Spatial indicators of vulnerability to climate related hazards in the UK

Social and Business Indices

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SUMMARY

Understanding the spatial variation in the vulnerability of people and businesses to climate-related hazards is central to making progress towards a well-adapted UK. In response, this report brings together some of the most important indicators that provide adaptation-relevant insights into the vulnerability of people and businesses.

A series of individual indicators (drawn from the latest Census and other datasets from across the UK) are gathered. Drawing upon published research and dialogue with the CCC, these data are used to develop two aggregated indices to describe the geographic variation in relative social vulnerability in a meaningful and useable way. These two indices consider the characteristics of people and the communities in which they live that would – if they were to be exposed to either a flood or heat hazard – make them more or less likely to experience a negative welfare outcome. The two aggregated indices are developed at a neighbourhood scale (defined by Lower layer Super Output Areas in England and Wales, Intermediate Zone Boundaries in Scotland, and Super Data Zones in Northern Ireland) and referred to as:

- *Neighbourhood Flood Vulnerability Index* (NFVI-CCRA4, a revision of Sayers *et al.,* 2017)
- *Neighbourhood (high temperature) Heat Vulnerability Index* (NHVI-CCRA4, a revision of Sayers *et al.,* 2023 and Lindley *et al.,* 2011)

A third index focused on business vulnerability to climate events is also provided at the same scale (the *Neighbourhood Business Vulnerability Index,* NBVI-CCRA4). Given the limited availability of published evidence, this third index is necessarily less mature (and more exploratory in nature) but nonetheless provides a useful first step towards understanding the relative business vulnerability to climate-related hazards.

Each index has been assessed twice, once as a relative measure across the UK and once as a relative measure at the scale of each nation. A series of summary maps are included to show the geographic distribution of the relative social and business vulnerability (including a comparison between the UK and nation-based indices). Given the scope of the commission, limited explanatory discussion of the results is included.

This Report is accompanied by Geo-package (of neighbourhood boundaries) and excel spreadsheet (with the shareable individual indicators and indices).

Keywords: climate change, risk, social vulnerability, business vulnerability, indicators, index

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LIST OF ABBREVIATIONS

CCC	Climate Change Committee (UK)
CCRA4	Fourth Climate Change Risk Assessment
DA	Devolved Administration
FDGiA	Flood Defence Grant in Aid
IZB	Intermediate Zone Boundary (Neighbourhood scale used in Scotland)
IMD	Index of Multiple Deprivation
JRF	Joseph Rowntree Foundation
LSOA	Lower Layer Super Output Area (Neighbourhood scale used in England and Wales)
MSOA	Middle Layer Super Output Area
NBVI	Neighbourhood Business Vulnerability Index (new here)
NFVI	Neighbourhood Flood Vulnerability Index (evolved from Sayers *et al.,* 2017)
NHVI	Neighbourhood Heat Vulnerability Index (evolved from Sayers *et al.,* 2022 and Lindley *et al.*, 2011)
NRD	National Receptor Database
ONS	Office of National Statistics
SDZ	Super Data Zone (Neighbourhood scale used in Northern Ireland)

GLOSSARY OF TERMS

Social Vulnerability	Refers to the combination of the inherent characteristics of people that make those exposed to a hazard more or less likely to experience a negative welfare outcome. Social vulnerability is influenced by multiple social factors, including bio-physical indicators such as older age groups and people with pre-existing ill-health as well as factors such as income, property tenure, and individual and community capacities to access and provide support (adapted from Sayers *et al,* 2023 building upon Penning-Rowsell and Priest, 2015 and Lindley *et al.,* 2011).
Business Vulnerability	Defined here as relating to how a given climate hazard or series of hazards (such as a flood or heat wave) may impact on, and create losses in, business health (including considerations of financial health, employee well-being, operational efficiency, and market competitiveness). This includes consideration of the combination of the inherent characteristics of businesses (including resources, supply chains, market access pathways, and workforce) that make those exposed to a hazard more or less likely to experience a negative business outcome. The perspective here is of the business, and no consideration is given to the impact (positive or negative) on the local, regional, or national economy.

1.0 INTRODUCTION

1.1 Background

Under the Climate Change Act 2008 the UK Government is required to publish a Climate Change Risk Assessment (CCRA) every five years. Following publication of the first three assessments (2012, 2017, 2022), the fourth is due in 2027. The Department for Environment, Food, and Rural Affairs (Defra) has, on behalf of the Government, asked the Adaptation sub-Committee of the Climate Change Committee (CCC) to prepare an Independent Assessment by 2026. The Government will then lay before Parliament its summary assessment. Both the CCC and Government reports will feed into the development of the next National Adaptation Programme due in 2028 (covering mainly England), as well as the equivalent programmes in Wales, Scotland, and Northern Ireland. These reports do not cover the Crown Dependencies or Overseas Territories.

Social vulnerability has been a central consideration in some aspects of previous assessments (*e.g.,* Sayers *et al.,* 2015, 2020), and CCRA4 is seeking to consider social and business vulnerability more broadly across all aspects. This is a welcome progression. As many authors have shown (*e.g.,* Cutter, 2009, Walker and Burningham, 2011 and others) the way in which risk, vulnerability, and resilience are assessed is crucial to the way they are understood and managed.

1.2 Aims and objectives

The aim of this study is to review spatial indicators of social and business vulnerability to climate-related impacts across the UK (including the Devolved Administrations (DAs) of Scotland, Wales, Northern Ireland, and inhabited islands), collate those considered most important (and available across the UK), and develop aggregated indices (for flood and heat social vulnerability and business vulnerability) for use across the CCRA4 assessment.

Note

No assessment of the climate related risks or fairness of adaptation measures of the type completed in CCRA3 is included here (Sayers *et al.,* 2020). Instead, the aim here is collate the available social and business inputs for such an assessment.

1.3 Target audience

This report is primarily for those involved in the assessment and management of climate-related risks, particularly lead authors of the CCRA4 Independent Assessment and supporting studies. Given the expertise of this target audience a reasonably high level of prior knowledge regarding the assessment of vulnerability (and previous work) is assumed.

Effort is made throughout the report to highlight the assumptions made as well as the confidence in the underlying data used and the results presented.

Note

The indices have been developed in collaboration with the CCC. In some cases, this has led to a revision of previously published approaches to reflect these discussions. The resulting indices are given the suffix of 'CCRA4' to highlight this focus.

1.4 Report structure

Following this introductory chapter, the report is structured as follows:

- **Chapter 2: Context of the assessment** – presents the assessment framework and important caveats.
- **Chapter 3: Basic attributes** – presents the basic attributes of each neighbourhood that do not relate to vulnerability directly but are likely to provide useful context for onward analysis.

- **Chapter 4: Social vulnerability** – presents the dimensions, domains, and indicators that relate to flood and heat related social vulnerability and the rationale for their inclusion. The integrated indices of the NFVI and NHVI are also presented.
- **Chapter 5: Business vulnerability** – presents the dimensions, domains, and indicators that relate to business vulnerability and the rationale for their inclusion. The integrated Index of the NBVI is also presented.
- **Chapter 6: Discussion and Recommendations** – the concluding chapter presents a brief discussion and recommendations for further development.
- **Chapter 7: References**

Supporting material is provided in four appendices:

Appendix A – provides a summary of the method used to develop the integrated indices using the NFVI to illustrate the approach.

Appendix B – sets out important caveats associated with the analysis. This should be understood before onward use of the datasets.

Appendix C – provides a series of tables setting out the data sources, data processing, and summary rationale for each individual indicator.

Appendix D – sets out the datasets delivered together with a brief description.

2.0 CONTEXT OF THE ASSESSMENT

2.1 Introduction

Climate-related risk is often falsely considered simply as an exposure to a hazard. Whilst important, hazard and exposure are only part of the story. More information is needed to understand where the most significant harm may be felt. For example, not everyone is affected by a heatwave in the same way. Some people may be more susceptible to the impacts of high temperatures due to their age or health than others. Social factors, as well as these biophysical ones, are also often important in determining the impact, as they can influence a person's ability to prepare for, respond to, and recover from a climate-related hazard, such as a heatwave or flood. In combination these factors determine a person's vulnerability and the degree of harm a person experiences when exposed to a hazard.

There are ethical, legal, and reputational reasons for wishing to avoid negative impacts in the most socially vulnerable groups. However, there are also financial arguments too. Where adaptive capacity is poor, more extensive individual, social and infrastructure impacts are likely. For instance, less well protected dwellings can lead to higher individual exposures to flooding and higher rates of uninsured physical building damage. There is more potential for longer-term community decline and impacts on education, employment, and businesses. Not considering how factors come together in particular places mean that the full potential for cost burdens on individuals, local authorities and central government will be overlooked and recovery times lengthened. This is not just a problem for current administrations, but could result in long-term impacts on health and care costs, waiting times, and budgets in the public and private sectors. In these cases, it can be vitally important that support services are in place to improve awareness, provide help and channel resources. Without such actions, inequalities can become persistent with ongoing and long-term impacts on the economy, health, and wellbeing.

Social and business perspectives

Both social and business perspectives on vulnerability are considered as follows:

- **Social vulnerability** refers to the combination of the inherent characteristics of people that make those exposed to a hazard more or less likely to experience a negative welfare outcome. Social vulnerability is influenced by multiple social factors, including bio-physical indicators such as older age groups and people with pre-existing ill-health as well as factors such as income, property tenure, and individual and community capacities to access and provide support (summarised from Sayers *et al.,* 2017 building upon Sayers *et al.,* 2023, Penning-Rowsell and Priest, 2015 Lindley *et al.,* 2011).
- **Business vulnerability** is defined here as relating to how a given climate hazard or series of hazards (such as a flood or heat wave) may impact on, and create losses in, business health (including considerations of financial health, employee well-being, operational efficiency, and market competitiveness). This includes consideration of the combination of the inherent characteristics of businesses (including resources, supply chains, market access pathways, and workforce) that that make those exposed to a hazard more or less likely to experience a negative business outcome. The perspective here is of the business, and no consideration is given to the impact (positive or negative) on the local, regional, or national economy.

Multiple indicators are used here to assess the relative social and business vulnerability at the scale of a 'neighbourhood'. In the case of social vulnerability, the range of indicators used vary subtly between the selected hazards focused on here (*i.e.,* flood and heat) but many are shared (as detailed in Chapter 3).

Note

Vulnerability stands alone from considerations of exposure. People and communities may be classified as socially vulnerable even if they are never exposed to a hazard – it is a measure of their potential to experience harm. This understanding reflects many previous studies (Adger and Kelly, 1999; Tapsell *et al.,* 2002, 2010; Lindley *et al.,* 2011; Twigger-Ross *et al.,* 2014; Kazmierczak *et al.,* 2015, Sayers et al., 2017, 2023).

Geographic and systemic perspectives

Delivering a well-adapted UK requires both social and business vulnerability to be understood and appropriately managed. To do so, spatial concentrations of vulnerability need to be identified, and the risks faced by different groups understood. It is however difficult to express vulnerability in *'absolute'* terms. Instead, vulnerability is typically expressed as a *'relative'* rather than *'absolute'* distributive measure using either a *geographic* or *systemic* lens as follows:

- **Geographic disadvantage (spatial variation in relative vulnerability, the focus of this report):** This relates to where vulnerability is likely to be higher or lower than elsewhere. This perspective provides a spatial understanding of vulnerability that when combined with a credible spatial understanding of exposure to a given climate-related hazard (such as flooding) can be used to identify those locations at greater risk (as defined by Sayers *et al.,* 2017 building upon Lindley *et al.,* 2011).
- **Systemic disadvantage (not covered in this report):** This relates to relative risks between different grouping (for example the vulnerability of those living in rural settings compared to those living in urban settings, or the relative vulnerability of different ethnic groups). Understanding systemic disadvantage provides an insight into issues of the fairness and the degree to adaptation policies (and their implementation in practice) influence outcomes for different groups (defined in Sayers *et al.,* 2017).

