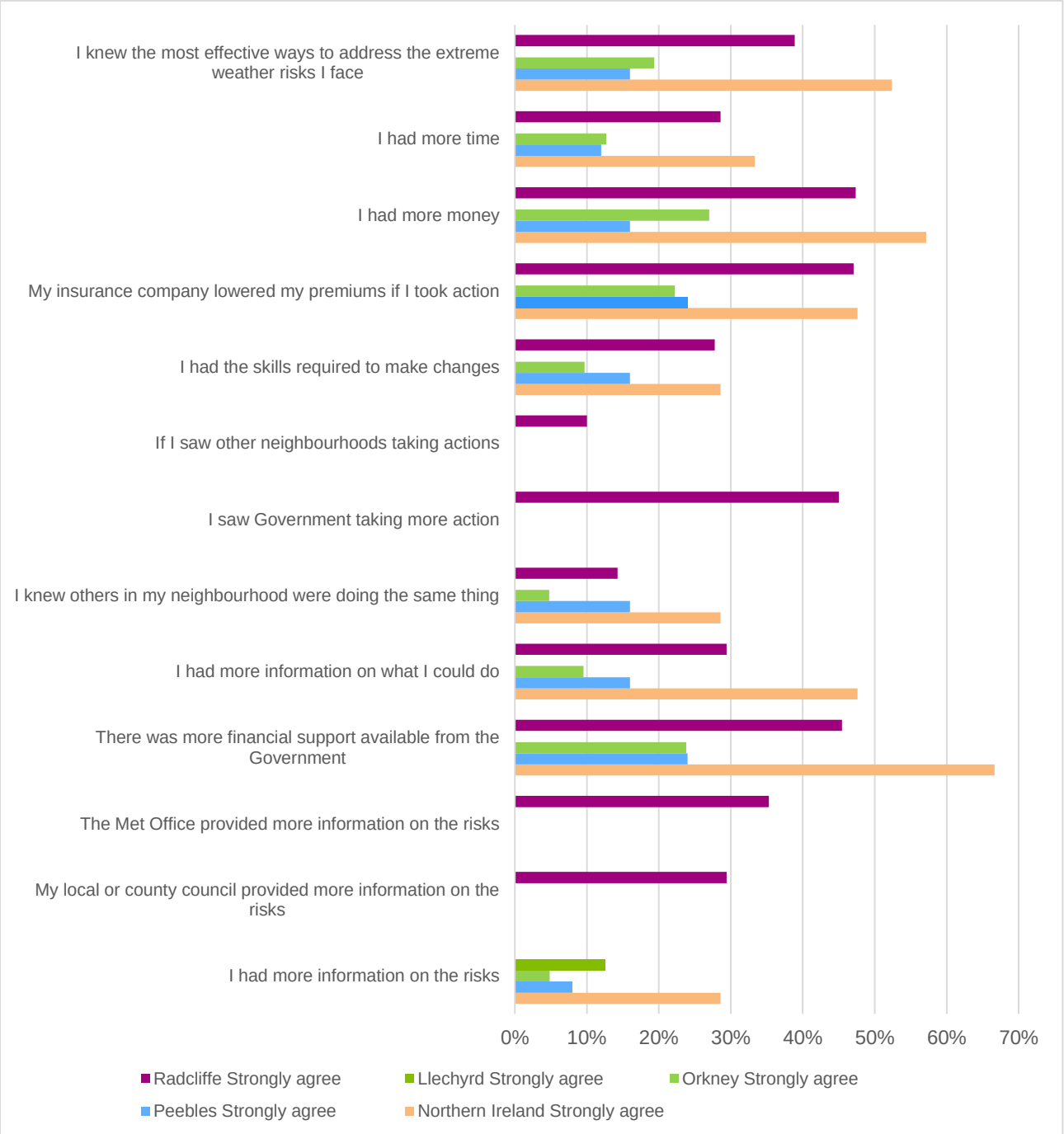
5.4 Incentivising risk reducing behaviours

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?**

This section discusses ways in which the identified behaviours can be incentivised. Figure 5.16 shows the responses to the survey question focused on incentives.

Figure 5.16 Response 'strongly agree' to the survey question 'I would be more likely to take action if...' split out by case study (n = 225)



5.4.1 Applying behavioural change techniques

Appendix D identifies several theoretical approaches that exist to conceptualise and achieve behaviour change. Of these, the COM-B model provides arguably the clearest model within which recommendations can be made for approaches to support climate-resilient decisions, as described in Figure 5.13. The choice of this framework as a foundation to assess means by which behaviours can be influenced was driven in

part by the results of the case studies and the thematic analysis identifying factors influencing behaviour.

For each following sub-section, a table is provided that outlines the target groups and behavioural typologies for which the incentivising mechanism is best-suited. Additionally, the relevant COM-B components associated with that mechanism are set out, alongside an example.

Table 5.14 mechanisms for influencing climate-resilient behaviours, framed by the COM-B model

COM-B Component	Description	Approaches that can support climate-resilient decisions
Physical capability	Having the physical (not mental) strength, skill, agility or stamina	Time-consuming, and sometimes impossible to build physical capabilities for those who do not possess them. More likely to be aided by providing third-party support or encouraging behaviours that can be effective without the need for physical exertion (e.g. power-operated blinds, rather than manually operated ones).
Psychological capability	Knowledge or psychological acumen (mental capacity or stamina)	Provision of relevant information around costs and benefits of certain adaptive actions; more likely to be effective if coupled with other techniques. Need for caution around use of ‘scare tactics’ that can drive negative affect.
Physical opportunity	Related to environmental factors – being physically located in a place that enables the behaviour; having the time or the necessary resources	Encourage those with resources to make them available to others (e.g. welcoming others into air conditioned private spaces).
Social opportunity	Opportunities enabled by social cues and cultural norms	Use trusted and well-respected community members as conduits for resilience-related information.
Automatic motivation	Related to ‘System 1’ thinking – instinctive brain processes such as impulses, inhibitions and application of simplifying heuristics	Difficult to actively change without significant work to form new habits and impulses. Often addressed through ‘nudge’ tactics, such as framing choices to ensure the most risk-reducing option is the default.
Reflective motivation	Related to ‘System 2’ thinking – deliberative and reflective brain processes, such as evaluation of options and plan-making	Provide easy frameworks in which plans can be made to support resilient outcomes, such as savings schemes or templates for Community Resilience Plans.

5.4.2 Financial incentives and support

X	Households
X	Small businesses
X	Large businesses
X	Land managers

HR	Hazard reduction
VR	Vulnerability reduction
PRec	Preparedness for recovery

Targets COM-B components:

- Physical opportunity
- Automatic motivation
- Reflective motivation

Examples:

Homeowner flood grant (Northern Ireland) - £10K to eligible, impacted households to purchase flood barriers

Financial incentives and support include grants, subsidies and reductions on premiums. These can be provided by public and private organisations.

The literature review indicated that, without public or private sector financial assistance, adaptation measures that require significant upfront capital are unlikely to occur in most cases. These actions tend to be either exposure or vulnerability reduction measures that involve some sort of structural modification (e.g. replacing carpets, tanking walls). This indicates that income can present a barrier to adaptation for those who want to undertake an action. As noted in Figure 5.16, about half of respondents in Northern Ireland (57%) and Radcliffe (47%) noted they would undertake adaptive action if they had access to financial support.

The Homeowner Flood Protection Grant Scheme – a successful Rivers Agency scheme in Northern Ireland - was mentioned in the case studies as a grant that the respondent used to purchase adaptation interventions (Interview 08). This scheme provided households with up to £10,000 to purchase flood barriers and other small materials for property level protection. The scheme was only accessible to properties who had been flooded, and a community organisation actively helped people access grants.

The most common private provider of financial incentives are insurance companies. Insurance companies have an important role in managing existing and future climate risk. To stay in business, insurance companies need to ensure even distribution of risk while incentivising those covered to reduce their risk. Many flood-related proactive adaptation behaviours identified in the literature review were linked to insurance premium reductions, where households and businesses who undertook pre-specified adaptations receive a decreased premium as they attempted to decrease their risk of damage (Brody et al. 2016; Müller-Fürstenberger & Schumacher, 2015; Bichard & Kazmierczak, 2012; Wedawatta, Ingirige & Proverbs, 2011; Harvatt, Petts & Chilvers, 2010; van den Bergh, 2009). New typologies of insurance, such as parametric insurance, may increase uptake in future. Parametric insurance provides ex ante agreement of insurance upon a triggering event (in this case, a specified climate event) (Markovic & Harry, 2020).

Many survey respondents, mostly property owners, somewhat or strongly agreed with the statement that they would be more likely to undertake protecting their property from flooding if their insurance provider would offer reduced premiums. One expert interview noted a project run by the EA in Sussex which provided funding to households to implement property-level flood protection measures, reducing insurance premiums (Expert Interview 31). Another expert interview noted that BRE commenced a research project with the insurance industry to develop a database with properties that have adopted property-level protection measures, however, the project stalled as it faced challenges in deciding on the effectiveness of the different measures and the standards it performs to (Expert Interview 34). The government flood reinsurance scheme is presently due to end in 2039 but does not fund betterment (FloodRe, n.d.).

In a 2018 report on the role of insurance in climate change adaptation, the European Commission noted the following characteristics that aim to integrate climate risk management into insurance, while ensuring that those at high-risk are not deterred by high premiums:

Figure 5.17 Characteristics of a high-performing climate-risk management insurance scheme
Source: European Commission, 2018.

High-performing insurance schemes

- Multiple extreme weather risks (floods, storms, hail etc.) are combined in a single insurance product, with a focus on yield insurance
- Purchase of extreme weather insurance is connected to a far more common and enforced product (e.g. mortage contracts, fire insurance)
- Requirements to insure all cultivated land
- Premium subsidies to direct investment in multi-risk policies
- Pool-like structures or public reinsurance for specific time-bound risks, such as frost and droughts
- Collaboration between public and private sectors with a commonly stated and understood objective. Governments and the insurance sector exchange data, set common objectives and divide responsibilities.
- Provision of a national pool or public reinsurance/support for catastrophic losses
- A tradition of collaboration between the public and private sector risk managers

5.4.3 Targeted communication about risks and effective action

X	Households
X	Small businesses
X	Large businesses
X	Land managers

HR	Hazard reduction
VR	Vulnerability reduction
PRes	Preparedness for response
CC	Coping during crisis
PRec	Preparedness for recovery

Targets COM-B components:

- Psychological capability
- Social opportunity
- Reflective motivation

Examples:

Water industry water saving campaigns and educational campaigns within schools.

The Sesame project, promoting SME adaptation to flood risk (Sesame, 2015).

Targeted communication on risk

The literature review suggests that the mere existence of fiscal incentives did not necessarily spark greater uptake. This relates to the importance of getting climate and risk communication right. Communication that is better-targeted is a means of spurring behaviour change (Brink & Wamsler, 2018; Arunrat et al. 2017; Doell, 2017; Salama & Aboukoura, 2017; Valdez, Nils Peterson & Stevenson, 2017; Huang, Lindell & Prate, 2016; Thomas et al, 2015; De Dominicis, 2014; Taylor, Dessai & Bruine de Bruin, 2014; Poussin, Botzen & Aerts, 2014; Bichard & Kazmierczak, 2012; Grothmann & Reusswig, 2006; Baan & Klijn, 2004). One expert interview described how, after the 2007 UK floods, many households did not take up grants due to communication issues and highlighted the importance of dedicated awareness-raising efforts (Expert Interview 37). An FSB (2015) study also indicated that SMEs may not respond to flood warnings because, even if they were aware of or signed up to flood warnings in the area, they may not understand the relative risk they faced.

The case study data highlighted the need for locally tailored communication and interventions, incorporating the past experience of the community. One expert interview noted that, following the 2007 floods in Hull, a Living with Water programme was initiated through a partnership between the Environment Agency, Hull City Council, the East Riding of Yorkshire Council, and Yorkshire Water (Expert Interview 32). One of the components of this programme was to work with local school pupils to retrofit sustainable drainage techniques into the area. Since then, local schools have also reworked the curriculum to teach about flood risk and how to deal with flooding. Schools organised water-themed obstacle runs for the wider community, resulting in increased sign up rates to flood warnings (supporting the observation from another expert interview that educational interventions are an effective way of changing community behaviour (Expert Interview 35). The fact that the programme accounted for the local past experience contributed to its success.