Note

Both the geographic and systemic aspects of flood disadvantage today and how these may change in response to climate change and alternative adaptation policies have been explored in previous CCRAs (using the Future Flood Explorer, Sayers *et al.,* 2015, 2020). The data collated here provides the foundation for updating and broadening these previous assessments across a broader range of climate hazards (flood and heat) and providing an initial consideration of business vulnerability to climate hazards.

A UK and nation-scale perspective of geographic disadvantage

Assessing the relative vulnerability of one neighbourhood compared to another varies depending upon the geographical scale considered. The assessment presented here considered two scales. The first considered the relative vulnerability of neighbourhoods within each nation (England or a Devolved Administration) and the second adopts a UK-wide perspective. The assessment approach (as elaborated in the following section) remains unchanged when applied to data at a nation or UK scale. It is only the reference point of the relative measure that changes (*i.e.,* whether vulnerability scores are given relative to an England or a Devolved Administration average or to the UK average).

Note

The data used to support the UK-scale analysis is necessarily limited to those datasets that can be considered reasonably comparable across the UK (as set out in later in Chapters 4 and 5).

2.2 Assessment framework

Overview

Individual, social, economic, and environmental factors all affect social vulnerability and can be intertwined. For example, people who are socially isolated have fewer people checking on their wellbeing during hot weather or in the aftermath of a flood. If they live in rented accommodation, or are on a low income, they may be unable to adapt their homes, such as with shutters or blinds or

install property level flood measures, even if they wish to. Those living in high rise flats or apartments may not have gardens or nearby greenspace to access during a heatwave, or if community services are flooded access to help may be difficult or impossible (*e.g.,* access to health services). These factors vary spatially and combine to make the potential for harm greater in some neighbourhoods compared to others. To make sense of this complexity a tiered assessment framework is used (Figure 2-1).

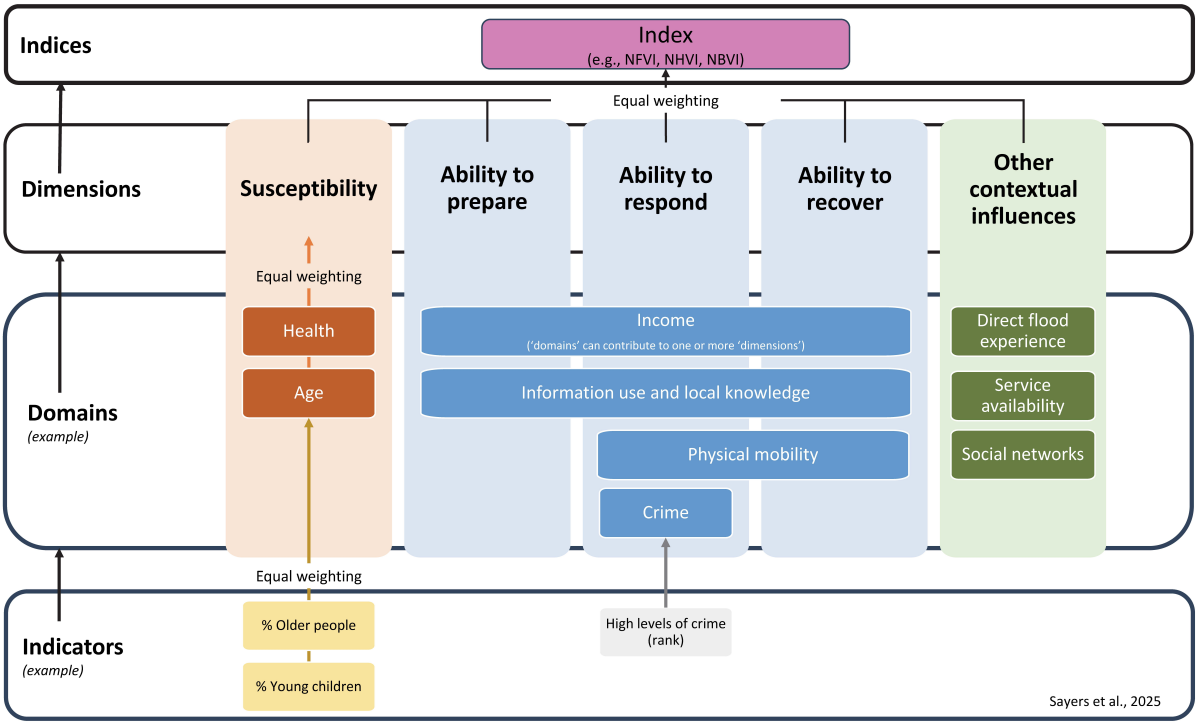


Figure 2-1 Framework of vulnerability assessment - A tiered approach

Within the assessment framework the geographic variation in vulnerability is expressed using a summary ***'Index'*** (*i.e.,* an aggregated statement of the relative vulnerability of one neighbourhood compared to another). To capture the subtleties of the relationship between different climate hazards and social vulnerability, and the differences between business and social vulnerability, three indices are used:

- *Neighbourhood Flood Vulnerability Index (*NFVI, Sayers *et al.,* 2017)
- *Neighbourhood Heat Vulnerability Index* (NHVI, Sayers *et al.,* 2023 and Lindley *et al.,* 2011)
- *Neighbourhood Business Vulnerability Index* (NBVI, developed here)

There are many conceptualisations of vulnerability and ways to consider who is vulnerable and why. There is, however, general agreement that the most important characteristics relate to five ***'Dimensions'*** (*susceptibility*; *ability to prepare*; *ability to respond*; a*bility to recover*; and o*ther contextual factors,* such as access to support, that reduce or exacerbate vulnerability). The assessment of each Index considers these five *'dimensions'* in the context of each Index (as elaborated later in Chapters 4 and 5). Each *'dimension'* is assumed to contribute equally to the overall Index.

A series of vulnerability ***'Domains'*** are considered to influence each Dimension. *'Age',* for example, is a *'domain*' that acts to influence social vulnerability by modifying the relative *'susceptibility'* of a neighbourhood to harm. The relevant '*Domains'* vary according to the *'Index'* and *'Dimension'* of interest (as set out in later in Chapters 4 and 5). Each relevant *'Domain'* is assumed to contribute equally to the related '*Dimension'.*

A series of vulnerability ***'Indicators'*** are used to quantify a given *'Domain'* in each '*Dimension'*. For example, in the case of *'Age'* the presence of *'Young children'* or *'Older people'* will be important drivers of heightened *'Age'*-related vulnerability. Each relevant *Indicator* is assumed to contribute equally to the related *Domain* (as set out in later in Chapters 4 and 5).

Note

The method used to develop the aggregated indices follows the approach adopted in earlier studies (Sayers *et al.,* 2017) and is summarised using the NFVI as an illustration in Appendix A. A similar approach using the relevant indicators is used to develop the NHVI and NBVI respectively.

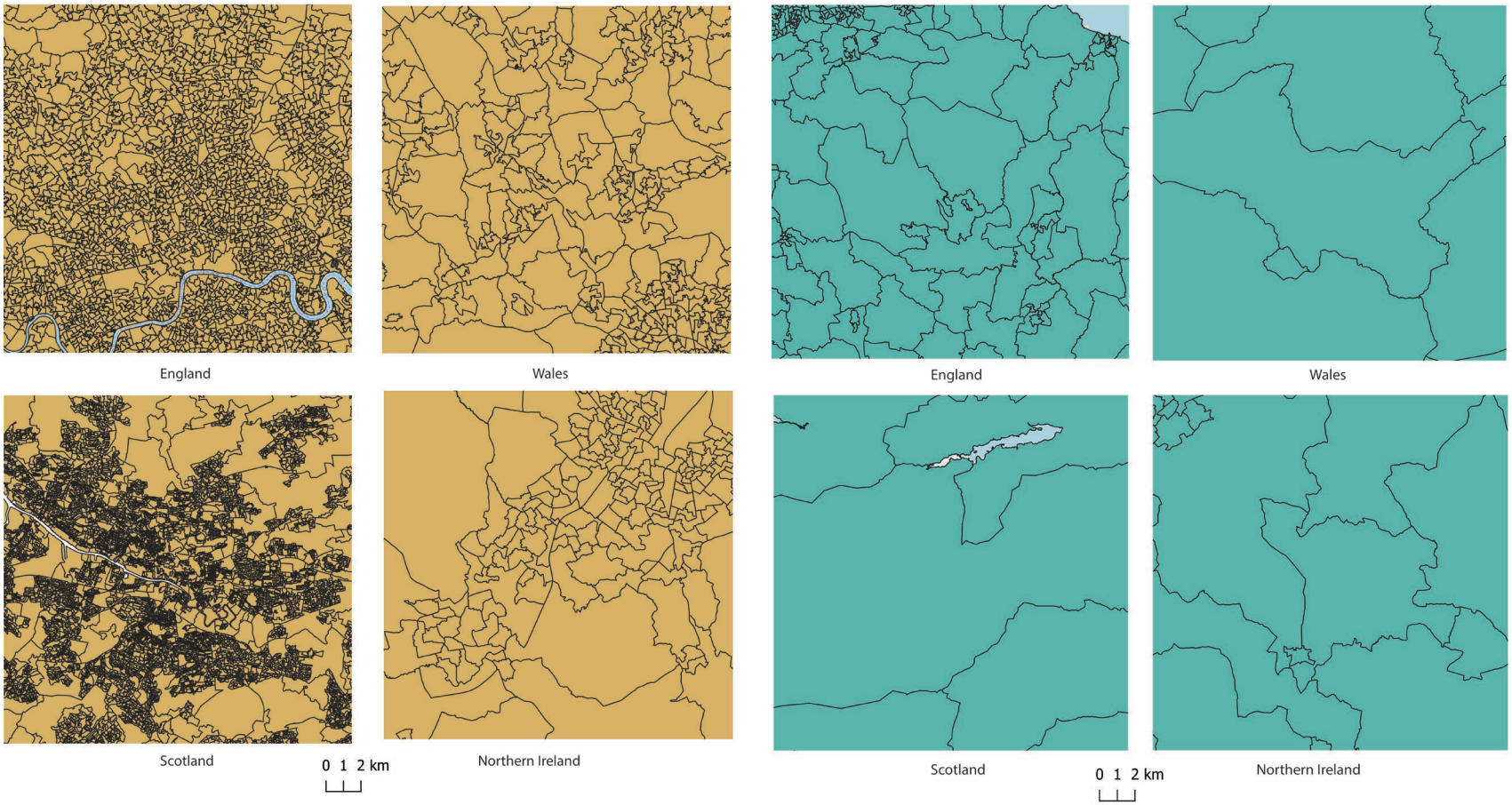
An assumption of equal weighting is used through the aggregation processes. This is used to avoid the inference that more is known about the relative importance of any given indicator, domain, or dimensions. Other approaches have been explored but in the absence of further research and evidence the assumption of equal weighting is considered the most robust.

Spatial framework – Neighbourhoods

The vulnerability indicators are gathered, and indices assessed, at the scale of a *'Neighbourhood'*. The definition of a Neighbourhood is based on Census geometries as follows:

- **England -** 2021 Lower layer Super Output Areas (LSOA, #33,755), typically 1,000-3,000 people
- **Wales -** 2021 Lower layer Super Output Areas (LSOA, #1,917), typically 1,000-3,000 people
- **Scotland** – 2011 Immediate Zone Boundaries (IZBs, #1,279), typically 2,500-6,000 people
- **Northern Ireland** – 2021 Super Data Zones (SDZ, #850), , typically 1,000-2,000 people

Within each nation, the Census based Neighbourhoods are expected to have similar population (as above). The geographic size of each Neighbourhood therefore reflects population density and hence varies between England and the Devolved Administrations as well as between urban and rural settings (Figure 2-2). The data sources used to define the spatial framework for each nation are given in Appendix Table C-1.



Left: Urban settings *Right: Rural settings*

Figure 2-2 Neighbourhoods – An illustration of the variation in scale between countries and between urban and rural settings

Temporal framework – Base date

The assessment uses, as far as possible, data from the Census 2021 and the latest data from other sources. For the purposes on onward analysis, it is suggested that it assumed the aggregated Indices developed from this data reflect the situation as of 2024.

Note

The assumption of a common base data is recognised as a simplification. For example, some indicators, such as Index of Multiple Deprivation (IMD) 2019, are pre-COVID, some are during the pandemic, such as the England and Wales Census, 2021 and some are post-pandemic, such as the Census 2022 for Scotland. Between Census periods, questions are reviewed and some no longer included. For those datasets providing important indicators which were not updated as part of Census 2021, data from the Census 2011 has been used. For other datasets, drawn from other or previous assessments, the data may also be several years old. No attempt is made here to reconcile these dates. The date of the data inputs is however recorded within the metadata tables associated with each indicator in Appendix B.

2.3 Assessment insights and data outputs

The results of the assessment are presented in later chapters and include:

- **Basic attributes of each neighbourhood** – this includes the population, setting (rural or urban), and average household size within each neighbourhood (Chapter 3).
- **Social vulnerability of each neighbourhood** – this includes discussion of the social dimensions of vulnerability, the indicators used, and the aggregated indices of the NFVI and NHVI (Chapter 4)
- **Business vulnerability of each neighbourhood** – this includes discussion of the business-related dimensions of vulnerability, the indicators used, and the aggregated indices of the NFVI and NHVI (Chapter 5)

The data products are provided in the associated Geo-package and Excel files.

2.4 Caveats

The data collated and the analysis undertaken to develop the aggregated indices provides a useful basis to explore the social and business climate-related vulnerabilities and inform progress towards a well-adapted UK. The assessment of vulnerability is however a complex endeavour. To ensure the indicators and indices presented here are used appropriately in these follow-on studies it is important users understand the limitations and nuances of the data to ensure they are used appropriately in onward analysis. Some of the most important of these are set out in Appendix B.

Note

An analysis of the findings and implications of adaptation choices is not included here but will be explored in other projects as part of CCRA4.

3.0 NEIGHBOURHOODS - BASIC ATTRIBUTES

Several basic attributes have been collected and assigned to each neighbourhood. These provide insight into the general setting of each neighbourhood. These basic attributes are introduced below.

Note:

These basic attributes are not used to differentiate the vulnerability between neighbourhoods but provide useful context for onward use in determining adaptation choices and impact alongside the vulnerability indices.

3.1 Urban and rural setting

The Office of National Statistics (ONS) is in the process of updating the rural-urban classifications, but at the time of drafting these are not available. Similar updates are planned for Scotland, but not for Wales or Northern Ireland. Given the importance of understanding the setting of each neighbourhood to any onward analysis, data previously processed by Sayers (Sayers *et al.,* 2017) and used in CCRA3 (Sayers *et al.,* 2020) is used. Given the variation in rural-urban classes across the UK, these classes are simplified here to be either 'rural' or 'urban'. The data used and the associated processing is summarised in Appendix Table C-2.

Note:

This data could be readily updated once updated classes are published by ONS and others.

3.2 Population and gender distribution

The Census-based neighbourhoods represent a similar number of usual residents. The Census geographies and the number of usual residents they represent however varies across the UK. Within each nation the number also varies (but less markedly). Four indicators are collated to provide an understanding of the number of people and their gender distribution within each neighbourhood (see reference tables for details):

- No. of people (Appendix Table C-3)
- No. of people - Male (Appendix Table C-4)
- No. of people - Female (Appendix Table C-5)
- No. of people - Gender assigned[1] (Appendix Table C-6)

3.3 Household size

Household size varies by neighbourhood. Understanding the average household size provides a means of translating population to dwellings. Also, although not used here, household size can have a direct influence on vulnerability, so this indicator may provide some useful insight into issues of overcrowding and differential opportunities for adaptation (but care is needed as the household size is the average for the Neighbourhood and not necessarily representative of any particular property). The data used and the processing is summarised in Appendix Table C-7.

[1] Gender is often considered a vulnerability factor but is not included here due to marginal differences across neighbourhoods in a UK context.

4.0 SOCIAL VULNERABILITY

4.1 Introduction

Two aggregated social vulnerability *'Indices'* are presented here:

- **Neighbourhood Flood Vulnerability Index** (NFVI-CCRA4, based on Sayers *et al.,* 2017)
- **Neighbourhood Heat Vulnerability Index** (NHVI-CCRA4, based on Sayers *et al.,* 2023 and Lindley *et al.,* 2011)

The assessment of each Index considers five '*dimensions'* of vulnerability (as introduced earlier) and a series of *'domains'* (*e.g.,* age, health *etc*.), that are, in turn, reflect one or more supporting *'indicators'* (Table 4-1). Each indicator is standardised to a z-score (derived by subtracting the mean value and dividing by the standard deviation). The resulting z-scores are then equally weighted to estimate each of the five *'dimensions'*. Not all indicators act to increase vulnerability; some act to reduce social vulnerability (*e.g.,* those with experience know how to cope better than those without). The way each indicator impacts vulnerability is recorded within Table 4-1 as the *'direction of increased vulnerability'*.

Not all indicators gathered are applicable to each aggregated Index. Those that are used are highlighted in Table 4-1 with a *'tick'*. The notional weight of each indicator within each Index is also presented in the Table (this is a result that derives from applying the assumption of equal weighting across *'dimensions'* and *'domains'* a given indicator is relates to). Where the detailed description or data format of an indicator varies between England, Scotland, Wales, and Northern Ireland this is also recorded in the table (column *'Is underlying data similar across UK?'*). This information is used to determine those indicators that can be used to support the assessment of the UK-wide aggregated indices (see Section 4.4).

Note

The NFVI and NHVI have been previously published (Sayers *et al.*, 2017, 2023). Although the dimensions and domains remain unchanged, through discussion with the CCC some of the indicators used have been removed or amended where better indicators were found. Comparisons with the original NFVI shows the differences to be small. However, to avoid confusion with backward comparability and the tracking of vulnerability through time, the indices developed here are referred to as **NFVI-CCRA4** and **NHVI-CCRA4**.

Table 4-1 Indicators used within each social vulnerability index

Individual indicators						Dimensions										Notional weight in national indices		Notional weight in UK indices	
						Susceptibility		Ability to prepare		Ability to respond		Ability to recover		Other influences					
Raw data provided?	If 'no', why?	Direction of heighten vulnerability reflected in aggregated index	Indicator ID	Is the underlying data similar across UK?		Flood	Heat	Flood	Heat	Flood	Heat	Flood	Heat	Flood	Heat	Flood	Heat	Flood	Heat
					No. of related domains	2	2	5	5	5	6	6	7	4	3				
					No. of related indicators	5	5	11	10	13	13	15	15	11	7	100%	100%	100%	100%
Yes		n/a	Bas1	No	Spatial units														
Yes		n/a	Bas3	No	Rural or urban setting														
Yes		n/a	Bas4	Yes	No. of people														
Age																13%	13%	14%	13%
Yes		Higher	a1	Yes	Young children	✓	✓									5%	5%	5%	5%
Yes		Higher	a2	Yes	Older people	✓	✓					✓	✓			8%	8%	9%	8%
Yes		n/a	a7	No	Households with one child under 5 years														
Sex																			
Yes	Spatial variation not significant	n/a	sx1	Yes	Male														
Yes	Spatial variation not significant	n/a	sx2	Yes	Female														
No	Inappropriate at neighbourhood scale	n/a	sx3	No	Gender assigned														
Health																21%	20%	10%	10%
Yes		Higher	h1	Yes	Disability / people in ill- health - A little	✓	✓									3%	3%	5%	5%
Yes		Higher	h2	Yes	Disability / people in ill- health - A lot	✓	✓									3%	3%	5%	5%
Yes		Higher	h9	No	People receiving home based care			✓	✓	✓	✓	✓	✓			6%	5%		
Yes		Higher	h10	No	Households with at least one person in long-term ill-health			✓	✓	✓	✓	✓	✓			6%	5%		
Yes		Higher	h12	No	Mood and Anxiety Disorders	✓	✓									3%	3%		
Income																11%	10%	16%	13%
Yes		Higher	i1	Yes	Unemployment (amongst economically active)			✓	✓	✓	✓	✓	✓			6%	5%	16%	13%
Yes		n/a	i2	No	Long-term unemployed														
Yes		n/a	i3	No	Low income occupations														
Yes		n/a	i4	No	Households with dependent children and no adults in employment														
Yes		Higher	i5	No	Income deprivation			✓	✓	✓	✓	✓	✓			6%	5%		
Yes		n/a	i6	No	Average Household Income														
Information use and local knowledge																11%	10%	16%	13%
Yes		Higher	f1	Yes	Recent arrivals to the UK			✓	✓	✓	✓	✓	✓			3%	3%	8%	7%
Yes		Higher	f2	No	Level of proficiency in English language			✓	✓	✓	✓	✓	✓			3%	3%		
Yes		n/a	f7	Yes	Internet access (not superfast)														
Yes		Higher	f8	Yes	Internet access (below USO)			✓	✓	✓	✓	✓	✓			3%	3%	8%	7%
Yes		Higher	k1	No	New migrants from outside the local area			✓		✓		✓				3%			
Physical Mobility																11%	10%	16%	13%
Yes		Higher	m1	No	Living in medical and care establishments					✓	✓	✓	✓			2%	2%		
Yes		Higher	m2	No	Lack of private transport					✓	✓	✓	✓			2%	2%		
Yes		n/a	m3	No	Limited access to employment opportunities by public transport														
Yes		n/a	m4	No	Extended public transport journey times														
Yes		Higher	m5	No	People living in medical and care establishment with a disability					✓		✓				2%			
Yes		Higher	m7	Yes	High levels of registered disability			✓	✓	✓	✓	✓	✓			6%	6%	16%	13%

Continued….