In Scotland, the Property Flood Resilience Delivery Group (PFRDG) as part of the 'Living with flooding: action plan' is aiming to support uptake of property-level resilience measures following the completion of the FloodRe programme. This

includes building an evidence base that will then be used to provide clear guidance to support positive changes (Scottish Government, 2019).

Information about the most effective mechanisms

Multiple interviews and survey respondents particularly in England and Wales noted, however, that information on effective mechanisms would be helpful (see Figure 5.16). “There are different things I can do but it’s difficult to know if it’s worth it. Should I insulate the roof better or would that make it worse? Is double glazing better or not? Should we just bite the bullet and get AC in the bedrooms?” (Interview 05). Financial support and communication on the risks will therefore be more helpful if provided in tandem with clearer information on effective adaptation.

Of particular note, the use of sandbags was commonly cited among survey respondents as a behaviour they have undertaken or would in future. This belies best practice advice that sandbags are less effective in comparison to purpose-designed flood protection products (Environment Agency, 2009). This indicates a disconnect between communication and uptake of best practice.

Role of community organisations in relaying information

As noted with community organisations supporting the uptake of the Homeowner Flood Protection Grant Scheme in Northern Ireland, community organisations play a key role in communicating information and building local capacity to implement adaptation behaviours (Environment Agency, 2019). These could also address the perceived gap between necessary adaptation and government (in)action noted in 5.3.4. Regulation, standards and policies

X	Households	**HR**	Hazard reduction
X	Small businesses	**VR**	Vulnerability reduction
X	Large businesses	**PRes**	Preparedness for response
X	Land managers	**CC**	Coping during crisis
		PRec	PRec

Targets COM-B components:

- Social opportunity
- Automatic motivation
- Reflective motivation

Examples:

Reporting requirements for businesses under the Climate Change Act of 2008

A stable policy environment and clear regulation can help businesses plan and take decisive action. For households, it can incentivise behaviour change, particularly relating to financial assistance for adaptation measures. The UK Climate Change Act 2008 provides a mechanism for government to ask organisations to report on the current and future predicted effects of climate change on their business, as well as their proposed actions to adapt to climate change. The main share of organisations involved are utility providers, airport operators, road and rail providers, and regulators. Over 100 organisations have provided reports to government, with large gaps of the private sector remaining. It should be explored further whether mandatory reporting incentivises adaptation, as no conclusive evidence was found. Refer to the following section for discussion of private sector disclosure of climate risk exposure.

Further incentives through regulation come from the financial and insurance sector. Basel III, a set of international banking regulations applicable to the UK, requires regulators to challenge banks to undertake more frequent stress tests that also account for climate risks. It furthermore stipulates how much capital banks must hold against their assets, after adjusting these for risks, including climate risks. Similarly, the Solvency II Directive 2009 outlines the minimum amount of resources that underwriters must hold to be able to cover the risks to which they are exposed, and describes the principles of diligent and frequent risk management.

5.4.4 Stakeholder and shareholder pressure

	Households
X	Small businesses
X	Large businesses
X	Land managers

HR	Hazard reduction
VR	Vulnerability reduction
PRes	Preparedness for response
CC	Coping during crisis
PRec	Preparedness for recovery

Targets COM-B components:

- Social opportunity
- Reflective motivation

Examples:

The Bank of England's Prudential Regulation Authority expectation for firms to undertake scenario planning to identify climate risks.

The stance of private sector organisation on climate change is increasingly scrutinised by a growing group of stakeholders. Stakeholders include the public, lobby groups, civil society organisations, clients, investors, governments, and scientific institutions. Each have their own tactics to exert pressure on companies. Businesses that demonstrate good risk management, including climate risks, are likely to be more attractive to investors (Acclimatise, 2016).

The Task Force on Climate-related Financial Disclosures (TCFD) is an example where voluntary corporate disclosure of climate risks has gathered wide traction, with 824 signatories globally. The Task Force on Climate-related Financial Disclosures (TCFD) is an example where voluntary corporate disclosure of climate risks has gathered wide traction, with 824 signatories globally. This 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 with nearly $34 trillion 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 of how disclosing climate-related financial information is changing corporate strategies on adaptation, and how investors are using the disclosed information to inform their decisions (TCFD, 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" (PRA, 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 their benefits be more difficult to communicate, the information could be a source of competitive advantage or disadvantage (TCFD, 2019; Agrawala et al., 2011).

A study on the UK building industry noted that businesses would be triggered to adapt if clients' attitudes urged them to do so (Morton et al. 2011). This is also relevant for businesses with a strong public-facing customer base, such as retail, as companies in this sector tend to be more attuned to reputational impacts. Marks and Spencer launched a study in 2015 to understand how it could protect its most valuable stores from climate impacts (Marks & Spencer, 2015).

In turn, there are examples where businesses are using their role as stakeholders to lobby government. In 2015, 57 companies, including a number of UK multinationals, signed a letter arranged by the Aldersgate Group to EU heads of state to set out a strong climate policy at the 2015 Paris Conference of Parties. Around the same time a similar letter was signed by CEOs of over 78 companies globally organised through the World Economic Forum. Also, in 2015, 80 UK businesses wrote an open letter to the UK government urging stronger climate action. In 2019, this number went up to 128 businesses. The letter urged the UK government to accept the recommendations from the Committee on Climate Change. It should be noted that it is difficult to trace back these statements to businesses implementing adaptive measures, but a stable and long-term policy environment is conducive to enabling autonomous adaptation.

5.4.5 Use of evolving digital and data technologies and information

X	Households	**HR**	Hazard reduction
X	Small businesses	**VR**	Vulnerability reduction
X	Large businesses	**PRes**	Preparedness for response
X	Land managers	**CC**	Coping during crisis
		PRec	Preparedness for recovery

Targets COM-B components:

- Psychological capability
- Social opportunity
- Reflective motivation

Examples:

Machine learning and algorithms developed to help communicate the impacts of extreme weather. Researchers used these to simulate what homes might look like after flooding or sea level rise. This could be used to impact people's motivation to act (although potentially inhibit action if it does not appropriately activate negative affect).

Climate information services are means to communicate climate information and solutions more directly to individuals, communities, businesses, and land managers (Morton et al. 2011). One such intervention is variations on automated telephone alert systems (e.g. Floodline, Notify). Households must sign up for this free service, so it would first be necessary to be informed about the service. Only 2% of survey respondents reported currently using this service. Businesses can also sign up for the Targeted Flood Warning Service, a paid-for service (free for not-for-profit organisations), though this service is unavailable in Northern Ireland. More commonly, mobile weather forecasting applications, such as BBC Weather, send push notifications and display flood warning alerts when opening the application. Beyond early warning information, climate services also aim to help communities and organizations make climate-smart decisions.

One option for increased use of a government alert service would be to make it opt-out, rather than opt-in. This nudging tactic, where the more desirable choice is made the default, has been deployed to good effect in the past – the most famous example relates to the UK private section pension scheme, which saw an almost threefold increase in enrolments over four years when the process was switched to an opt-out approach in 2012. However, care must be taken with this approach, as when deployed without appropriate supporting communications, or applied to a highly divisive intervention, it can create a public backlash. UK privacy regulations may also present barriers to implementation.

The continued improvement of high-resolution information and spatial analysis also provides a clear opportunity to support targeted communication as it can be sued to address the challenges around lack of data. A recent study in Italy (Maragno, Dalla Fontana & Musco, 2020) identified a methodology that produces sensitivity, adaptive capacity, vulnerability, exposure and risk indicators using combined crowdsourced geospatial data and high-resolution spatial information. This information can then be used to drive neighbourhood-level adaptation measures. While this methodology specifically focused on heat stress, such localised and novel methodologies that rely on enhanced data can be adapted across climate events and contexts.

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. One expert interview described how, notwithstanding the importance of local radio in some geographies, some media platforms with direct messaging services are more useful during an event, whereas platforms such as Facebook and Flickr have proven useful to share information around wider adaptive action (Kryvasheyeu et al. 2016). These could provide a space to share knowledge among groups who have undertaken various types of autonomous adaptation. A respondent in Northern Ireland described how after significant flooding the affected community came together to create a community resilience group, instigating text and email alerts and appointing flood wardens (Interview 13) Reported benefits include better knowledge on how to contact each other, but also improved understanding of weather data:

- "*We now know how to read graphs and the real time information, which is available online, and we've had a new water monitoring sensor put in on one of the rivers."* (Interview 13)
- Ready Scotland are currently trialling a pilot scheme to recognise the work of community resilience groups with awards, to understand whether this is an effective mechanism to encourage action (Expert Interview 46).

For businesses, digital innovation plays a different role. With the abundance of data and the rapid development of predictive modelling, decision-making based on algorithms has potential to change the way businesses view, understand, and analyse risks, as well as adopt adaptive behaviours (Ford et al. 2016). Algorithmic modelling and big data are perceived as a promising way to support climate change adaptation, and can reduce research costs for businesses (Huntingford et al. 2019). Businesses increasingly rely on algorithmic reasoning for decision-making, such as using artificial intelligence to process large datasets to discover historical weather patterns, optimise climate forecasting, predict early crop yield or crop issues, and real time disaster risk mapping. Water companies are exploring these technologies applied to smart metering or analysing demand and consumption trends.

Risks arising from digital approaches include cyber risks (e.g. hackers accessing warning systems), inability to control malevolent algorithms, ethical concerns, job displacement, increased energy demand to run algorithms, and liability for mistakes. For example, artificial intelligence (AI) early disaster warning systems are trained using historical data on weather patterns, but there is a lack of understanding how factors drive model predictions. This could result in false or negative alarms (Sakata, 2018).

To ensure AI is used responsibly, government and industry leaders need to work closely together to use its potential to aid corporate decision-making. Frameworks for decision-making under uncertainty suggest that it can feel rational to delay significant and irreversible investment (Agrawala et al. 2011), but if evidence generated through AI or otherwise shows that benefits will eventually be accrued, this supports a business case for investing in adaptation.

6. Concluding remarks and next steps

This report aimed to undertake a comprehensive assessment of adaptation behaviours presently adopted in the UK by households, businesses, and land managers. Further, the report aimed to expand upon these types by using existing literature, expert interviews, and case studies to identify underlying factors that drive different adaptation behaviours (including taking no action) and interventions that have proven effective to incentivise behaviours that reduce vulnerability, decrease sensitivity, or increase adaptive capacity. Finally, the report aimed to develop a comprehensive methodology with which to assess estimated direction of change in behavioural adoption.

6.1 Summary of key findings

1. What behaviours do different groups adopt in anticipation of or in response to a chronic or acute climate event? Do the behaviours vary by geographic region or land use type?

This study identified 86 unique behaviours (see Appendix I), which are taken in advance of, during, or in response to an extreme weather event. The types of behaviours taken vary according to several different factors, including the type of climate event being experienced. Extreme cold and heat events tend to elicit reactive coping responses rather than proactive strategies before the event due to the widespread nature and avoidance difficulties associated with these hazards. Conversely, adaptation to flooding includes more proactive vulnerability reduction and preparedness for response mechanisms, in part because flooding has historically been a common occurrence and is arguably the most well-known climate impact in the UK, with flood-risk zones being clearly defined.

The evidence reviewed suggests that few households take permanent protective measures to prepare their homes for severe weather events. However, the most common permanent proactive actions taken included removing or not planting large trees close by (in response to risks from high winds), installing water tanks (to adapt to drought risk), and raising appliances (to adapt to flood risk). Conversely, agricultural land managers were more likely to proactively manage climate risk due to placing a greater importance on variations in climate and weather in relation to protecting their livelihoods, and therefore also having a greater awareness of these variations. Adaptation from large businesses tended to also be more proactive than individuals or households, seemingly due to the wider range of skills, capital, and understanding of operational risk posed by climate hazards.