Individual indicators						Dimensions										Notional weight in national indices		Notional weight in UK indices	
						Susceptibility		Ability to prepare		Ability to respond		Ability to recover		Other influences					
Raw data provided?	If 'no', why?	Direction of heighten vulnerability reflected in aggregated index	Indicator ID	Is the underlying data similar across UK?		Flood	Heat	Flood	Heat	Flood	Heat	Flood	Heat	Flood	Heat	Flood	Heat	Flood	Heat
					No. of related domains	2	2	5	5	5	6	6	7	4	3				
					No. of related indicators	5	5	11	10	13	13	15	15	11	7	100%	100%	100%	100%
Housing type																5%	7%	5%	20%
Yes		Higher	ht1	Yes	Households - Caravan or other mobile or temporary structures									✓		2%		2%	
Yes		n/a	ht2	Yes	Households - Detached properties														
Yes		n/a	ht3	Yes	Households - Semi-detached properties														
Yes		n/a	ht4	Yes	Households - Terraced properties														
Yes		Higher	ht5	Yes	Households - Purpose-built block of flats or tenement										✓		2%		10%
Yes		n/a	ht6	Yes	Households - Converted or shared house, including bedsits														
No	licences	Higher	ht9	Yes	Basements									✓		2%		2%	
No	Data relies on OS licence	Higher	ht11	No	High rise flats										✓		2%		
Yes		Higher	ht12	Yes	Homelessness									✓	✓	2%	2%	2%	10%
Tenure																7%	7%	9%	8%
Yes		Higher	t1	Yes	Private renters			✓	✓			✓	✓			4%	3%	5%	4%
Yes		Higher	t2	Yes	Social renters			✓	✓			✓	✓			4%	3%	5%	4%
Yes		n/a	t3	No	Owner occupied														
Household characteristics																			
Yes		n/a	Hc1	Yes	Household size														
Insurance																			
No	Data not appropriate at local scales	n/a	pi3	Yes	Insurance take-up														
Direct previous experience of climate events																5%		5%	
Yes		Lower	e1	Yes	Previous experience of climate events									✓		5%		5%	
Crime																4%	3%		
Yes		Higher	c1	No	High levels of crime					✓	✓					4%	3%		
Air pollution (indoor sources)																			
Yes		n/a	pol4	Yes	Indoor sources (smoking behaviour)														
Yes		n/a	pol5	No	Indoor sources (fuel use)														
Service access times																	7%		
Yes		Higher	ast1	No	Journey times to health services - GP surgeries										✓		3%		
Yes		Higher	ast2	No	Journey times to health services - Hospitals										✓		3%		
Access to green space																	7%		
Yes		Higher	ags1	No	Distance to green spaces										✓		3%		
No	Data licence required at local scale	Lower	ags2	No	Size of local green space										✓		3%		
Service availability																5%		5%	
No	Data not appropriate at local scales	Higher	s1	Yes	Emergency services exposed to flooding									✓		1%		1%	
No	Data not appropriate at local scales	Higher	s2	Yes	Care homes exposed to flooding									✓		1%		1%	
No	Data not appropriate at local scales	Higher	s3	Yes	GP surgeries exposed to flooding									✓		1%		1%	
No	Data not appropriate at local scales	Higher	s4	Yes	Schools exposed to flooding									✓		1%		1%	
Social networks																5%	6%	5%	8%
Yes		Higher	n1	Yes	Single-pensioner households						✓		✓	✓		2%	3%	2%	4%
Yes		Higher	n2	Yes	Lone-parent households with dependent children									✓		2%		2%	
Yes		Higher	n3	Yes	Lack of school-related networks						✓		✓	✓		2%	3%	2%	4%

4.2 Dimensions – Social vulnerability

The relationship between the five dimensions of vulnerability (introduced earlier) and social vulnerability to floods and high temperatures as set out below.

Susceptibility to flood or high temperatures

Susceptibility describes the predisposition of an individual to experience a loss of well-being when exposed to hazard, such as a flood or high temperature. It is widely evidenced that the dominant characteristics that influence susceptibility to harm are biophysical, and relate to age (the old and young) and health.

Ability of an individual to prepare for a flood or high temperatures

Preparedness refers to the actions taken by an individual during normal conditions (*i.e.,* in the absence of a forecast or actual climate event, such as a flood) to reduce the 'harm' they suffer when a future event does occur. Although an area of continued research, an individual's ability to prepare is acknowledged to be influenced by their income, individual capacities to act (for example, some may be limited in their ability to make home-based modifications by a tenancy agreement), local knowledge and perception of the threat.

Ability of an individual to respond to a flood or high temperatures

The underlying reasons why some individuals act more effectively in the run up to, and during, a climate hazard event is an area of continued research. There is however broad agreement that an individual's ability to respond is influenced by their income, capacity to access and use formal and informal information, local knowledge, their physical mobility, and mental health.

Ability of an individual to recover from a flood or high temperatures

Individuals and households have a varying ability to autonomously recover from a climate event. There are limits to this capacity and the degree to which an individual can aid their own recovery is influenced by several factors, particularly their income, capacity to use information, and physical mobility. Recovery can take significant time, particularly those events that lead to the damage of physical infrastructure that requires repair.

Other contextual factors that influence social vulnerability

The availability and quality of services provided by health and emergency services as well as broader care and social services have a real influence on the severity of harm caused when someone is exposed to climate hazard. Despite a lack of quantified evidence, there is also strong anecdotal evidence that community networks can help reduce vulnerability by providing informal support to affected groups. A formal representation of community cohesion and its influence on social vulnerability is not, however, available. In recognition of the importance of community support, but in the absence of more detailed insights, community support is recognized alongside other *'other influencing factors'* such as housing characteristics (such as basements, or high rise flats), the collective experience of past events, the likely availability of community services 'on demand' during an event (including emergency service provides, schools, hospitals, GPs) and the social networks that exist (through parent networks developed through schools *etc.*). This is recognised as very much a first step and further research will be required to better quantify supportive community contexts.

Note

The impact of a climate event is not an absolute. The context of that event (such as a flood during winter may coincide with a flu pandemic), and the severity of the event (such a persistence and intensity of a heat wave) will drive different outcomes. The quantification of these outcomes is inherent within a risk assessment but is not the focus here. Instead, focus here is to understand the spatial differences in vulnerability.

4.3 Domains and indicators – Social vulnerability

To assess the five '*Dimensions'* of vulnerability set out in Section 2.2, a series of vulnerability *'Domains'* are considered (such as '*Age'*, *'Health'*, *etc*.) that are likely to influence each '*Dimension'*. The rationale for each domain and the supporting indicators used to represent each domain are presented below. A series of supporting tables (given in Appendix C) present further details of the rationale for the inclusion of each indicator (including references to supporting literature where possible), record the input data source used, and the is processing undertaken (if any). The tables also record if a given indicator contributes to the development of the aggregated indices (discussed later in Section 4.3).

Note

In a large part, this work builds upon previous work by Lindley *et al.*, 2011, Kazmierczak *et al.*, 2015, Sayers *et al.,* 2017. Much of this work and further extensive references are given on the Climate Just website (https://www.climatejust.org.uk).

Age

Young children and older people are more biophysically susceptible to hazards, including exposure to flood waters (particularly if contaminated) and heat stress from hot weather (Vardoulakis and Heaviside, 2012). Three indicators are collated to provide an understanding of the characteristics of the *'Age'* domain within each neighbourhood:

- Young children (Appendix Table C-8)
- Older people (Appendix Table C-9)
- Households with one child under 5 years (Appendix Table C-10)

Health

Poor health significantly increases vulnerability to both flood and heat events because of the potential for events to aggravate existing health conditions. In some cases, medicines used may also increase susceptibility to effects, e.g. of heat stress (Page *et al.,* 2012). Five indicators are collated to provide an understanding of the characteristics of the *'Health'* domain within each neighbourhood:

- Disability / people in ill-health - A little[2] (Appendix Table C-11)
- Disability / people in ill-health - A lot[3] (Appendix Table C-12)
- People receiving home-based care (Appendix Table C-13)
- Households with at least one person in long-term ill-health (Appendix Table C-14)
- Mood and Anxiety Disorders (Appendix Table C-15)

Income

Low income is important because a lack of financial resources restricts people's ability to prepare for, respond to and recover from hazard events. In addition to a reduced choice in terms of goods and services, there is also evidence of lower self-esteem and higher levels of stress and anxiety (*e.g.,* Marmot Review, 2010). People in this group are more likely have negative impacts on their health and wellbeing in the aftermath of climate events. Analysis of past events demonstrated that the perception of negative financial implications increased the potential for anxiety, depression and

[2] Within England this refers to those considered 'Disabled under the Equality Act: Day-to-day activities limited a little'. Similar definitions are used within the Census questions across the UK.

[3] Within England this refers to those considered Disabled under the Equality Act: Day-to-day activities limited a lot'. Similar definitions are used within the Census questions across the UK.

PTSD and these mental health symptoms were significantly higher in unemployed people (*e.g.,* Paranjothy *et al.,* 2011). Income is also important for heat-related vulnerabilities, for example as low-income households may be less able to adapt their homes. There may be more reluctance to take advice to open windows if a household is uninsured or has poorer security measures (*e.g.,* Tiley *et al., 2011*), thus increasing the potential for heat stress.

Six indicators are collated to provide an understanding of the characteristics of the *'Income'* domain within each neighbourhood:

- Unemployment (amongst the economically active) (Appendix Table C-16)
- Long-term unemployed (Appendix Table C-17)
- Low-income occupations (Appendix Table C-18)
- Households with dependent children and no adults in employment (Appendix Table C-19)
- Income deprivation (Appendix Table C-20)
- Average Household Income (Appendix Table C-21)

Information use and local knowledge

Understanding the local context, the risks, and where and how to access help are all important influences on vulnerability. Five indicators are collated to provide an understanding of the characteristics of the *'Information use and local knowledge'* domain within each neighbourhood:

- Recent arrivals to the UK (Appendix Table C-22)
- Level of proficiency in English language (Appendix Table C-23)
- Internet access (not Superfast Broadband, SFBB, at least 24 Mb/s) (Appendix Table C-24)
- Internet access (below Universal Service Obligation, USO, i.e. <10 Mb/s) (Appendix Table C-25)
- New migrants from outside the local area (Appendix Table C-26)

Physical mobility

Limited physical mobility tends to make people more susceptible to negative effects of climate events, and can reduce their ability to respond to**,** and recover from**,** environmental stresses like high temperatures and flood events. Six indicators are collated to provide an understanding of the characteristics of the *'physical mobility*' domain within each neighbourhood:

- Living in medical and care establishments (Appendix Table C-27)
- Lack of private transport (Appendix Table C-28)
- Limited access to employment opportunities by public transport (Appendix Table C-29)
- Extended public transport journey times (Appendix Table C-30)
- People living in medical and care establishments with a disability (Appendix Table C-31)
- Elevated levels of registered disability (Appendix Table C-32)

Housing type

Housing type can influence the householder's ability to take action to prepare and respond to a climate event as well as exacerbate the risks they face. Nine indicators are collated to provide an understanding of the characteristics of the *'housing type'* domain (including the prevalence of homelessness) within each neighbourhood:

- Caravan or other mobile or temporary structures (Appendix Table C-33)
- Detached properties (Appendix Table C-34)
- Semi-detached properties (Appendix Table C-35)
- Terraced properties (Appendix Table C-36)
- Purpose-built block of flats or tenements (Appendix Table C-37)
- Converted or shared houses, including bedsits (Appendix Table C-38)

- Basements (Appendix Table C-39)
- High rise flats (Appendix Table C-40)
- Homelessness (Appendix Table C-41)

Tenure

Property tenure is an important influence on property maintenance and a householder's ability to take autonomous action. Three indicators are collated to provide an understanding of the characteristics of the *'tenure'* domain within each neighbourhood:

- Private renters (Appendix Table C-42)
- Social renters (Appendix Table C-43)
- Owner occupied (Appendix Table C-44)

Insurance

Insurance (and associated incentives) are a significant contributor to recovery and preparation. The impact of a climate event on those without insurance is likely to be much greater than on those with access to appropriate insurance (as reflected by the metric of *Relative Economic Pain* that describes the ratio of uninsured loss to income; Sayers *et al.,* 2017). The most socially vulnerable are less likely to have insurance than others as low incomes and living in social and private rented accommodation are both important barriers to the take-up of insurance (as reported by Flood Re, Sayers *et al.,* 2020). Insurance can be a powerful motivator of adaptation. For example, the Flood Re *'building back better'* incentive encourages flood damaged properties to be repaired to higher flood resilience standards post event. A neighbourhood scale assessment of insurance take up is provided in the data collated. Given the commercial sensitives and the lack of published data at this scale, this is based on the inferred values derived by Sayers *et al.,* (2017).

- Insurance take-up (Appendix Table C-45)

Direct previous experience of climate events

A large body of research from Kates (1962) onwards, shows that those with experience of a given hazard are less vulnerable in subsequent events as they have more knowledge as to what to do and how to respond. Those without experience are likely to be less able to cope. Previous experience of a flood, for example, has been shown to be a key factor in level of willingness to take preventative action against future floods, and respond seriously to warnings. However, links between flood experience and flood perception are complex and knowledge from past events is not always indicative of the ability to cope (*e.g.,* where floods differ in severity or when people endure higher levels of stress and anxiety, Hopkins and Warburton, 2015). Despite this complexity here, previous experience is included here as contextual influence likely to reduce vulnerability.

- Previous experience of climate events (Appendix Table C-46)

Crime

People living in areas with higher rates of crime (or perceived high crime) may be more reluctant to take preventative measures in reaction to flood warnings or heat wave events. Where crime rates are high, residents may hesitate to evacuate properties during floods for fear of looting and may have reduced adaptive capacity during heat wave events due to an unwillingness to leave windows open at night. Where dwelling-related crime levels are highest, residents are more likely to have extra security mechanisms on their houses such as multiple locks on doors and windows that may cause delays in evacuation and rescue attempts.

- Higher levels of crime (Appendix Table C-47)

Air pollution (indoor sources)

High temperature events are frequently associated with episodic air pollution. Sources of indoor air pollution, such as smoking and solid fuel burning, can exacerbate the impact of poor air quality during climate events and elevate air pollution within the home and hence potential impacts. The evidence however remains largely anecdotal. Two indicators are collated to provide an understanding of the characteristics of indoor sources of air pollution that may act to exacerbate the impact of climate-related poor air quality within a neighbourhood:

- Indoor sources (smoking behaviour) (Appendix Table C-48)
- Indoor sources (fuel use) (Appendix Table C-49)

Service access times

People living in areas which are more physically isolated from health care and other support services are less likely to be able to access those services than others. This places constraints on accessing medical help or medicines quickly if experiencing heat stress or in the aftermath of a flood. These difficulties manifest in an increase in vulnerability compared to other areas. Two indicators are collated to provide an understanding of the characteristics of the *'service access times'* within each neighbourhood:

- Journey times to health services - GP surgeries (Appendix Table C-50)
- Journey times to health services - Hospitals (Appendix Table C-51)

Access to green space

Availability of and proximity to greenspace is important during heatwaves for two main reasons. The first is due to greenspace providing opportunities for people to access cooler areas during heat waves (urban parks have been shown to be on average 1°C cooler than the surrounding built-up areas due to shading and evapotranspiration, Bowler *et al.,* 2010). The second is that green (and blue) spaces act to cool neighbourhoods beyond their boundaries as well as reduce the intensity of the urban heat island effect (Voogt and Oke, 2003; Spronken-Smith and Oke 1999; Smith *et al.,* 2011). Urban neighbourhoods with less green cover and fewer opportunities to access green space are therefore likely to experience greater impact during heat waves. Previous studies have corroborated the link, for instance demonstrating that greener cities are associated with lower heat mortality relative risk (Choi *et al.,* 2022), though this association may be amplified by wider health and wellbeing benefits (Marselle, *et al.,* 2021; Markevych *et al.,* 2017).

- Access to green space (Appendix Table C-52)
- Neighbourhood greenspace (Appendix Table C-53)

Note:

This differential in access is only considered in the context of urban settings. In rural neighbourhoods, ready access to green space is assumed.

Service availability

Several studies highlight the link between institutional (such as the police, the fire brigade, ambulances, and local authority social care) and community support networks and the vulnerability of the individuals in those communities (*e.g.,* Penning-Rowsell et al., 2013). Research by the National Flood Forum confirms this to be the case and shows that higher levels of post-flood institutional support (in this case from a charity) accelerates the pace of recovery. Emergency services aim to target the most vulnerable households in assistance efforts but the ability to do this effectively relies on the flood resilience of these services themselves. If a police station, ambulance station, GP surgery or hospital is impacted by a flood, the ability to service the community at its time of need is severely impacted. Similarly, if a school floods, children are often temporarily transferred to other

schools, which may be some distance away, while the original school is restored. This adds to family disruption and dislocation, increasing their vulnerability. If care or nursing homes are flooded, highly vulnerable residents must be evacuated and suitable placements for them must be found. Care homes will also often take in vulnerable residents who have been evacuated from their own homes. This system is severely hampered if the care home itself is flooded (e.g., Donovan, 2014).

Four indicators are collated to provide an understanding of the characteristics of the *'service availability'* within each neighbourhood:

- Emergency services exposed to flooding (Appendix Table C-54)
- Care homes exposed to flooding (Appendix Table C-55)
- General Practitioner (GP) surgeries exposed to flooding (Appendix Table C-56)
- Schools exposed to flooding (Appendix Table C-57)

Social networks

Sayers *et al.,* (2017) highlight the importance of social networks in driving differential vulnerability. Several studies have made the connections between a lack of social or community networks and levels of social deprivation in an area. Where social networks are good there is evidence of a better response to emergency situations and quicker recovery (*e.g.,* Preston et al., 2014). Individuals that are more likely to feel socially isolated include single parents, lone pensioners, and new arrivals to an area, who may face practical difficulties in responding to a flood as there is less direct within-the-family support (*e.g.,* Tapsell *et al.,* 2002). Adults who live alone (including those with dependent children) are more likely to struggle to act when receiving a flood warning. For example, it may be physically impossible to move furniture or other items, and they will also feel more uncertain and anxious with no-one to confide in (*e.g.,* Thrush *et al.,* 2005). With limited social networks people may face difficulties in accessing short-term alternative accommodation from family and friends, and so are more likely to need to use public shelters in the event of an evacuation, but also may be less likely to know about the existence and location of such services. Opportunities for informal networks (via school or community groups) are much reduced or even absent during a flood (*e.g.,* Penning-Rowsell and Tapsell, 2002).

Three indicators are collated to provide an understanding of the characteristics of the '*social networks'* within each neighbourhood:

- Single-pensioner households (Appendix Table C-58)
- Lone-parent households with dependent children (Appendix Table C-59)
- Lack of school-related networks[4] (Appendix Table C-60)

4.4 Aggregated indices – Neighbourhood Flood and Heat Vulnerability Indices

A sub-set of the indicators gathered (as set out in previous section) are used to develop two integrated social vulnerability indices:

- **Neighbourhood Flood Vulnerability Index** (NFVI, based on Sayers *et al.,* 2017)
- **Neighbourhood Heat Vulnerability Index** (NHVI, based on Sayers et al., 2023 and Lindley *et al.,* 2011)

[4] Those households with Primary School aged children tend to have greater social network within the local community that those without. The absence of these networks can increase vulnerability.

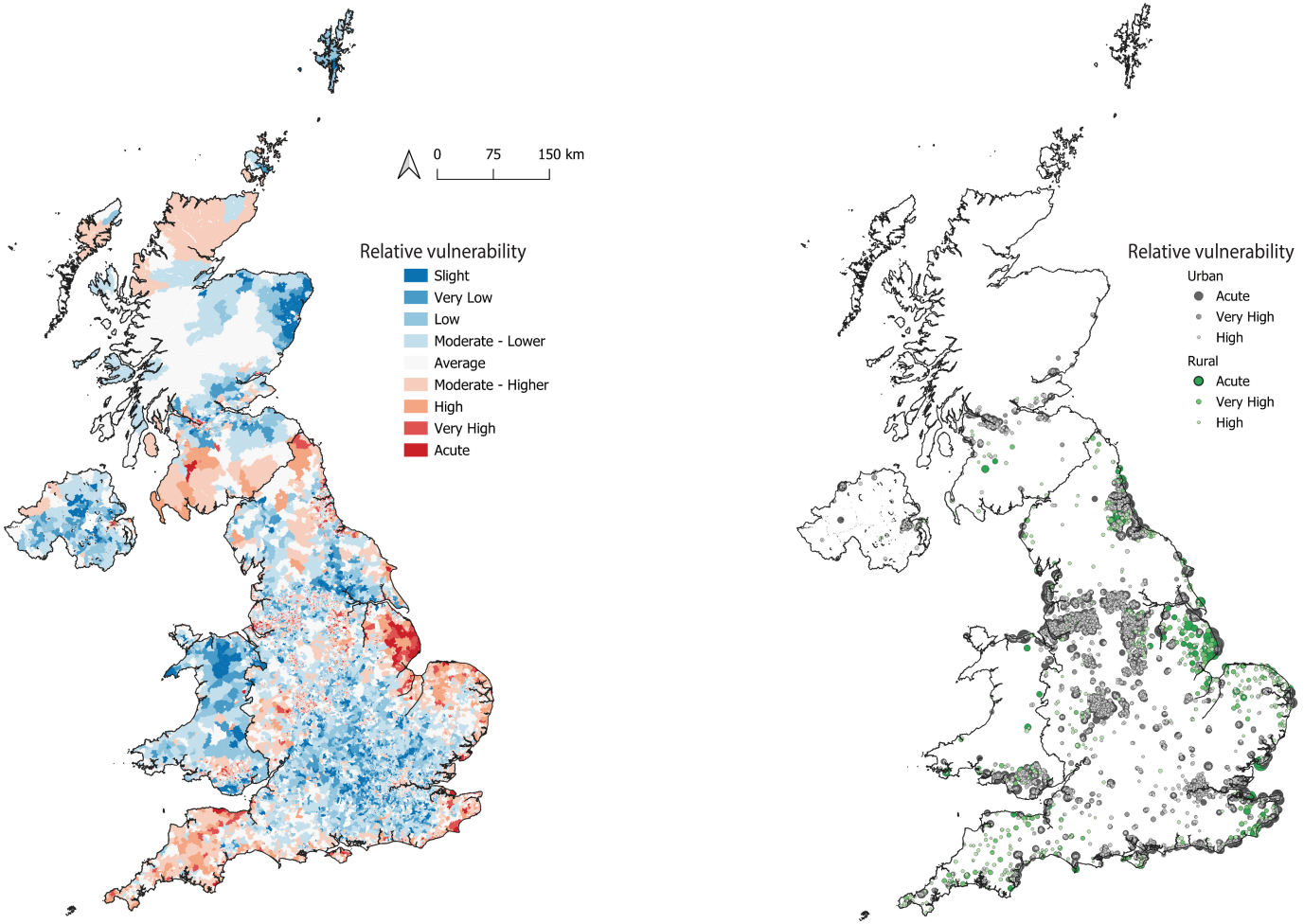
The indicators considered relevant to each Index have been chosen based on the underlying research that supports its inclusion, discussion with the CCC team, and the experience of the project team gained since their initial development.