Storm behaviours were found to be rare across the UK due the minority of communities that experience regular storm events, and there is uncertainty around how storms events and resulting behaviours will change in the future. However, among communities impacted by storms, target groups typically had a good understanding of actions to take to reduce their risk, relative to how commonly they had experienced storms. For example, the discrepancy between long-term residents of Orkney compared to incomers evidenced that the length of residence and previous and repeated experience of storms impacted actions taken. For impacted communities, vulnerability reduction measures were the most common measures taken.

With regard to geographic region and land use type, no firm conclusions are able to be drawn due to the limitations of the study.

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?

Based on an analysis from the interviews, a set of **national impact scores** were calculated. The scores were calculated based on an assessment of the adoption of the behaviour, and the resulting impact of that behaviour on risk, using a table of criteria set out in tables 3.4 and 3.5 in the main body of the report.

These scores are intended to demonstrate, given the current level of adoption, to what extent each behaviour contributes to risk reduction across the UK relative to other types of behaviours. The scoring sought to provide a high level view as to the impact of different behaviours, and not their desirability in any one location or type of hazard.

Some of the most impactful behaviours by hazard were:

- **Flooding**: applying tanking (a process in which a liquid coating bonds to damp masonry to form a waterproof barrier when it dries) to all ground floor walls; routine clearance of drains; online data back-up; moving vulnerable items within the house as well as static items like sockets up walls; and purchasing flood insurance.

- **Extreme heat**: Seeking shady areas; drinking more water to stay hydrated; installing air conditioning (for businesses, though to note this can be maladaptive); keeping windows open at night; changing clothing, and reducing physical activity.
- **Drought**: planning for longer periods of peak water demand; water-efficient landscaping; implementing water saving practices; and climate-smart agriculture.
- **Extreme cold**: Changing clothing; insulating buildings; changing work practices to avoid coldest parts of the day.
- **Storms**: Installing surge protectors; turn off mains power; unplug electronic devices; tie down potentially loose objects; have salt or sand ready if snowstorm

Some of the least impactful behaviours (due to limited effectiveness, expense, and/or limited uptake) by hazard were:

- **Flooding**: Stockpiling sandbags (limited effectiveness); and increasing floor elevation (difficult and expensive)
- **Extreme heat**: spraying down pavements (maladaptive); changing how children are taken to school (no respondents indicated they had undertaken this behaviour); and keeping children home from school (limited uptake)
- **Drought**: installing greywater harvesting systems (difficult and expensive), applying more water to lawns/landscaping (maladaptive)
- **Extreme cold**: attend community warming centres (limited uptake on average across the UK)
- **Storms**: Implement backup plan for building access (maladaptive), generate own electricity independent from grid (higher upfront costs)

Not all behaviours in response to climate events are inherently positive, and some carry risk of maladaptation, whereby they increase the vulnerability and/or exposure of the individual, collective, or organisation, or create trade-offs with other objectives such as climate change mitigation. This is particularly common for behaviours in response to drought and extreme heat, for example some respondents were observed to more frequently water their lawns during periods of drought (which has little impact and uses up scarce water resources) or increase their use of air conditioning during extreme heat events (which has negative trade-offs for energy use and expels waste heat into the environment). These maladaptive behaviours may decrease in the future due to improved information and awareness. However, the evidence reviewed and collected suggests that air conditioning use could continue to increase as heatwaves become more intense and frequent in the future.

3. 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)?

This study's review of the factors influencing behaviour suggests that direct past experience was one of the most significant drivers of adopting some adaptation behaviours, particularly permanent proactive ones. This may mean that some behaviours will become more widely adopted as the frequency and severity of climate impacts increase. For example, many flood risk-reducing behaviours may increase in the UK as more areas became flood prone and those areas that are currently flood prone experience more frequent and intense flooding. Drought-risk reducing actions could become more common, particularly among agricultural land managers, and the ecological and economic co-benefits of climate-resilient agriculture and land management become more well-known and widely referenced in the policy environment (e.g. through the implementation of the government's 25-Year Environment Plan).

In addition to these factors, the case studies demonstrated that behaviours and the factors affecting behaviours vary according to local context, as different communities have collective mindsets shaped in part by their historical and cultural backgrounds, which therefore influence their behaviours.

Additionally, the literature review highlighted the need to consider actions that might disproportionately increase people's sense of preparedness or decrease their sense of risk. For example, people living in a community where there already are flood defence mechanisms may feel that it is unnecessary to take any further precautions. Similarly, target groups who took one action may feel that this action is sufficient, and overestimate their preparedness.

Finally, communities that experience frequent extreme weather may be overconfident in their ability to cope with a range of extreme weather events

However, this study also found that there are various barriers which mean adaptation behaviours are not being adopted now and may not be adopted in the future even with greater experience of climate events. The study points towards the issue that the target groups may not make the connection between increasing extreme weather events and climate change when applicable, although the field of attribution is relatively nascent and studies presently indicate that this association may not necessarily be a catalyst for change (Bruegger et al. 2015). People also tend to associate adaptive measures with hard adaptation actions, while low-cost, flexible solutions, which can increase adaptive capacity and reduce sensitivity, are typically the most easily accessible. Therefore, educating communities and individual stakeholders on different types of adaptation would likely have benefits in reducing the negative impacts of climate events. For example, many case study respondents did not realize that a behaviour they had undertaken likely reduced their risk despite the fact that it was not a structural modification. This misconception that adaptation only includes structural or property adjustments could be deterring greater action.

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?

Among the studied groups, businesses were found to have unique factors driving adaptation actions, including: company size, sector and location; access to information and resources; and extent of a public-facing customer base. Companies tend to be motivated to undertake adaptive action in order to demonstrate preparedness and achieve recognition, with potentially different underlying intentions to other groups, such as increasing profit, enhancing the value of their assets or services, and to win and keep business. Finally, regulatory frameworks, standards and reporting requirements are key drivers for business adaptation actions.

Adaptation responses are context specific and therefore future incentives to encourage uptake of behaviours will need to be designed considering the specific characteristics of the location and community. Generally, this study found that adaptation measures that require significant upfront capital are unlikely to occur without provision of material public or private sector support. Additionally, more effective climate and risk communication is required, with the evidence highlighting the need for more information on which measures are most effective.

This study highlights the utility of considering different behaviour change frameworks. In particular it has considered the COM-B model (Michie et al. 2011) (changing behaviour requires a change to one's 'capability' to undertake the behaviour, and/or 'opportunity' and 'motivation' to carry out the behaviour) and the theory of planned behaviour change (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). In particular, financial support and knowledge transfer were identified as necessary interventions for increasing adaptive behaviours among the different groups. However, this study highlighted the limits of financial support for encouraging behaviours, demonstrating the importance of considering other factors such as social norms, stakeholder pressure and clear policies and regulations.

Data and digital innovations will continue to change the landscape of autonomous adaptation. For example, climate services can continue to become more targeted to support communities and organisations to make climate-smart decisions. For businesses, advances in AI can be used to support decision-making by optimising climate forecasting, historical weather patterns, and support climate and disaster risk mapping in real time. Continued focus on this space, particularly in understanding how it can be integrated with or complement existing or planned incentive schemes.

Conclusions

In conclusion, this study has highlighted four key points:

1. Vulnerability reduction and preparedness for response measures, which are generally lower-cost and more flexible, are the most common behaviours adopted before, during or after a climate event; however, the type of behaviour varies depending on the nature of the event and the target group.
2. Age, direct past experience, and social norms were found to be the most common factors driving behavioural change among households and small and medium-sized enterprises. Conversely, income was noted as a barrier or enabler of adaptation, but not a driver itself.
3. Small and medium-sized enterprises have unique factors driving adaptation actions including company In addition, SMEs and particularly large businesses also have unique factors driving adaptation actions, including company size,

sector and location; access to information and resources; and sector-specific regulations, standards or reporting requirements. Most behaviours identified would reduce the impacts of climate events on people to a certain extent, with the exception of some maladaptive behaviours that have negative outcomes.

4. People want to know more about the effectiveness of different adaptation measures that they can take, and want support to take the best actions. Public and private sector support is necessary for encouraging adaptation measures. However, it is critical to ensure that climate and risk communication contains information on the most effective measures and is designed with specific target groups in mind.

6.2 Limitations of study

This study has several clear limitations. First, for the breadth of the research questions, the sample size is small, with only 277 respondents as part of the case studies. Within the study's constraints, it has not been possible to seek representative samples for surveys and follow-up interviews. The findings may be affected by selection bias, particularly a tendency for respondents to have an existing interest in climate change and environmental issues.

The case studies are not representative of the broader population, as most respondents were older (50+), property owners, and living in smaller communities, and may have incurred selection bias. Further, households dominated the case studies, with most information about the behaviours, small and large businesses and land managers source from the literature review.

Due to the small sample size and bias that arises from the survey collection methodology, this report should be taken as a qualitative assessment and does not provide quantitative conclusions surrounding the current and future impact and uptake of the behaviours identified.

Certain statements made in this report are not historical facts – instead they may constitute estimates, projections or other forward-looking statements, and although they are based on reasonable assumptions as of the date of the report, such forward-looking statements by their nature involve risks and uncertainties that could cause actual results to differ materially from the results predicted.

6.3 Areas for further research

This study intends to be a starting point for further detailed research on the quantifiable impacts of these autonomous adaptation (e.g. cost savings of avoided damages resulting from adaptation measures implemented; statistical significance of the risk-reducing effects of these behaviours). This study provides a significant albeit likely not comprehensive list of all the behaviours that target groups have or will uptake as a baseline to conduct further evaluation of their impacts. Additionally, future research can investigate the statistical variation of different typologies or behaviour among geographic regions or other variables noted in the study. Of particular note, nationality is recommended as a variable to include that was not referenced in this study, as non-UK nationals residing in the UK may have past experience of climate events that influence their behaviour in anticipation of UK climate events. Further, land managers perspectives, while captured to some degree in this study from both case studies and literature, require further study in future research.

Additionally, the National Impact Scores are for high-level decision-making purposes only. Further research or work should seek to iterate on these scores to improve their specificity. Another area for future focus is likely to be on the influence of increased media discussion of climate change (e.g. youth strikes etc.) and whether that spurs increasing motivation for adaptive as opposed to only mitigating climate action. Potential positive social responses to the coronavirus outbreak may also have implications for social resilience following climate events, although this is a fast-moving and ongoing situation.

This report focused only on behaviours in isolation and looked into property-level modifications or behaviours. An area to expand on is how these behaviours might interact with local government and services, or else identify behaviours that might affect how people interact with infrastructure and services outside of their specific property.

Ultimately, this report sheds light on the breadth of autonomous adaptation that is occurring at multiple levels and external of government policy – be that within the private sector, on an individual basis, or within communities. The findings can be used to develop further actions to enable positive autonomous adaptation and discourage maladaptive behaviours. In addition, the report indicates that autonomous adaptation is mediated by complex and occasionally conflicting cognitive, socio-cultural, and experiential biases.

Further research to distinguish scenarios in which some factors are more dominant than others would support development of mechanisms to support adaptation and direct target groups away from maladaptive practices. In this way, autonomous and planned adaptation can serve as complementary components to ensuring the well-being of the UK populace and the ecosystems on which it depends.

7. References

This section lists out all references that have been used in this study, as referred to in the main report and/or the appendices.

ABI. (2019) Storms. [online] Available from: https://www.abi.org.uk/products-and-issues/topics-and-issues/flooding/storms/ [Accessed 09/12/19].

Abid, Muhammad & Ngaruiya, Grace & Scheffran, Jürgen & Zulfiqar, Farhad. (2017). The role of social networks in agricultural adaptation to climate change: Implications for sustainable agriculture in Pakistan. Climate. 5. 85.

Abrahamson, V., Wolf, J., Lorenzoni, I., Fenn, B., Kovats, S., Wilkinson, P., Adger WN., Raine, R. (2009) Perceptions of heatwave risks to health: interview-based study of older people in London and Norwich, UK. Journal Public Health 31(1): 119 – 1126.

Acclimatise. (2017) Business Opportunities in a Changing Climate: Managing Impacts and Market Opportunities. Report for the Environment Agency. [online] Available from: http://www.adaptationlearning.net/sites/default/files/resource-files/EA%20report.pdf [Accessed 17/03/20].

Adaptation Scotland. (2017) Is your business Climate Ready? [online] Available from: https://adaptationscotland.org.uk/application/files/9515/2025/5149/LOW_RES_AS_Business_Adaptation_Guidance.pdf [Accessed 09/12/19].

Adaptation Sub-Committee of the Committee on Climate Change. (2017) UK Climate Change Risk Assessment 2017 Evidence Report – Summary for Northern Ireland. [online] Available from: https://www.theccc.org.uk/wp-content/uploads/2016/07/UK-CCRA-2017-Northern-Ireland-National-Summary.pdf [Accessed 17/03/20].

Adger, W. & Dessai, Suraje & Goulden, Marisa & Hulme, Mike & Lorenzoni, Irene & Nelson, Don & Naess, Lars & Wolf, Johanna & Wreford, Anita. (2008). Are There Social Limits to Adaptation to Climate Change? Climatic Change. 93. 335-354.

Agrawala, S., Carraro, S., Kingsmill, N., Lanzi, E., Mullan, M. and G. Prudent-Richard. (2011), "Private Sector Engagement in Adaptation to Climate Change: Approaches to Managing Climate Risks", OECD Environment Working Papers, No. 39.

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.

Arunrat, Noppol & Wang, Can & Pumijumnong, Nathsuda & Sereenonchai, Sukanya & Cai, Wenjia. (2017). 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.

Assefa Mersha, Azeb & Van Laerhoven, Frank. (2018). The interplay between planned and autonomous adaptation in response to climate change: Insights from rural Ethiopia. World Development. 107. 87-97.

Averchenkova, Alina & Crick, Florence & Kocornik-Mina, Adriana & Leck, Hayley & Surminski, Swenja. (2016). Multinational and large national corporations and climate adaptation: are we asking the right questions? A review of current knowledge and a new research perspective: Multinational and large national corporations and climate adaptation. Wiley Interdisciplinary Reviews: Climate Change. 7. 517-536.

Baan, Paul & Klijn, F. (2004). Flood risk perception and implications for flood risk management in the Netherlands. International Journal of River Basin Management. 2. 113-122.

Babcicky, Philipp & Seebauer, Sebastian. (2016). The Two Faces of Social Capital in Private Flood Mitigation: Opposing Effects on Risk Perception, Self-efficacy and Coping Capacity. Journal of Risk Research. 20. 1017-1037.

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.

Bamberg, Sebastian & Masson, Torsten & Brewitt, Katrin & Natascha, Nemetschek. (2017). Threat, coping and flood prevention – A meta-analysis. Journal of Environmental Psychology. 54. 116-126.

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.

Barnett, Jon & O'Neill, Saffron. (2013). Minimising the risk of maladaptation: A framework for analysis. Climate Adaptation Futures. 7. 87-93.

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.

Barreca, Alan & Clay, Karen & Deschenes, Olivier & Greenstone, Michael & Shapiro, Joseph. (2012). Adapting to Climate Change: The Remarkable Decline in the U.S. Temperature-Mortality Relationship Over the 20th Century. Journal of Political Economy. 124. 105-159.

Becker, Julia & Taylor, H.L & Doody, Brendan & Wright, Kim & Gruntfest, Eve & Webber, D. (2015). A Review of People's Behavior in and around Floodwater. Weather, Climate, and Society. 7. 321.

BEIS. (2017) Fuel Poverty Factsheet England, 2017. Fuel Poverty Factsheet England. [online] Available from: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/808300/Fuel_poverty_factsheet_2019__2017_data_.pdf [Accessed 30/01/20].

Berhe, Melaku & Hoag, Dana & Tesfay, Girmay & Tadesse, Tewodros & Oniki, Shunji & Kagatsume, Masaru & Keske, Catherine. (2017). The effects of adaptation to climate change on income of households in rural Ethiopia. Pastoralism. 7. 12.

Berkhout, Frans & Hertin, Julia & Gann, David. (2006). Learning to Adapt: Organisational Adaptation to Climate Change Impacts. Climatic Change. 78. 135-156.

Bichard, Erik & Kazmierczak, Aleksandra. (2012). Are homeowners willing to adapt to and mitigate the effects of climate change? Climatic Change. 112. 1-22.

Biagini, Bonizella & Bierbaum, Rosina & Stults, Missy & Dobardzic, Saliha & McNeeley, Shannon. (2014). A typology of adaptation actions: A global look at climate adaptation actions financed through the Global Environment Facility. Global Environmental Change. 25. 97-108.

Blakeslee, Sarah. (2004). The CRAAP Test. LOEX Quarterly. 31. 4.

Bonaiuto, Marino & Alves, Susana & De Dominicis, Stefano & Petruccelli, Irene. (2016). Place attachment and natural environmental risk: Research review and agenda. Journal of Environmental Psychology. 48. 33-53.

Borgomeo, Edoardo & Mortazavi-naeini, Mohammad & Hall, Jim & Guillod, Benoit. (2018). Risk, Robustness and Water Resources Management under Uncertainty. Earth's Future. 6. 468-487.

Braun, V. & Clarke, V. (2006) Using thematic analysis in psychology. Qualitative Research in Psychology. 3. 77 - 101.

Brink, Ebba & Wamsler, Christine. (2017). Collaborative Governance for Climate Change Adaptation: Mapping citizen–municipality interactions. Environmental Policy and Governance. 28. 82-97.

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.

Brody, Samuel & Highfield, Wesley & Wilson, Morgan & Lindell, Michael & Blessing, Russell. (2016). Understanding the motivations of coastal residents to voluntarily purchase federal flood insurance. Journal of Risk Research. 20. 760-775.

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.

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.

Brüegger, A, Rauto Dessai, SX, Devine-Wright, P et al. (2 more authors) (2015) Psychological responses to the proximity of climate change. Nature Climate Change, 5. 1031 - 1037. ISSN 1758-678X Bruno Soares, Alexander, M & Dessai, S. (2018). Sectoral use of climate information in Europe: A synoptic overview. Climate Services. 9. 5-20.

Bryan, Kimberly & Ward, Sarah & Barr, Stewart & Butler, David. (2019). Coping with Drought: Perceptions, Intentions and Decision-Stages of South West England Households. Water Resources Management. 33. 1185–1202.

Bubeck, P. (2012). A Review of Risk Perceptions and Other Factors that Influence Flood Mitigation Behaviour. Risk analysis: an official publication of the Society for Risk Analysis. 32. 1481-95.

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.

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.

Bury Council. (2018). Bury Local Flood Risk Management Strategy. [online] Available from: https://councildecisions.bury.gov.uk/documents/s15512/LFRMS%202018%20April.pdf [Accessed 17/03/20].

Burchell, Kevin; Fagan-Watson, Ben;King, Mike; Watson, Tom. 2017. Urban heat: Developing the role of community groups in local climate resilience. *Policy Studies Institute*. [Online] Availabe from:

http://www.psi.org.uk/urban_heat_docs/UrbanHeatReport_mainreport_FINAL%2031-01-17.pdf [Accessed 20 March 2020].

Carbon Brief. (2017). Mapped: Where £4.4bn is being spent on flood protection in England. [online] Available from: https://www.carbonbrief.org/mapped-where-four-point-four-billion-being-spent-flood-protection [Accessed 10/09/19].

CARE International. (no date) 'How we raise money.' [online]. Available from: https://www.careinternational.org.uk/who-we-are/how-we-raise-money [Accessed 02/12/19].

CCWater. (No Date). Water industry map [online] available from: https://www.ccwater.org.uk/wp-content/uploads/2018/04/Water-Industry-Map.png [Accessed 09/12/19]

CDP for Defra. (2012). Insights into Climate Change Adaptation by UK companies. [online] Available from: https://www.cdproject.net/CDPResults/insights-into-climate-change-adaptation-by-uk-companies.pdf [Accessed 17/03/20].

Centre for Ecology and Hydrology. (2016). Snow in Britain: the historic picture and future projections. [online] Available from: https://nerc.ukri.org/research/partnerships/ride/lwec/report-cards/watersource11/ [Accessed 17/03/20].

CDC. N.d. Extreme heat can impact our health in many ways. [Online]. https://www.cdc.gov/climateandhealth/pubs/EXTREME-HEAT-Final_508.pdf [Accessed 15 March 2020].

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.

Chu, Haoran & Yang, Z. Janet. (2018). Taking climate change here and now – mitigating ideological polarization with psychological distance. Global Environmental Change. 53. 174-181.

CIF. (2019). UK Cloud adoption rate climbs to 84%, finds new research from the Cloud Industry Forum. [online] Available from: https://www.cloudindustryforum.org/content/uk-cloud-adoption-rate-climbs-84-finds-new-research-cloud-industry-forum [Accessed 17/03/20]

City Hall Greens & JCSC. (2019) Climate change risks for London. A review of evidence under 1.5 °C and different warming scenarios. [online] Available from: https://www.london.gov.uk/sites/default/files/climate_change_risks_for_london_-_a_review_of_evidence_under_1.5degc_and_different_warming_scenarios.pdf [Accessed 19/11/19].

CIWEM. (2019). Climate resilience and extreme events. [online] Available from: https://www.ciwem.org/assets/pdf/Policy/Reports/Climate%20Resilience%20and%20Extreme%20Events%20.pdf [Accessed 17/03/20].

Clifford, Katherine & Travis, William. (2018). Knowing climate as a social-ecological-atmospheric construct. Global Environmental Change. 49. 1-9.

Cologna, Viktoria & Bark, Rosalind & Paavola, Jouni. (2017). Flood risk perceptions and the UK media: Moving beyond "once in a lifetime" to "Be Prepared" reporting. Climate Risk Management. 17. 1-10.

Committee on Climate Change. 2017. UK Climate Change Risk Assessment 2017 Evidence Report. [online] Available at: https://www.theccc.org.uk/tackling-climate-change/preparing-for-climate-change/uk-climate-change-risk-assessment-2017/synthesis-report/ [Accessed 1 January 2019].

Committee on Climate Change. (2018) Managing the coast in a changing climate. [online] Available from: https://www.theccc.org.uk/publication/managing-the-coast-in-a-changing-climate/ [Accessed 09/12/19].

Committee on Climate Change. (2019) Progress in preparing for climate change: 2019 Report to Parliament. [online] Available from: https://www.theccc.org.uk/wp-content/uploads/2019/07/CCC-2019-Progress-in-preparing-for-climate-change.pdf [Accessed 01/12/19].

Committee on Climate Change. (2019) Third CCRA method document. Unpublished.

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.

Cornes, Isabel & Cook, Brian. (2018). Localising climate change: heatwave responses in urban households. Disaster Prevention and Management: An International Journal. 27. 159.

Dah-gbeto, Afiavi & Villamor, Grace. (2016). Gender-specific responses to climate variability in a semi-arid ecosystem in northern Benin. Ambio. 45. 297-308.

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.

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.

DCLG (02010) Code for Sustainable Homes: Technical Guide. [online] Available from; https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/5976/code_for_sustainable_homes_techguide.pdf [Accessed 01/11/19].

De Dominicis, Stefano & Crano, William & Cancellieri, Uberta & Mosco, Benedetta & Bonnes, Mirilia & Hohman, Zachary & Bonaiuto, Marino. (2014). Vested interest and environmental risk communication: Improving willingness to cope with impeding disasters. Journal of Applied Social Psychology. 44. 364-374.

De Dominicis, Stefano & Fornara, Ferdinando & Cancellieri, Uberta & Twigger-Ross, Clare & Bonaiuto, Marino. (2015). We are at risk, and so what? Place attachment, environmental risk perceptions and preventive coping behaviours. Journal of Environmental Psychology. 43. 66-78.

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.

Defra. (2018) The National Adaptation Programme and the Third Strategy for Climate Adaptation Reporting: Making the country resilient to a changing climate. HM Government. [online] Available from: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/727252/national-adaptation-programme-2018.pdf [Accessed 01/12/19].

Defra. (2019). Annual Report and Accounts for the year ended 31 March 2019. [online] Available from: https://www.daera-ni.gov.uk/sites/default/files/publications/daera/daera-resource-accounts-2018-19-final.PDF [Accessed 04/12/19]

Defra. 2019. Annual Report and Accounts for the year ended 31 March 2019. [online] Available from: https://www.daera-ni.gov.uk/sites/default/files/publications/daera/daera-resource-accounts-2018-19-final.PDF [Accessed 4 December 2019]

Defra. 2019. Supporting the uptake of resilient repair in the recovery process (FD2706): Final Report.