National-scale indices

The national-scale assessment considers the vulnerability of a given neighbourhood relative to all other neighbourhoods within the same nation. The national-scale analysis uses all available indicators considered relevant to each Index (as highlighted in Table 4-1). The availability, scale, as well as the detailed definition of these indicators may vary between England and each DA. These differences are well-handled by the structure of the method. The use of equal weighting in the process of aggregating domains to dimensions, and dimensions to indices enables different indicators to be used to support the understanding of each domain (where this is necessary given data differences between England and the DAs). The relative weight of a given indicator will change if the number of indicators used in a given domain varies across the nations, but the overall weight given to the domain itself will be the same across the nations (unless no relevant indicators are available). The weighting given to each indicator (set out in Table 4.1) provides a sense of their relative contributions to the overall index. However, the importance of any indicator in contributing to neighbourhoods with high social vulnerability is determined by the joint value of that indicator and others in addition to their weights.

The spatial distributions of the NFVI and NHVI based on the national-scale analysis are illustrated in Figure 4-1 and Figure 4-2 respectively. Percentile values are used to determine the relative categories used within each map as follows:

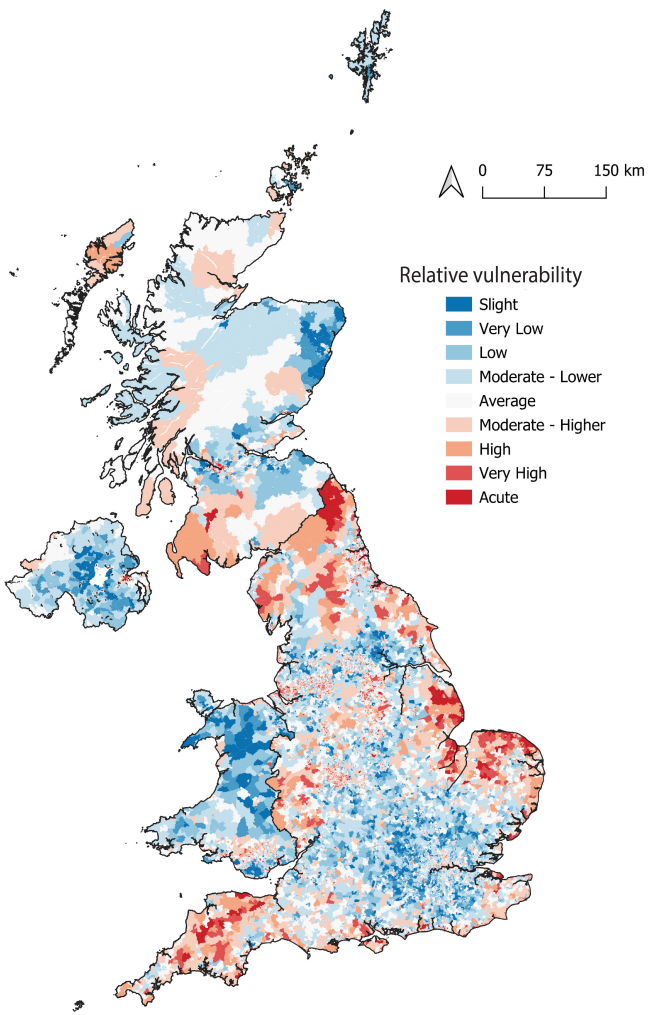
- **Acute:** 5% *most* socially vulnerable neighbourhoods
- **Very high:** 5-10% *most* socially vulnerable neighbourhoods
- **High:** 10-20% *most* socially vulnerable neighbourhoods
- **Moderately high:** 20-40% *most* socially vulnerable neighbourhoods
- **Average:** those neighbourhoods considered to have *average* vulnerability
- **Moderately low:** 40-20% *least* socially vulnerable neighbourhoods
- **Low:** 20-10% *least* socially vulnerable neighbourhoods
- **Very low:** 10-5% *least* socially vulnerable neighbourhoods
- **Slight:** 5% *least* socially vulnerable neighbourhoods



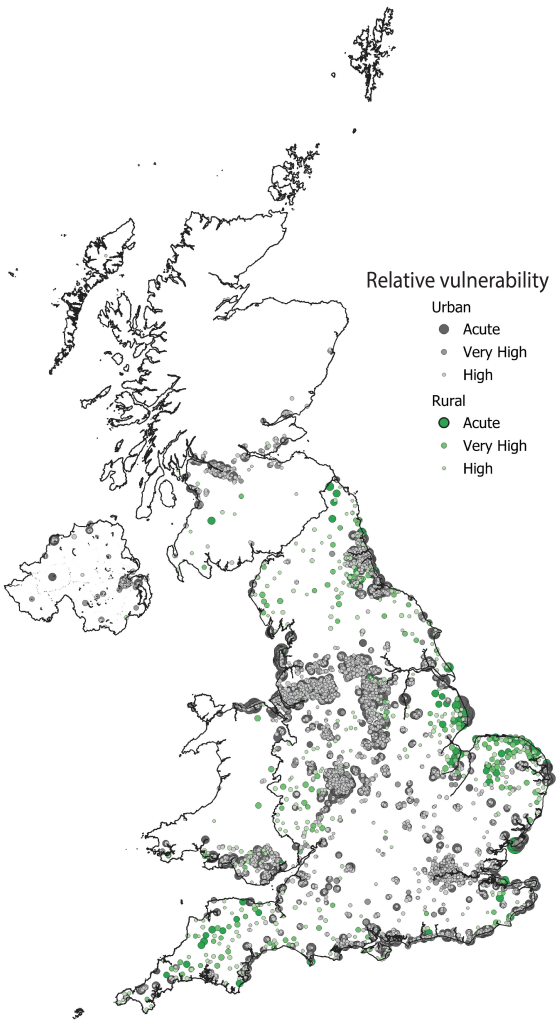
Left: *The relative social vulnerability of each neighbourhood by category*

Right: *The 20% most socially vulnerable neighbourhoods. Coloured coded by rural (green) and urban (grey) neighbourhoods. The dark to light shading indicates the 5%, 10% and 20% most vulnerability neighbourhoods. The size of the dot reflects the absolute z-score (larger more vulnerable).*

Figure 4-1 NFVI (Flood) – Spatial variation based on national-scale analysis



Left: *The relative social vulnerability of each neighbourhood by category*



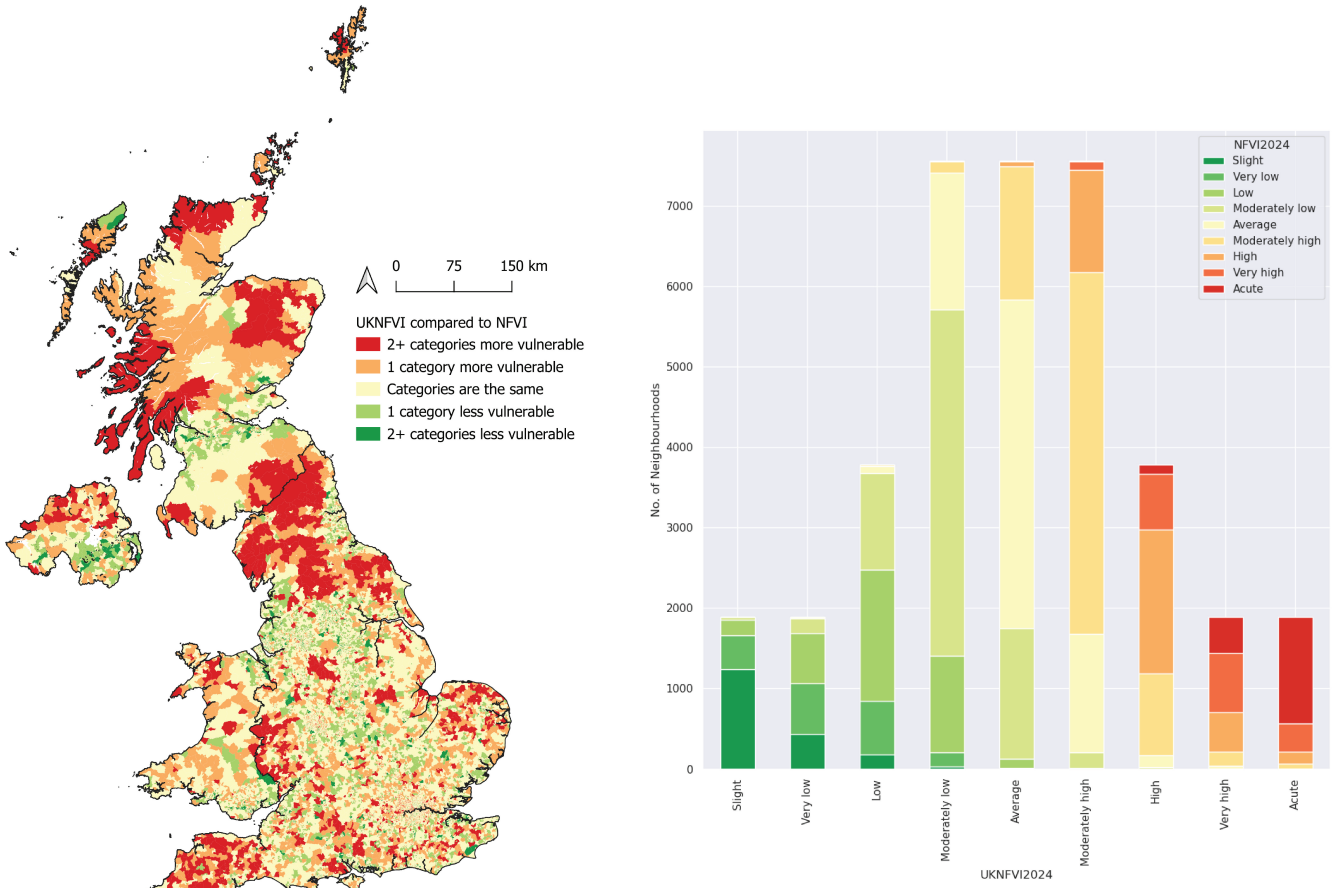
Right: *The 20% most socially vulnerable neighbourhoods. Coloured coded by rural (green) and urban (grey) neighbourhoods. The dark to light shading indicates the 5%, 10% and 20% most vulnerability neighbourhoods. The size of the dot reflects the absolute z-score (larger more vulnerable).*