Demski, Christina & Capstick, Stuart & Pidgeon, Nick & Sposato, Robert & Spence, Alexa. (2016). Experience of extreme weather affects climate change mitigation and adaptation responses. Climatic Change. 140. 149–164.

Demuth, Julie & Morss, Elliott & Lazo, Jeffrey & Trumbo, Craig. (2016). The Effects of Past Hurricane Experiences on Evacuation Intentions through Risk Perception and Efficacy Beliefs: A Mediation Analysis. Weather, Climate, and Society. 8. 327-344.

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.

Dessai, Suraje & Adger, W. & Hulme, Mike & Turnpenny, John & Köhler, Jonathan & Warren, Rachel. (2004). Defining and Experiencing Dangerous Climate Change. Climatic Change. 64. 11-25.

Di Falco, Salvatore & Sharma, Sindra. (2018). Investing in Climate Change Adaptation: Motivations and Green Incentives in the Fiji Islands. Ecological Economics. 154. 394-408.

Dias N., Amaratunga, D., Haigh, R. (2018) Challenges associated with integrating CCA and DRR in the UK – A review on the existing legal and policy background. Procedia Engineering (212) 978 – 985.

Doell, Petra. (2017). Cartograms facilitate communication of climate change risks and responsibilities: Cartograms and climate change. Earth's Future. 5. 1182-1195.

Duinen, Rianne & Filatova, Tatiana & Geurts, Peter & Veen, Anne. (2014). Coping with drought risk: empirical analysis of farmers' drought adaptation in the south-west Netherlands. Regional Environmental Change. 15. 1-13.

Elrick-Barr, Carmen. (2015). Household adaptation to climate change and the resilience of Australian urban areas. Conference Paper. Australian Cities Research Network.

EA Technology. (No Date). Energy Project 2 Climate Change Impacts on the U.K. Energy Industry Project.

EPA. (2014). Reducing Urban Heat Islands: Compendium of Strategies. [online] Available from: https://www.epa.gov/sites/production/files/2014-06/documents/basicscompendium.pdf [Accessed 17/03/20].

EPA. (2014). Moisture Control. [online] Available from: https://www.epa.gov/sites/production/files/2014-08/documents/moisture-control.pdf [Accessed 17/03/20].

Environment Agency. (2009) Sandbags and how to use them properly for flood protection. [online] Available from: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/467902/LIT_3833.pdf [Accessed 09/12/19].

Environment Agency. (2017) Drought response: our framework for England. [online] Available from: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/625006/LIT_10104.pdf#page=6&zoom=100,0,228 [Accessed 09/12/19]

Environment Agency. (2018) Lewisham and Catford flood alleviation scheme. [online] Available from: https://www.gov.uk/government/publications/lewisham-and-catford-flood-alleviation-scheme/lewisham-and-catford-flood-alleviation-scheme [Accessed 19/11/19].

Environment Agency (2019) Working together to adapt to a changing climate: flood and coast. [online] Available from: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/827643/Community_engagement_on_climate_adaptation___slide_pack.pdf [Accessed 17/03/20].

European Commission. (2018). Using insurance in adaptation to climate change. [online] Available from: https://ec.europa.eu/clima/sites/clima/files/docs/insurance_adaptation_en.pdf [Accessed 17/03/20].

Evans, Matthew. (2013). PREPARE - Barriers and enablers to organisational and sectoral adaptive capacity - quantitative study. [online] Available from: http://randd.defra.gov.uk/Default.aspx?Menu=Menu&Module=More&Location=None&ProjectID=18552 [Accessed 17/03/20].

FAO. (No date), The 10 Elements of Agroecology: Guiding the Transition to Sustainable Food and Agricultural Systems. [online] Available at: http://www.fao.org/agroecology/knowledge/10-elements/en/ [10/01/20].

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.

Few, Roger & Brown, Katrina & Tompkins, Emma. (2007). Public Participation and Climate Change Adaptation: Avoiding the Illusion of Inclusion. Climate Policy. 7. 46-59.

Findlater, K.M, Donner, S.D., Satterfield, T., and Kandlikar, M. (2018) Integration anxiety: The cognitive isolation of climate change. Global Environmental Change. 50. 178-189.

Fishbein, M. & Ajzen, Icek. (1975). Belief, attitude, intention and behaviour: An introduction to theory and research. MA: Addison-Wesle.

FloodRe. (2020). A flood re-insurance scheme. [online]. Available from: https://www.floodre.co.uk/ [Accessed 17/03/20].

Floyd, D. L., Prentice Dunn, S., and Rogers, R. W. (2000). A meta-analysis of research on protection motivation theory. *J. Appl. Soc. Psychol.* 30, 407–429.

Ford, James & Tilleard, Simon & Berrang-Ford, Lea & Araos, Malcolm & Biesbroek, Robbert & Lesnikowski, Alexandra & MacDonald, Graham & Hsu, Angel & Chen, Chen & Bizikova, Livia. (2016). Opinion: Big data has big potential for applications to climate change adaptation. Proceedings of the National Academy of Sciences. 113. 39.

Forsyth, Tim. (2013). Community-based adaptation: A review of past and future challenges. Wiley Interdisciplinary Reviews: Climate Change. 4. 439-446.

Fosas, D., Coley, D., Natrajan, S., Herrear, M., de Pando, M., Ramallo-Gonzalez, A. (2018). Mitigation versus adaptation: Does insulating dwellings increase overheating risk? Building and environment. 143. 740 -759.

Fox-Rogers, PhD, Linda & Devitt, Catherine & O'Neill, Eoin & Brereton, Finbarr & Clinch, J. Peter. (2016). Is there really “nothing you can do”? Pathways to enhanced flood-risk preparedness. Journal of Hydrology. 543. 330-343.

Frondel, Manuel, Simora, Michael & Sommer, Stephan. (2017). Risk Perception of Climate Change: Empirical Evidence for Germany. Ecological Economics. 137. 173-183.

Frontier Economics for Defra. (2018). Economics of Climate Resilience. [online] Available from: http://randd.defra.gov.uk/Default.aspx?Module=More&Location=None&ProjectID=18016 [Accessed 17/03/20].

Garbutt, Nick. (2018). Climate Change: Northern Ireland and the rising sea. [online] Available from: https://scopeni.nicva.org/article/climate-change-northern-ireland-and-the-rising-sea [Accessed 17/03/19].

Gasbarro, Federica & Pinkse, Jonatan. (2015). Corporate Adaptation Behaviour to Deal With Climate Change: The Influence of Firm-Specific Interpretations of Physical Climate Impacts. Corporate Social Responsibility and Environmental Management. In press.

Gifford, Robert & Comeau, Louise. (2011). Message framing influences perceived climate change competence, engagement, and behavioural intentions. Global Environmental Change. 21. 1301-1307.

Gifford, Robert. (2011). The Dragons of Inaction: Psychological Barriers That Limit Climate Change Mitigation and Adaptation. American Psychologist. 66. 290-302.

GLA Intelligence. (2012) 2011 Census first results: London boroughs’ populations by age by sex. [online] Available from: https://data.london.gov.uk/dataset/981e9136-a06a-44ec-a067-10f3d786cd3f [Accessed 19/11/19].

Government Statistical Service. (2017) The 2011 Rural-Urban Classification for Local Authority Districts in England. [online] Available from: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/591464/RUCLAD_leaflet_Jan2017.pdf [Accessed 25 /11/19].

Grothmann, Torsten & Patt, Anthony. (2005). Adaptive capacity and human cognition: The process of individual adaptation to climate change. Global Environmental Change. 15. 199–213.

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.

Hajat, S., Chalabi, Z., Wilkinson, P., Erens, B., Jones, L., Mays, N. (2016) Public health vulnerability to wintertime weather: time-series regression and episode analyses of national mortality and morbidity databases to inform the Cold Weather Plan for England. Public Health 137: 26 – 34.

Haque, Shamima & Islam, Muhammad. (2015). Stakeholder pressures on corporate climate change-related accountability and disclosures: Australian evidence. Business and Politics. 17. 355-390.

Hart, P. & Feldman, Lauren. (2016). The Influence of Climate Change Efficacy Messages and Efficacy Beliefs on Intended Political Participation. PLOS ONE. 11. 1-16.

Harries, Tim. (2012). The anticipated emotional consequences of adaptive behaviour – impacts on the take-up of household flood-protection measures. Environment and Planning A. 44. 649-668.

Harvatt, Joanne & Petts, Judith & Chilvers, Jason. (2010). Understanding householder responses to natural hazards: Flooding and sea-level rise comparisons. Journal of Risk Research. 14. 63-83.

Hedger, Merylyn & Connell, Richenda & Bramwell, Penny. (2006). Bridging the gap: Empowering decision-making for adaptation through the UK Climate Impacts Programme. Climate Policy. 6. 201-215.

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.

Hertin, Julia & Berkhout, Frans & Gann, David & Barlow, James. (2003). Climate change and the UK house building sector: Perceptions, impacts and adaptive capacity. Building Research and Information. 31. 278-290.

Heutel, Garth & Miller, Nolan & Molitor, David. (2018) Adaptation and the mortality effects of the temperature across US climate regions. NBER Working Paper Series. No. 23271.

HIE. (2019) Orkney. [online] Available from: https://www.hie.co.uk/our-region/our-areas/orkney/ [Accessed 15/11/19].

Highlands and Islands Enterprise. (No Date) Our Region in Detail. [online] Available from: https://www.hie.co.uk/research-and-reports/our-region-in-detail/ [Accessed 01/12/19].

Hopkins, Debbie & Maclean, Kate. (2014). Climate change perceptions and responses in Scotland's ski industry. Tourism Geographies. 16. 400–414.

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.

Hornsey, Matthew & Harris, Emily & Bain, Paul & Fielding, Kelly. (2016). Meta-analyses of the determinants and outcomes of belief in climate change. Nature Climate Change. 6. 622–626.

Howarth, C., Kantenbacher, J., Guida, K., Roberts, T., and Rohse, M. (2019) Improving resilience to hot weather in the UK: The role of communication, behaviour and social insights in policy interventions. *Environmental Science and Policy* (94): 258 -261.

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.

Hutton, Nicole & Tobin, Graham & Montz, Burrell. (2018). The Levee Effect Revisited: Processes and Policies Enabling Development in Yuba County California. Journal of Flood Risk Management. 12. 1-161.

Huang, Shih-Kai & Lindell, Michael & Prater, Carla. (2015). Who Leaves and Who Stays? A Review and Statistical Meta-Analysis of Hurricane Evacuation Studies. Environment and Behaviour. 43. 991-1029.

Humphrey, K., and Murphy, J., (2016) UK Climate Change Risk Assessment Evidence Report: Chapter 1, Introduction. Contributing authors: Harris, G., Brown, S., Lowe, J., McCarthy, M., Jevrejeva, S., Watts, G., Johns, D. and Bell, M. Report prepared for the Adaptation Sub-Committee of the Committee on Climate Change, London.

Huntingford, C., Jeffers, E., Bonsali, M., Christensen, H., Lees, T., and Yang, H. (2019) Machine learning and artificial intelligence to aid climate change research and preparedness. Environment Research Letters. 14. 396–417.

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.

IEA. (2018). The Future of Cooling. [online] Available from: https://www.iea.org/reports/the-future-of-cooling [Accessed 17/03/20].

IEMA. (2013) Climate Change Adaptation business case. [online] Available from: https://www.iema.net/assets/uploads/CCA%20Business%20Case%20Guidance%202013 [Accessed 17/03/20].

INTRAC. (2017). Realist Evaluation. [online] Available at: https://www.intrac.org/wpcms/wp-content/uploads/2017/01/Realist-evaluation.pdf [Accessed 21/01/20].

IPCC. (2001). Climate change 2001: Synthesis report. Cambridge University Press. Cambridge, UK.

IPCC. (2014). Emergent risks and key vulnerabilities, in: Climate Change 2014: Impacts, Adaptation, and Vulnerability. [online] Available from: http://www.ipcc.ch/pdf/assessment-report/ar5/wg2/WGIIAR5-Chap19_FINAL.pdf [Accessed 09/12/19].

IPCC. (2018). Annex I: Glossary. In: Global Warming of 1.5°C. An IPCC Special Report on the impacts of global warming of 1.5°C above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change, sustainable development, and efforts to eradicate poverty. [online] Available from https://www.ipcc.ch/site/assets/uploads/sites/2/2019/06/SR15_AnnexI_Glossary.pdf [Accessed 19/03/20].

IPPR. (2016). Known unknowns: The hidden threats that climate risks pose to British prosperity (2nd ed). [online] Available from: https://www.ippr.org/files/publications/pdf/known-unknowns_2nd-ed_March2016.pdf [Accessed 17/03/20].

James, Rachel. (2015) Climate services: Impacts, risks, and adaptation. [online] Available from: https://www.eci.ox.ac.uk/people/downloads/rjames-climateservices.pdf [Accessed 09/12/19]

Javeline, Debra & Kijewski-Correa, Tracy. (2018). Coastal homeowners in a changing climate. Climatic Change. 152. 259-274.

Jenkins, Willis & Berry, Evan & Beck Kreider, Luke. (2018). Religion and Climate Change. Annual Review of Environment and Resources. 43. 85-108.

Jongman, Brenden. (2018). Effective adaptation to rising flood risk. Nature Communications. 9. 1-3.

Kahneman, D. (2011) Thinking, Fast And Slow. New York: Farrar, Straus And Giroux. Print.

Kahneman, Daniel & Tversky, Amos. (1979). Prospect Theory: An Analysis of Decision under Risk. Econometrica. 47. 263-291.

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.

Kent, Nikki & Porter, James & Dessai, Suraje & Miller, Kate & Sibille, Robert & Horrocks, Lisa & Lonsdale, Kate & Ballard, David. (2013). PREPARE - The contribution and role of local level adaptation in overall UK adaptation. [online] Available form: http://randd.defra.gov.uk/Document.aspx?Document=11260_PREPARECA0513Localandhouseholdadaptation-Finalreport.pdf [Accessed 17/03/20].

Khare, Swarna & Hajat, Shakoor & Kovats, Sari & Lefevre, Carmen & Bruine de Bruin, Wändi & Dessai, Suraje & Bone, Angie. (2015). Heat protection behaviour in the UK: Results of an online survey after the 2013 heatwave. BMC Public Health. 15. 878.

Kievik, Milou & Gutteling, Jan. (2011). Yes, we can: Motivate Dutch citizens to engage in self-protective behaviour with regard to flood risks. Natural Hazards. 59. 1475-1490.

Kinoshita, Youhei & Tanoue, Masahiro & Watanabe, Satoshi & Hirabayashi, Yukiko. (2017). Quantifying the effect of autonomous adaptation to global river flood projections: Application to future flood risk assessments. Environmental Research Letters. 13. 67-74.

Koerth, Jana & Vafeidis, Athanasios & Hinkel, J. & Sterr, H.. (2013). What motivates coastal households to adapt pro-actively to sea-level rise and increasing flood risk?. Regional Environmental Change. 15. 1-13.

Koerth, Jana, Vafeidis, A. T. and Hinkel, J. (2017) Household-Level Coastal Adaptation and Its Drivers: A Systematic Case Study Review Risk Analysis. 37. 629-646.

Konisky, David & Hughes, Llewelyn & Kaylor, Charles. (2015). Extreme weather events and climate change concern. Climatic Change. 134. 533–547.

Kreibich, Heidi & Seifert-Dähnn, Isabel & Thieken, Annegret & Lindquist, Eric & Wagner, Klaus & Merz, Bruno. (2010). Recent changes in flood preparedness of private households and businesses in Germany. Regional Environmental Change. 11. 59-71.

Kryvasheyeu, Yury & Chen, Haohui & Obradovich, Nick & Moro, Esteban & Van Hentenryck, Pascal & Fowler, James & Cebrian, Manuel. (2016). Rapid assessment of disaster damage using social media activity. Science Advances. 2. 779.

Lamond, Jessica & Rose, Carly & Bhattacharya-Mis, Namrata & Joseph, Rotimi. (2018). Evidence review for property flood resilience phase 2 report. [online] Available from: https://www.floodre.co.uk/wp-content/uploads/UWE-report_Evidence-review-for-PFR_Phase-2-report-1.pdf [Accessed 19/03/20].

Leclère, David & Jayet, Pierre-Alain & de NOBLET, Nathalie. (2013). Farm-level Autonomous Adaptation of European Agricultural Supply to Climate Change. Ecological Economics. 87. 1-14.

Lefevre, Carmen; Bruin de Bruin, Wandi; Taylor; Andrea; Dessai, Suraje; Kovats, Sari; Fischhoff, Baruch. 2015. Heat protection behaviours and positive affect about heat during the 013 heat wave in the United Kingdom. *Social Science and Medicine* 128: 282 – 289.

Lewisham Council. 2012. 2011 Census second release outputs. [online] Available from: https://lewisham.gov.uk/inmyarea/census-2011 [Accessed 19/11/19].

Li, Sen & Juhász-Horváth,Linda & Harrison, Paula A & Pintér, László & Rounsevell, Mark. D. A. (2017) Relating farmer's perceptions of climate change risk to adaptation behaviour in Hungary. Journal of Environmental Management. 185. 21-30.

Linnenluecke, Martina & Griffiths, Andrew & Winn, Monika. (2012). Extreme Weather Events and the Critical Importance of Anticipatory Adaptation and Organizational Resilience in Responding to Impacts. Business Strategy and the Environment. 21. 17-32.

Lindley, S. J., O'Neill, J., Kandeh, J., Lawson, N., Christian, R. & O'Neill M. (2011) Climate change, justice and vulnerability, Joseph Rowntree Foundation Report, York. [online] http://www.jrf.org.uk/publications/climate-change-justice-and-vulnerability. [Accessed 17/03/20].

Liu, Tao & Xu, Yan & Zhang, Yong & Yan, Qing & Song, Xiu-Ling & Xie, Hui & Luo, Yuan & Rutherford, Shannon & Chu, Cordia & Lin, Hualiang & Ma, Wen. (2013). Associations between risk perception, spontaneous adaptation behavior to heat waves and heatstroke in Guangdong province, China. BMC public health. 13. 913.

Lo, Alex & Chan, Faith. (2017). Preparing for flooding in England and Wales: the role of risk perception and the social context in driving individual action. Natural Hazards. 88. 367–387.

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.

Magnan, A. (2014) Avoiding maladaptation to climate change: towards guiding principles. Sapiens. [online] Available from: http://sapiens.revues.org/1680 [Accessed 09/12/19].

Markovic, Tom and Harry, Steve. 2020. Parametric insurance: a tool to increase climate resilience. [Online] Available from: https://www.mmc.com/insights/publications/2018/dec/parametric-insurance-tool-to-increase-climate-resilience.html [Accessed 16 March 2020].

Marks & Spencer. (2015) Annual Report 2015. [online] Available from: http://annualreport2015.marksandspencer.com/ [Accessed 17/03/20].

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.

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.

Mccaffrey, Sarah & Toman, Eric & Stidham, Melanie & Shindler, Bruce. (2013). Social Science Research Related to Wildfire Management: An Overview of Recent Findings and Future Research Needs. International Journal of Wildland Fire. 22. 15-24.

Mccaffrey, Sarah. (2015). Community Wildfire Preparedness: a Global State-of-the-Knowledge Summary of Social Science Research. Current Forestry Reports. 1. 81-90.

McEvoy, D., Iftekhar, A., Mullett, J. (2012) The impact of the 2009 heat wave on Melbourne's critical infrastructure. The International Journal of Justice and Sustainability 17. 783-796.

Mcfarlane, Bonita & McGee, T. & Faulkner, Hilary. (2012). Complexity of homeowner wildfire risk mitigation: An integration of hazard theories. International Journal of Wildland Fire. 20. 921-931.

Meinel, Ulrike & Höferl, Karl-Michael. (2017). Non-Adaptive Behaviour in the Face of Climate Change: First Insights from a Behavioral Perspective Based on a Case Study among Firm Managers in Alpine Austria. Sustainability. 9. 1132.

Met Office. (2018). UK Climate Projections. [online] Available from: https://www.metoffice.gov.uk/research/approach/collaboration/ukcp/index [Accessed 17/03/20].

Met Office. (No date). National Severe Weather Warning Service (NSWWS).

Michie, Susan & van Stralen, Maartje & West, Robert. (2011). The Behaviour Change Wheel: a new method for characterising and designing behaviour change interventions. Implementation science 6. 42.

Ministry of Housing, Communities, and Local Government. (2018). National Planning Policy Framework. [online] Available from: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/810197/NPPF_Feb_2019_revised.pdf [Accessed 17/03/20].

Mofat, A. (2014) Land estates in Scotland: Perceptions of climate change and climate policy – Implications for Future Support. Climate xChange. [online] Available from: https://www.climatexchange.org.uk/media/1468/land_estates_in_scotland_-_perceptions_of_climate_change_and_climate_policy.pdf [Accessed 12/11/19].

Morris, JI & Beedell, J. & Hess, Tim. (2014). Mobilising Flood Risk Management Services from Rural Land: principles and practice. Journal of Flood Risk Management. 9. 50-68.

Morris, Steven; Weaver, Matthew; & Halliday, Josh. (2018) UK storm death toll reaches 10 as ice warnings follow snow chaos. The Guardian. [online] Available at: https://www.theguardian.com/uk-news/2018/mar/02/death-toll-reaches-10-as-destructive-weather-batters-uk [Accessed 31/01/20].

Morton, Thomas & Bretschneider, Pamela & Coley, David & Kershaw, Tristan. (2011). Building a better future: An exploration of beliefs about climate change and perceived need for adaptation within the building industry. Building and Environment. 46. 1151-1158.

Müller-Fürstenberger, Georg & Schumacher, Ingmar, 2015. Insurance and climate-driven extreme events. Journal of Economic Dynamics and Control. 54. 59-73.

National Association of Cider Makers. (2010). A changing climate for cider. [online] Available from: https://www.ukcip.org.uk/wp-content/Business_casestudies/BCS_NACM-2014.pdf. [Accessed 17/03/20].

National Grid. (2018) Winter Review and Consultation. [online] Available from: https://www.nationalgrideso.com/document/145396/download [Accessed 17/03/20].

National Records of Scotland. (2018) Orkney Islands Council Area Profile. [online] Available from: https://www.nrscotland.gov.uk/files/statistics/council-area-data-sheets/orkney-islands-council-profile.html [Accessed 15/11/19].

National Records of Scotland. (2019) Scottish Borders Council Area Profile. [online] Available from: https://www.nrscotland.gov.uk/files/statistics/council-area-data-sheets/scottish-borders-council-profile.html [Accessed 15/11/19].

Neslen, Arthur. (2019). Climate change could make insurance too expensive for most people – report. [online] Available form: https://www.theguardian.com/environment/2019/mar/21/climate-change-could-make-insurance-too-expensive-for-ordinary-people-report [Accessed 17/03/20].

NHS. (2019). Heatwave: how to cope in hot weather. [online] Available from: https://www.nhs.uk/live-well/healthy-body/heatwave-how-to-cope-in-hot-weather/ [Accessed 17/03/20].

NI Department of the Environment. (2019) Northern Ireland Climate Change Adaptation Programme.

NI Direct. (No Date). Coasts and beaches. [online] Available from: https://www.nidirect.gov.uk/articles/coasts-and-beaches [Accessed 19/11/19].

NISRA (2018). Northern Ireland Population estimates 2018 [online] Available from: https://www.ninis2.nisra.gov.uk/InteractiveMaps/DataVis/NI%20Population%202018.pdf [03/12/19].

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.

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.

Nomis. (2011) Ceredigion. [online] Available from: https://www.nomisweb.co.uk/reports/localarea?compare=W06000008 [Accessed 21/11/19].

Nomis. (2011). Lewisham. [online] Available from: https://www.nomisweb.co.uk/reports/lmp/la/1946157254/report.aspx [Accessed 17/03/19].