Figure 4-2 NHVI (Heat) – Spatial variation based on national-scale analysis

UK-scale indices

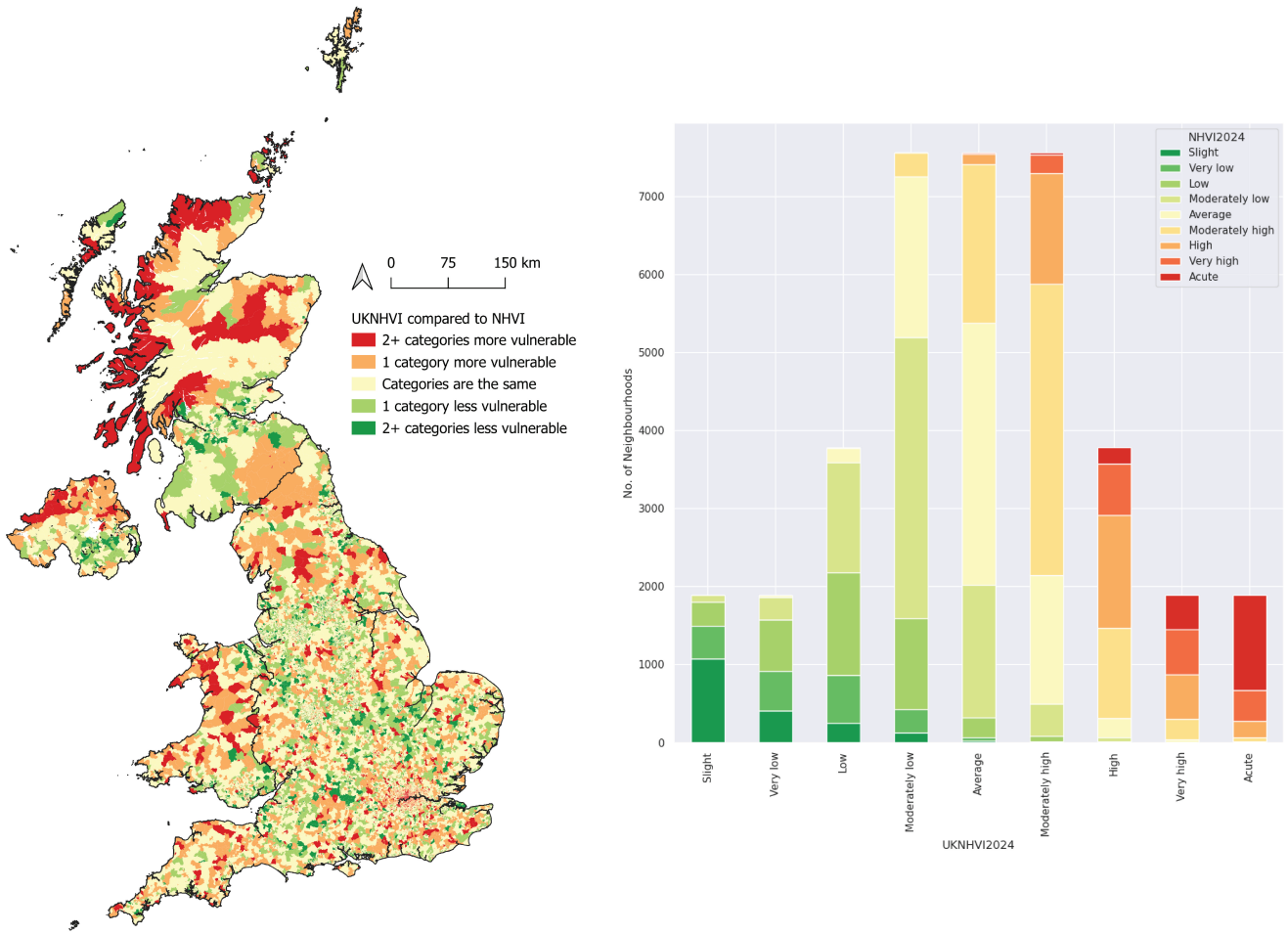
The UK-scale assessment considers the vulnerability of a given neighbourhood relative to all other neighbourhoods within the UK. The analysis uses only those indicators that are consistently represented (in broad terms) in each nation (as highlighted in Table 4-1). This significantly restricts the number of indicators used but enables a consistent UK scale perspective.

The spatial pattern of relative vulnerability changes when neighbourhoods are compared across the UK rather than within each nation (see Figure 4-3 and Figure 4-4 for the NFVI and NHVI respectively). In most cases the change in category is limited (remaining the same or changing to by one category higher or lower). There are many neighbourhoods where the change is more significant. It is difficult to know if this is an artefact of the reduced number of indicators, an inherent variation in some indicators that are treated as comparable but are not (such as nuanced variations in the definitions of unemployment in England and the Devolved Administrations), or a true variation in vulnerability between nations.



Left: *Spatial view of the difference in vulnerability category between the UK-scale and national-scale index.* ***Right:*** *Distribution view of the variation. X-axis represented the category assigned through country-scale analysis and y-axis the national-scale*

Figure 4-3 NFVI (Flood) – Variation in NFVI category between UK-scale and national-scale analysis



Left: *Spatial view of the difference in vulnerability category between the UK-scale and national-scale index.* ***Right:*** *Distribution view of the variation. X-axis represented the category assigned through country-scale analysis and y-axis the national-scale*

Figure 4-4 NHVI (Heat) – Variation in NHVI category between UK-scale and national-scale analysis

5.0 BUSINESS VULNERABILITY

The range of business impacts that arise from flooding and heatwaves are well rehearsed (Surminski *et al.,* 2021). Extreme heat can impact operations and productivity, especially in sectors where outdoor work is common, and increase cooling costs for indoor workers (*ibid*). Businesses can also be impacted by indirect risks, such as those affecting their investment portfolios, supply chains, and distribution networks regionally or globally (particularly for industries reliant on *just-in-time* delivery systems).

Recent years have seen an increased focus on business resilience and emergence of various tools to help businesses to assess, measure, track, and report on their resilience in response to evolving regulatory demands and good practice. Businesses that rely upon physical infrastructure (either on-site or through their supply chains) are also increasingly encouraged to manage the climate-related risks they face, and assess the benefit of investing to enhance the climate resilience of that infrastructure. More broadly, various approaches are emerging to help investors screen actions within different sectors and target companies for investment, as well as help insurers better understand the resilience of the markets and business they insure.

Most frameworks tend to use indicators that seek to capture business resilience from the perspective of business growth over the medium to longer term (customer retention, innovation *etc*.) as well as continuity in response to a '*shock'* (such as a cyber-attack, climate event, or a pandemic such as COVID-19). Here the focus is the latter. Typically, this would be addressed through self-assessment (*e.g.,* using resilience maturity tools), surveys or supplies and customers, as well as scenario-based simulations. This bespoke analysis is not possible in the context here. Instead, a data-driven approach is adopted to provide an assessment of the business vulnerability in one geographical area compared to another.

The **Neighbourhood Business Vulnerability Index** (NBVI-CCRA4) has been developed here to provide an integrated perspective on the relative business vulnerability between neighbourhoods. In alignment with the assessment of social vulnerability, the NBVI considers five '*dimensions'* of vulnerability (Susceptibility; Ability to Prepare; *etc,* outlined for the business case in the next section) that each reflect a series of *'domains'* (*e.g.,* organisational capacity, financial resources *etc*.) , that are, in turn, based upon one or more supporting *'indicators'* (Table 5-1). The aggregation of indicators to domains through to the overall index uses the same framework as set out for the social vulnerability indices.

Not all indicators gathered are applicable to the business index. The indicators that are used for NBVI-CCRA4 are highlighted in Table 5-1. The notional weight given to each indicator is also presented in the Table (based on the assumption of equal weighting across *'dimensions'* and *'domains'*). Where the detailed description or data format of an indicator varies between England, Scotland, Wales, and Northern Ireland this is also recorded in the table (column *'Is the underlying data similar across UK?*'). This information is used later when developing integrated indices for the UK and each nation (see Section 5.3).

Note

No consideration is given here to the impacts on the UK economy. For example, no consideration is given to the transfer of business activities if a business fails, or the opportunity loss if a business with high growth potential fails, or the opportunity gain if a poorly performing business fails enabling capital to be redeployed more productively. The focus here is to compare the present relative business vulnerability in one area relative to another and does not factor in potential future cascading effects of an initial shock. For consistency with the social vulnerability assessment, the geography of neighbourhoods is used as the spatial framework. This does not imply that the customers and suppliers of a business are within that neighbourhood. It is important emphasise this is a first assessment of business vulnerability and further research is needed.

Table 5-1 Indicators used within the business vulnerability index

Individual indicators						Dimensions					Indicator weighting...	
						Susceptability	Ability to prepare	Ability to respond	Ability to recover	Other influences	In National index	In UK index
Raw data provided?	If 'no', why?	Direction of heighten vulnerability reflected in aggregated index	Domain and indicator ID	Is the underlying data similar across UK?		Business	Business	Business	Business	Business	Business	Business
					No. of related domains	1	2	1	1	1		
					No. of related indicators	2	4	2	2	2	100%	100%
Business presence												
No	Relies on third party licenced data	n/a	bb1	No	Non-residential properties							
Operational flexibility												
No	No data readily available	n/a	bb13	No	Multiple site business							
Work place											**20%**	
Yes		n/a	bt1	No	Outdoor workers (living within the area)							
Yes		Higher	bt2	No	Outdoor workers (working in the area)	✓					10%	
Yes		n/a	bt3	No	Share of outdoor workers in permanent activities (working in the area)							
Yes		Higher	bt4	No	Share of outdoor workers in transient activities (working in the area)	✓					10%	
Yes		n/a	bt6	No	Home workers							
Organisational capacity											**10%**	**17%**
No	Data poorly resolved at neighbourhood scale	Higher	bb2	Yes	Micro companies		✓				5%	8%
No	Data poorly resolved at neighbourhood scale	Higher	bb3	Yes	Small companies		✓				5%	8%
No	Data poorly resolved at neighbourhood scale	n/a	bb4	Yes	Medium companies							
No	Data poorly resolved at neighbourhood scale	n/a	bb5	Yes	Large companies							
Financial resources											**50%**	**83%**
No	Data poorly resolved at neighbourhood scale	Higher	bb8	Yes	SME loans		✓	✓	✓		25%	42%
No	Data poorly resolved at neighbourhood scale	Lower	bb9	Yes	Gross value added per hour		✓	✓	✓		25%	42%
No	No data readily available	n/a	bb11	No	High Street vibrancy							
No	Data poorly resolved at neighbourhood scale	Unclear	bb10	Yes	Productive hours							
No	No data readily available	n/a	bd6	No	Productivity							
No	No data readily available	n/a	bd7	No	Liquidity							
No	No data readily available	n/a	bd8	No	Insurance (Business)							
Market access and supply flexibility												
No	No data readily available	n/a	bd2	No	Supply disruption (in-country)							
No	No data readily available	n/a	bd3	No	Supply disruption (international)							
No	No data readily available	n/a	bd5	No	Market access redundancy							
Other influences											**20%**	
Yes		Lower	be4	No	Adult skills					✓	7%	
No	Data poorly resolved at neighbourhood scale	Lower	bt7	No	Employment sector diversity					✓	7%	
No	Data poorly resolved at neighbourhood scale	Lower	bb12	No	Public sector employment					✓	7%	

Note: A direction of vulnerability is assigned to those indicators used to support the aggregated index.

5.1 Dimensions – Business vulnerability

The impact of a climate hazard on a business will vary according to its exposure to that event (as well as the exposure of its supply chain and customers), the vulnerability of the business (its operations, suppliers, and customer). Here the focus is on vulnerability, including its pre-event trading conditions, and its organisational capacity to have appropriately prepared for such an event as well as the ability to respond to, and recover from, such an event. To capture this the five dimensions of vulnerability set out earlier are revised below in the context of business vulnerability.

Note

The maturity of the assessment of business vulnerability continues to emerge. Although various consultancy tools and approaches exist, and some reviews of past events have been published, the approach set out here is to be regarded as an initial step.