Nomis. (2011). Radcliffe East, Radcliffe North. Radcliffe West. [online] Available from: https://www.nomisweb.co.uk/reports/localarea?compare=E35000933#section_8_0 [Accessed 21/11/19].

Northern Ireland Statistics and Research Agency. (2012) Census 2011 Key Statistics for Northern Ireland. [online] Available from: https://www.nisra.gov.uk/sites/nisra.gov.uk/files/publications/2011-census-results-key-statistics-northern-ireland-report-11-december-2012.pdf [Accessed 19/11/19].

ODI. (2015) Climate change, private sector and value chains: constraints and adaptation strategies. [online] Available from: https://www.odi.org/publications/9862-climate-change-private-sector-and-value-chains-constraints-and-adaptation-strategies [Accessed 09/12/19].

OEDC. (2015) Adapting to the impacts of climate change. [online] Available from: https://www.oecd.org/environment/cc/Adapting-to-the-impacts-of-climate-change-2015-Policy-Perspectives-27.10.15%20WEB.pdf [Accessed 09/12/19].

Office for National Statistics. (2011). Rural and urban areas: comparing lives using rural/urban classifications. Regional Trends 43. [online] Available from: https://www.ons.gov.uk›ons›rel›regional-trends›no--43--2011-edition [Accessed 25/11/19].

Office of National Statistics. (2018) Population estimates for the UK, England and Wales, Scotland and Northern Ireland: mid-2017. [online] Available from: https://www.ons.gov.uk/peoplepopulationandcommunity/populationandmigration/populationestimates/bulletins/annualmidyearpopulationestimates/mid2017 [Accessed 04/12/19].

OfWat. (2019) Contact Details. [online] Available from: https://www.ofwat.gov.uk/households/your-water-company/map/ [Accessed 09/12/19].

O'Hare, Paul & White, Iain & Connelly, Angela. (2015). Insurance as maladaptation: Resilience and the 'business as usual' paradox. Environment and Planning C: Government and Policy. 34. 1175-1193.

Osbahr, Henny & Dorward, Peter & Stern, Roger & Cooper, Sarah. (2011). Supporting agricultural innovation in Uganda to respond to climate risk: Linking climate change and variability with farmer perceptions. Experimental Agriculture. 47. 293-316.

Osberghaus, Daniel (2017). The effect of flood experience on household mitigation—Evidence from longitudinal and insurance data. Global Environmental Change. 43. 126-136.

Osberghaus, Daniel. (2015). The Determinants of Private Flood Mitigation Measures in Germany – Evidence from a Nationwide Survey. SSRN Electronic Journal. 110. 14-32.

Osberghaus, Daniel & Finkel, Elyssa & Pohl, Max. (2010). Individual Adaptation to Climate Change: The Role of Information and Perceived Risk. SSRN Electronic Journal. Discussion Paper No. 10-061.

Our Scottish Borders. (2011) Population of Borders Towns & Villages. [online] Available from: http://www.ourscottishborders.com/live/towns/populations [Accessed 15/11/19].

Pateman, T. (2011). Office for National Statistics. Rural and urban areas: comparing lives using rural/urban classifications. Regional Trends 43. 401-414.

Paul, Bimal. (2011). Factors Affecting Evacuation Behaviour: The Case of 2007 Cyclone Sidr, Bangladesh. Professional Geographer. 64. 401-414.

Penning-Rowsell, Edmund & Johnson, Clare & Priest, Sally. (2014). The evolution of UK flood insurance: Incremental change over six decades. International Journal of Water Resources Development. 30. 694-713.

Phadke, Roopali & Manning, Christie & Burlager, Samantha. (2015). Making it Personal: Diversity and Deliberation in Climate Adaptation Planning. Climate Risk Management. 41. 62-76.

Porter, James & Dessai, Suraje & Tompkins, Emma. (2014). What do we know about UK household adaptation to climate change? A systematic review. Climatic Change. 127. 371–379.

Poussin, J.K & Botzen W.J.W & Aerts J.C.J.H. (2014). Factors of Influence on Flood Damage Mitigation Behaviour by Households. Environmental Science & Policy. 40. 69-77.

Property Care Association. (2013). Code of Practice for the Recovery of Flood Damaged Buildings. [online] Available from: https://www.property-care.org/wp-content/uploads/2015/05/Code-of-Practice-for-Recovery-of-Flood-Damaged-Buildings.pdf [Accessed 19/03/20].

Property Care Association. (2020). A review of moulds and health issues. [online] Available from: https://www.property-care.org/review-moulds-health-issues/ [Accessed 19/03/20].

Prudential Regulation Authority. (2016) The Prudential Regulation Authority's approach to banking supervision. [online] Available from: https://www.bankofengland.co.uk/prudential-regulation/publication/2018/pra-approach-documents-2018 [Accessed 17/03/20].

Prudential Regulation Authority. (2018) Transition in thinking: The impact of climate change on the UK banking sector. [online] Available from: https://www.bankofengland.co.uk/prudential-regulation/publication/2018/transition-in-thinking-the-impact-of-climate-change-on-the-uk-banking-sector [Accessed 17/03/20].

Prudential Regulation Authority. (2019). Enhancing banks' and insurers' approaches to managing the financial risks from climate change. [online] Available from: https://www.bankofengland.co.uk/prudential-regulation/publication/2018/enhancing-banks-and-insurers-approaches-to-managing-the-financial-risks-from-climate-change [Accessed 17/03/20].

Public Health England. (2014). Guidance on Recovery from Flooding. [online] Available from: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/348917/Guidance_on_Recovery_from_Flooding_essential_info_from_frontline_responders.pdf [Accessed 19/03/20].

Public Health England. (2018). The Cold Weather Plan for England. [online] Available from: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/748492/the_cold_weather_plan_for_england_2018.pdf [Accessed 09/12/19].

Public Health England. (2018) Heatwave plan for England. [online] Available from: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/801539/Heatwave_plan_for_England_2019.pdf [Accessed 09/12/19].

Rahman, H.M. & Hickey, Gordon. (2019). What Does Autonomous Adaptation to Climate Change Have to Teach Public Policy and Planning About Avoiding the Risks of Maladaptation in Bangladesh?. Frontiers in Environmental Science. 7. 2.

Rajkovich, Nicholas. (2016). A System of Professions Approach to Reducing Heat Exposure in Cuyahoga County, Ohio. Michigan Journal of Sustainability. 4. 81-101.

Rapaport, Carmit & Hornik-Lurie, Tzipi & Cohen, Odeya & Lahad, Mooli & Leykin, Dima & Aharonson-Daniel, Limor. (2018). The relationship between community type and community resilience. International Journal of Disaster Risk Reduction. 31. 470-477.

Raymond, Christopher & Lechner, Alex & Lockwood, Michael & Carter, Oberon & Harris, Rebecca & Gilfedder, Louise. (2015). Private land manager capacity to conserve threatened communities under climate change. Journal of Environmental Management. In Press.

Reckien, Diana & Salvia, Monica & Heidrich, Oliver & Church, Jon & Pietrapertosa, Filomena & Hurtado, Sonia & D'Alonzo, Valentina & Foley, Aoife & Simões, Sofia & K. Lorencova, Eliska & Orru, Hans & Orru, Kati & Wejs, Anja & Flacke, Johannes & Olazabal, Marta & Geneletti, Davide & Feliu, Efrén & Vasilie, Sergiu & Nador, Cristiana & Dawson, Richard. (2018). How are cities planning to respond to climate change? Assessment of local climate plans from 885 cities in the EU-28. Journal of Cleaner Production. 191. 207-219.

Reser, Joseph & Bradley, Graham & Ellul, Michelle. (2014). Encountering climate change: 'Seeing' is more than 'believing'. Wiley Interdisciplinary Reviews: Climate Change. 5. 521-537.

Reynaud, Arnaud & Aubert, Cecile & Nguyen, Manh. (2013). Living with Floods: Protective Behaviours and Risk Perception of Vietnamese Households. The Geneva Papers on Risk and Insurance - Issues and Practice. 38. 547-579.

Richert, Claire & Erdlenbruch, Katrin & Figuières, Charles. (2017) The determinants of households' flood mitigation decisions in France - on the possibility of feedback effects from past investments. Ecological Economics, Elsevier. 131. 342-352.

Roberts, M. (2019) Summer heatwave 'death spike' seen in the UK. BBC. [online] Available from: https://www.bbc.co.uk/news/health-49958201 [Accessed 05/12/19].

Sakata, T. (2018). The Good, The Bad and The Ugly of Artificial Intelligence and Machine Learning. Medium. [online] Available from: https://medium.com/applied-innovation-exchange/the-good-the-bad-and-the-ugly-of-artificial-intelligence-and-machine-learning-3f7e663c317a [Accessed 02/11/19].

Salama, Sefat & Aboukoura, Khalil. (2017). Role of Emotions in Climate Change Communication. Handbook of Climate Change Communication.1.137-150.

Salamanca, F. Georgescu, M., Mahalov, A., Moustaoui, M., Wang, Y. (2014) Anthropogenic heating of the urban environment due to air conditioning. JGR Atmospheres. 119. 10.

Samaddar, Subhajyoti & Chatterjee, Roshni & Misra, Bijayanad & Tatano, Hirokazu. (2014). Outcome-expectancy and self-efficacy: Reasons or results of flood preparedness intention?. International Journal of Disaster Risk Reduction. 8. 91-99.

Sanchez, O. (2019) Triple-digit temperatures could bring blackouts in New York City, DC and Chicago. USA Today. [online] Available from: https://eu.usatoday.com/story/news/nation/2019/07/16/heat-wave-could-cause-power-outages-new-york-city-chicago-d-c/1749257001/ [Accessed 02/12/19].

Sayers, P.B., Horritt, M., Penning Rowsell, E., and Fieth, J. (2017). Present and future flood vulnerability, risk and disadvantage: A UK scale assessment. A report for the Joseph Rowntree Foundation published by Sayers and Partners LLP.

Scottish Borders Council. (2013) Scottish Borders Economic Profile. [online] Available from: https://www.scotborders.gov.uk/downloads/file/457/economic_profile [Accessed 09/12/19]

Scottish Borders Council. (2019) Tweed local Plan District: Local Flood Risk Management Plan, Interim Report. [online] Available from: https://scottishborders.moderngov.co.uk/documents/s33371/Item%20No.%207%20-%20Appendix%201%20-%20Tweed%20LPD%20S37%20Interim%20Report%20V1.6%20Draft.pdf [Accessed 24/11/19].

Scottish Government. 2019. Climate Ready Scotland: Second Scottish Climate change Adaptation Programme: 2019 – 2024. [online] Available from: https://www.gov.scot/publications/climate-ready-scotland-scottish-climate-change-adaptation-programme-2019-2024-consultation-draft/ [Accessed 17/03/20].

Scottish Government. No date. Climate Change. [online] Available from: https://www.gov.scot/policies/climate-change/climate-change-adaptation/ [Accessed 01/12/19].

Scottish Government. 2019. Living with flooding: action plan. [Online] Available from: https://www.gov.scot/publications/living-flooding-action-plan-delivering-property-flood-resilience-scotland/pages/4/ [Accessed 14 March 2020].

Seafish to the UK Government. (2016) Understanding and responding to climate change in the UK seafood industry: Climate change risk adaptation for wild capture seafood. [online] Available from: https://www.seafish.org/media/1476673/climate_change_report_-_lr.pdf [Accessed 17/03/20].

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 behaviour change. American Journal of Preventive Medicine. 35. 479-487.

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.

SEPA. (2013) Tweed Flood Risk Management Strategy. [online] Available from: http://apps.sepa.org.uk/FRMStrategies/pdf/lpd/LPD_13_Overview.pdf [Accessed 17/11/19].

Sesame. (2015). Preparing for and responding to flooding. [online] Available from: http://sesame.uk.com/changing-behaviour/ [Accessed 19/03/20].

Shao, Wanyun & Xian, Siyuan & Lin, Ning & Kunreuther, Howard & Jackson, Nida & Goidel, Kirby. (2017). Understanding the effects of past flood events and perceived and estimated flood risks on individuals' voluntary flood insurance purchase behavior. Water Research. 108. 391-400.

Sharma, Upasna & Patt, Anthony. (2011). Disaster warning response: The effects of different types of personal experience. Natural Hazards. 60. 409-423.

Shonkwiler, Ronald & Herod, James. (2009). Mathematical biology. An introduction with Maple and Matlab. 2nd ed. Springer Science & Business Media.

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

Singh, R. and Ryvola, R. (2018) ‘Cognitive Biases in Climate Risk Management.’ Red Cross Climate Centre: BRACED. [online] Available rom: http://www.braced.org/contentAsset/raw-data/533c48ab-749c-49e9-971b-3d0a83293256/attachmentFile [Accessed 19/11/19].

Smit, B., Burton, I., Klein, R.J.T., Wandel, J. (2000) An anatomy of adaptation to climate change and variability. Climate Change 45, 223–251.

Smith, Rose-Ann. (2017). Risk perception and adaptive responses to climate change and climatic variability in northeastern St. Vincent. Journal of Environmental Studies and Sciences. 8. 1-13.

Sovacool, B. (2011) Hard and soft paths for climate change adaptation. Climate Policy. 11. 1177-1183.

Speakman, Dorian. (2017). Growing at the Margins: Adaptation to Severe Weather in the Marginal Lands of the British Isles. Weather, Climate, and Society. 10. 3.

Spence, Alexa & Poortinga, Wouter & Butler, Catherine & Pidgeon, N.F.. (2011). Perceptions of Climate Change and Willingness to Save Energy Related to Flood Experience. Nature Climate Change. 1. 46-49.

Steentjes, K., Demski, C., Seabrook, A., Corner, A. & Pidgeon, N. (2020). British Public Perceptions of Climate Risk, Adaptation Options and Resilience (RESiL RISK): Topline findings of a GB survey conducted in October 2019. Cardiff: Cardiff University.

Stein, Robert & Dueñas-Osorio, Leonardo & Subramanian, Devika. (2010). Who Evacuates When Hurricanes Approach? The Role of Risk, Information, and Location*. Social science quarterly. 91. 816-34.

Strathclyde Centre for Environmental Law and Governance and Scottish Island Federation for the Islands Team of the Scottish Government. (2019) Islay Report. University of Strathclyde. [online] Available from: https://www.strath.ac.uk/media/1newwebsite/departmentsubject/law/strathclydecentreforenvironmentallawandgovernance/pdf/eilean/Islay_Report.pdf [Accessed 03/12/19].

Stoker, P., Chang, H., Wentz, E., Crow-Miller, B., Jehle, G., & Bonnette, M. (2019) Building Water-Efficient Cities, Journal of the American Planning Association. 85. 511-524.

Surminski, Swenja & Mauro, Manuela & Baglee, J. & Connell, Richenda & Hankinson, Joel & Haworth, Anna & Ingirige, Bingunath & Proverbs, David. (2018). Assessing climate risks across different business sectors and industries: An investigation of methodological challenges at national scale for the UK. Philosophical Transactions of The Royal Society A Mathematical Physical and Engineering Sciences. 376. 34.

Surminski, S., Style, D., Di Mauro, M., Townsend, A., Baglee, A., Cameron, C., Connell, R., Deyes, K., Haworth, A., Ingirige, B., Muir-Wood, R., Proverbs, D., Watkiss, P., and Sze Goh, L. (2016). UK Climate Change Risk Assessment Evidence Report: Chapter 6, Business and Industry. Report prepared for the Adaptation Sub-Committee of the Committee on Climate Change, London.

Surminski, Swenja (2014) The role of insurance in reducing direct risk: the case of flood insurance. International. Review of Environmental and Resource Economics. 7. 241-278.

Task Force on Climate-related financial disclosures. (2019) 2019 Status Report. [online] Available from: https://www.fsb-tcfd.org/publications/tcfd-2019-status-report/ [Accessed 17/03/20].

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.

Terpstra, Teun. (2011). Emotions, Trust, and Perceived Risk: Affective and Cognitive Routes to Flood Preparedness Behaviour. Risk analysis : an official publication of the Society for Risk Analysis. 31. 1658-75.

Tessema, Yibekal Abebe & Patt, Anthony & Joerin, Jonas. (2017). Factors affecting smallholder farmers' adaptation to climate change through non-technological adjustments. Environmental Development. 25. 33-42.

The Conversation. (2019) Climate pioneers: how small farmers could be leading the way towards sustainable agriculture. [online] Available from: https://theconversation.com/climate-pioneers-how-small-farmers-could-be-leading-the-way-towards-sustainable-agriculture-109117 [Accessed 09/12/19]

The Grocer -Property and Planning. (2015) M&S commissions study into protecting stores from climate change. [online] Available from: https://www.thegrocer.co.uk/property-and-planning/mands-commissions-study-into-protecting-stores-from-climate-change/520924.article [Accessed 17/03/20].

Thomas, Merryn & Pidgeon, Nick & Whitmarsh, Lorraine & Ballinger, Rhoda. (2015). Mental models of sea-level change: A mixed methods analysis on the Severn Estuary, UK. Global Environmental Change. 33. 71-82.

Thompson, Rebecca & Garfin, Dana & Silver, Roxane. (2016). Evacuation from Natural Disasters: A Systematic Review of the Literature. Risk analysis: an official publication of the Society for Risk Analysis. 37. 812-839.

Tod, Angela; Lusambili; Adelaide; Cooke, Jo; Homer, Catherine; Abbot, Jo; Stocks, Amanda; McDaid, Kath. (2013) Barriers to keeping warm in later life. Nursing Older People 25(10): 22 – 29.

Trust for London. (2017) Poverty and inequality data for Lewisham. [online] Available from: https://www.trustforlondon.org.uk/data/boroughs/lewisham-poverty-and-inequality-indicators/ [Accessed 18/12/19]

Twyman, Chasca & Adger, W. & Thomas, David. (2010). Evaluating Successful Livelihood Adaptation to Climate Variability and Change in Southern Africa. Ecology and Society. 15. 27.

Tyndall Manchester Climate Change Research. (2016) Air Conditioning Demand assessment. [online] Available from: https://www.enwl.co.uk/globalassets/innovation/enwl001-demand-scenarios--atlas/enwl001-closedown-report/appendix-3---tyndall-uom---air-conditioning-demand-report-may2016.pdf [Accessed 17/03/20].

UK Centre for Ecology & Hydrology. (2018) UK Hydrological Status Update early August 2018. [online] Available from: https://www.ceh.ac.uk/news-and-media/blogs/uk-hydrological-status-update-early-august-2018 [Accessed 09/12/19].

UK Government. (2012) UK Climate Services. [online] Available from: https://www.gov.uk/government/publications/uk-climate-services [Accessed 09/12/19]

UKCIP. (2013) Glossary. [online] Available from: https://www.ukcip.org.uk/glossary/ [Accessed 06/12/2019]

UNDRR. UNDRR Terminology. [online] Available: http://www.un.org/en/development/desa/policy/untaskteam_undf/thinkpieces/3_disaster_risk_resilience.pdf [Accessed 17/03/20].

UNISDR (2009). 209 UNISDR Terminology on Disaster Risk Reduction. Available from: https://www.unisdr.org/files/7817_UNISDRTerminologyEnglish.pdf [Accessed 12 November 2019].

USAID (2019) Integrating Social and Behaviour Change in Climate Change Adaptation: An Introductory Guide. [online] Available from: https://www.climatelinks.org/sites/default/files/asset/document/2019_USAID_ATLAS_SBC%20Guide.pdf [Accessed 02/08/19].

Valdez, Rene & Stevenson, Kathryn. (2017). How communication with teachers, family and friends contributes to predicting climate change behaviour among adolescents. Environmental Conservation. 45. 183-191.

van den Bergh, Jeroen. (2009). Willingness of homeowners to mitigate climate risk through insurance. Ecological Economics. 68. 2265-2277.

van der Linden, Sander. (2014). On the relationship between personal experience, affect and risk perception: The case of climate change. European Journal of Social Psychology. 44. 430-440.

van der Linden, Sander. (2015). The social-psychological determinants of climate change risk perceptions: Towards a comprehensive model. Journal of Environmental Psychology. 41. 112-124.

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.

Vulturius, Gregor & André, Karin & Gerger Swartling, Asa & Brown, Calum & Rounsevell, Mark & Blanco, Victor. (2017). The relative importance of subjective and structural factors for individual adaptation to climate change by forest owners in Sweden. Regional Environmental Change. 1. 1-10.

Wallace, R., Sanders, G. P. & Ferl, R. J. 1991. Biology: the Science of Life. 3rd edition. New York: Harper Collins.

Wamsler, Christine & Brink, Ebba. (2014). Moving beyond short-term coping and adaptation. Environment and Urbanization. 26. 86-111.

Wamsler, Christine & Brink, Ebba. (2018). Mindsets for Sustainability: Exploring the Link Between Mindfulness and Sustainable Climate Adaptation. Ecological Economics. 151. 55-61.

Wamsler, Christine. (2016). From Risk Governance to City-Citizen Collaboration: Capitalizing on individual adaptation to climate change: Capitalizing on Individual Adaptation to Climate Change. Environmental Policy and Governance. 26. 184-204.

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.

Wedawatta, Gayan & Ingirige, Bingunath & Proverbs, David. (2011). Adaptation to flood risk: the case of businesses in the UK. [online] Available from: http://usir.salford.ac.uk/id/eprint/18256/1/Wedawatta_Ingirige_Proverbs_Kandalama_Final.pdf [Accessed 17/03/20].

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.

Welsh Government. (2018) Draft Climate Change Adaptation Delivery Plan for Wales. Consultation document.

Werg, Jana & Grothmann, Torsten & Schmidt, Peter. (2013). Assessing social capacity and vulnerability of private households to natural hazards - Integrating psychological and governance factors. Natural hazards and earth system sciences. 13. 1613-1628.

Whitmarsh, Lorraine. (2008). Are flood victims more concerned about climate change than other people? The role of direct experience in risk perception and behavioural response. Journal of Risk Research. 11. 351-374.

Williams, Sarah & Schaefer, Anja. (2013). Small and Medium-Sized Enterprises and Sustainability: Managers' Values and Engagement with Environmental and Climate Change Issues. Business Strategy and the Environment. 22. 173-186

World Health Organisation. (2018). WHO Housing and Health Guidelines. [online] Available from: https://www.ncbi.nlm.nih.gov/books/NBK535285/ [Accessed 17/03/20].

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.

Wolf, Johanna & Adger, W. & Lorenzoni, Irene. (2010). Heat waves and cold spells: An analysis of policy response and perceptions of vulnerable populations in the UK. Environment and Planning A. 42. 2721-2734.

Woodland Trust. (2019) About us: Northern Ireland. [online] Available from: https://www.woodlandtrust.org.uk/about-us/where-we-work/northern-ireland/ [Accessed 19/11/19].

Woodward, M. Kapelan, Z. Gouldby, B. (2014). Adaptive flood risk management under climate change uncertainty using real options and optimization. Risk Analysis 34. 75-92.

World Atlas. (No date) Statistics Northern Ireland Geography. [online] Available from: https://www.worldatlas.com/webimage/countrys/europe/northernireland/uknilandst.htm [Accessed: 17/12/19]

Zaalberg, Ruud & Midden, Cees & Meijnders, Anneloes & McCalley, Teddy. (2009). Prevention, Adaptation, and Threat Denial: Flooding Experiences in the Netherlands. Risk analysis: an official publication of the Society for Risk Analysis. 29. 1759-78.

Zamawe, F.C. (2015) The Implication of Using NVivo Software in Qualitative Data Analysis: Evidence-Based Reflections. Malawi Medical Journal; 27(1): 13–15.

Zhai, Shi-yan & Song, Gen-xin & Qin, Yao-chen & YE, Xin-yue & Leipnik, Mark. (2018). Climate change and Chinese farmers: Perceptions and determinants of adaptive strategies. Journal of Integrative Agriculture. 17. 949-963.

Zografos, C., Anguelosvki, I. Grigorova, M. (2016) When exposure to climate change is not enough: Exploring heatwave adaptive capacity of a multi-ethnic, low-income urban community in Australia. Urban Climate (17): 248-265.