Susceptibility

The susceptibility of businesses to harm reflects the likelihood that business operations would reduce or stop, and losses would be incurred, if the business (including its suppliers or customers) were to be exposed to a climate event. Flexibility is central to resilience in this context, and those businesses with limited flexibility are more likely to experience a negative outcome when exposed to a climate hazard than others. The flexibility (or lack thereof) may be associated with limited ***operational flexibility*** (*e.g.,* narrowness of the market, product, or service provided) or the demands of the ***workplace*** *(e.g.,* the fixed location or operational imperatives, for example, requiring *'outdoors workplace settings').* As climate events impact some but not others, it is reasonable to assume that businesses with flexibility in operational capacity across multiple (spatially diverse) sites are less likely to experience a negative outcome that those without. This flexibility enables operations to temporally reorganise if any single site is impacted by a climate hazard (such as a flood). Businesses operating from a single site, or from multiple sites with unique functions attributable to each (that in combination deliver the business service or product), are unlikely to experience this benefit, and consequently can be considered more vulnerable. Equally, some workplace activities are inherently weather dependent. Businesses that rely on outdoor workers, for example, are more likely to experience disruption due to climate events, such as heat waves and floods, than others. Equally, homeworkers may have more limited access to climate-controlled workspaces, and hence businesses that rely upon homeworkers may be more susceptible to disruption due to heat or flood events.

Ability to prepare

The ability to put in place measures to avoid future business impacts underpins the notion of a well-adapted business. Proactively preparing for future climate events however demands the ***organisational capacity*** and ***financial resources*** to do so. These capacities cut across operational and strategic business management domains, requiring a leadership and culture that encourages proactive preparedness and recovery planning, and operational procedures that embed resilience across the business activities. Financial resources enable businesses to invest in climate adaptation and resilience measures, such as upgrading infrastructure, diversifying supply chains, as well as implementing on-site adaptations and ensuring appropriate insurance cover.

Preparedness for climate events reflects many similar actions to those associated with business resilience more generally (including business continuity and crisis planning, to establishing data management plans that include offset backups and cloud-based provisions *etc.*). Some challenges posed by climate events however require special consideration. These may include, for example, understanding the range of climate risks that may impact on business operations (including on-site impacts as well as those faced by supply chains and customers), making provision for home working

options should access to the site be distributed by a climate event, as well as ensuring climate contingency plans are available and understood. A lack of preparation increases the likelihood that a climate event will have a negative impact on business operations.

Ability to respond

Market access and supply chain flexibility helps a business to offset any negative impacts during the events themselves (through flexibility of sales and supply chains). A business that accesses the market through a single pathway (either geographic or sectoral) is likely to experience significant impacts if that pathway is disrupted by a climate event. A business with a diversity of markets and multiple access pathways (in both geography and sector) are likely to be less vulnerable to climate events. Similarly, those relying upon unique suppliers, or supply chains with the potential to be exposed to the same climate events and risks, are also likely to be more vulnerable than those with diverse supply chains with limited shared climate risk. This may include local, regional, and international supply chains, with the potential for remote climate events to significantly impact business not directly exposed (van den Hurk *et al.,* 2023). Adequate ***financial resources*** are also important consideration in the immediate aftermath of an event. Having sufficient liquidity allows businesses to cover immediate expenses and maintain operations during disruption and seek alternatives to address property damage or supply chain disruption.

Ability to recover

The health of a company's balance sheet broadly reflects their commitment to debtors and creditors, and cash reserves. A business with a healthy balance sheet is more likely to have the ***financial resources*** to direct investment towards preparing for future events (see ability to prepare) but also to be able to survive a short-term downturn. A business exposed to a climate event is likely to experience significant demands on financial resources to address property damage, address supply chain disruptions, and cover increased insurance premiums.

Other contextual factors that influence business vulnerability

A range of other contextual factors are likely to be meaningful in determining impact of a climate event on business losses. These may include how much the business environment offsets or exacerbates the negative effects from extreme events. For example, relying upon local staff may suggest the workforce is experiencing the same event and unable to come to work. A diversity of skills may enable a business access to a flexible workforce and change their offering over time to respond to a climate event or change in respond to a longer-term climate trend.

Note

Our understanding of business vulnerability is evolving. The approach set out here is very much a first pass in the absence of an alternative. There has not been scope within this commission to understand supporting research but instead the framing is based on discussions with the CCRA4 team and experts within the CCC and CCRA4 drafting group. It is hoped this is provides a useful initial platform to be developed as an aide towards a well-adapted business sector.

5.2 Domains and indicators – Business vulnerability

Non-residential properties

For a neighbourhood to exhibit business vulnerability, businesses must be present in that neighbourhood. The presence of non-residential properties is used to provide an indication of concentration of commercial activities within a neighbourhood. Although not possible to provide absolute numbers (due to licence restrictions) a relative measure of non-residential properties is provided via a z-score assigned to each neighbourhood where possible. The data sources and processing used are presented in the following table:

- Non-residential properties (Appendix Table C-61)

Note

The number of residential properties does not influence the integrated vulnerability index. There is an argument that suggests it should be, but here it is assumed to be a measure of potential exposure, and hence not included in the vulnerability index.

Operational flexibility

There are few data sources available that credibly capture the operational flexibility of businesses across the UK. As a simple proxy, this could be captured through consideration of the number of sites a business operates from (referred to here as Multiple site business) or through a more detailed exploration of the business records and the operation accounts. This latter investigation has not been possible given the resource constraints of this study. Data for multiple site business could not be sourced for this study.

Workplace

The workplace environment can significantly influence a business's vulnerability to climate change (e.g., Cox *et al.,* 2022). This includes both those working conditions on-site, but also the wider workforce factors including health, access to sites, ability to work remotely; a challenge increasingly recognised (e*.g.,* Health Action Alliance, 2024). This is particularly the case if a business relies upon outdoor workers. Climate events such as heat waves and floods can disrupt operations and, in more extreme cases, pose significant health and safety risks. Outdoor workers are more likely to suffer heat-related illnesses, reducing worker productivity and increasing absenteeism. Outdoor work often involves activities that can be disrupted by climate-related events, affecting production. Climate events can also damage infrastructure that may be critical to outdoor work, such as roads, bridges, and equipment, leading to increased repair costs and operational delays. Implementing strategies to mitigate these risks relies on organisational capacity and financial resources to identify and invest in climate-resilient infrastructure, providing adequate training and protective equipment, as well as developing contingency plans.

Census data provides some insight to the prevalence of outdoor workers by neighbourhood and these data are used here.

- Outdoor workers (living within the area) (Appendix Table C-65)
- Outdoor workers (working in the area) (Appendix Table C-62)
- Share of outdoor workers in permanent activities (working in the area)[5] (Appendix Table C-63)
- Share of outdoor workers in transient activities (working in the area) (Appendix Table C-64)
- Home workers (Appendix Table C-66)

Organisational capacity

Organisational capacity to prepare for, and respond to, climate events is a vital component of organisation resilience (*e.g.,* BSI, 2017). These capacities can be significantly influenced by company size. Larger companies often have more financial and human resources to invest in climate adaptation measures, such as upgrading infrastructure, and developing resilience strategies as well as the expertise to develop and implement more comprehensive plans. With more resources and expertise, larger companies can invest in operational practices and innovations to mitigate climate risks, and develop partnerships with other organizations to share the risk. Larger companies typically have more robust risk management frameworks, which can help them identify, assess, and address climate-related risks more effectively, as well as greater influence over their supply chains, allowing

[5] This is not considered in the development of the NBVI as it is represented by with the number of outdoor works minus the share of outdoor workers in transient activities.

them to work with suppliers to reduce the risk. As regulation continues to develop (obliging corporations to assess and report climate risk through initiatives such as the Task Force on Climate-related Financial Disclosures, TCFD) preparedness should improve and vulnerabilities reduce. Previous work within CCRA3 reflects these inferences but suggests that while larger companies are increasingly aware of the risks and are taking steps to adapt, there is still a significant gap in preparedness among small and medium-sized enterprises (SMEs) (Surminski *et al.,* 2021). This distinction is reflected here (with small and medium companies assumed to be more vulnerable that larger companies), however it could be argued that small companies are more agile and better placed to adapt that larger corporations.

There is limited data which would enable a detailed understanding of organisational capacity to be developed at the national scale. A simple perspective is therefore adopted based on summary data of business size as follows.

- Micro companies (Appendix Table C-67)
- Small companies (Appendix Table C-68)
- Medium companies (Appendix Table C-69)
- Large companies (Appendix Table C-70)

Note

For these, data on micro and small companies are carried forward to the integrated index as a single combined variable. This enables those places with a higher number of companies that are micro companies or small companies to be reflected as higher vulnerability.

Financial resources

Financial resources provide the buffer and flexibility needed to navigate the uncertainties and challenges posed by climate events and to survive a climate shock. Sufficient liquidity allows businesses to cover immediate expenses and maintain operations during disruptions, whilst healthy financial resources enable businesses to invest in climate adaptation and resilience, and direct effort towards opportunities that may emerge through new market conditions.

Detailed data capture on the differential agility in financial resources of businesses across the UK is limited. For the purposes here, three data sets have been collated as follows:

- SME loans (Appendix Table C-71)
- Gross value added per hour (Appendix Table C-72)
- Productive hours (Appendix Table C-73)

Efforts have been made to collate comparable business scale data on *'productivity', 'High Street vibrancy'*, *'liquidity', and 'business insurance'* but this has not been possible given the constraints of the project.

Market access and supply flexibility

Market access and supply flexibility play a crucial role in influencing business vulnerability to climate shocks. Businesses with broader market access can diversify their customer base, reducing dependency on a single market and helping to limit the impact of the climate event. Companies with flexible supply chains also tend to have greater capacity to quickly adapt to disruptions caused by climate events. This includes sourcing materials from different suppliers or regions, adjusting transportation routes, and maintaining buffer stocks. Diversification in markets and supply chains can also promote a *'resilience dividend'* by enhancing financial stability and providing businesses with a secure platform for future growth.

The importance of better understanding the complex set of trading relationships within the UK and with the rest of the world, and the influence of climate change (here and aboard) on supply chains is increasingly recognised (*e.g.,* Climate Change Committee, 2022). The potential for cascading and

interacting risks, as impacts 'knock-on' from one business to the next, through such networks and into the economy more broadly is also an increasingly recognised risk. However, there are limited datasets that provide insight into the relative market access and supply flexibility that different business exhibit. Consequently, within the resources of this project, no data sets have been collated despite efforts to source information on *'Supply disruption (in-nation)',* '*Supply disruption (international)'*, and *'Market access redundancy'.*

Other influences

Various contextual factors will act to influence business vulnerability. Despite a lack of detailed literature on these issues, three factors are used here to provide some insight into the relative businesses in one area compared to another, namely:

- *Adult skills:* A workforce with strong adult skills, including technical and soft skills, is better equipped to adapt to new challenges posed by climate change. Continuous learning and upskilling can help employees innovate and support their organisation in implementing effective climate adaptation strategies.
- *Employment sector diversity:* From a national economic perspective, diverse employment sectors can reduce vulnerability to climate events by spreading risk across different industries. At the scale of a single business (the focus here) diversity in the employment market can help support businesses to access the skills needed to adapt.
- *Public sector employment:* Public sector employers tend to have greater resources to limit the impact of climate event and support employees. The business vulnerability within an area (the focus here) is therefore assumed to be lower in those areas where public sector employment is higher. This reflects the financial and organisational resources associated with public sector activities which may or may not the available within the private sector. Evidence, however, is limited.

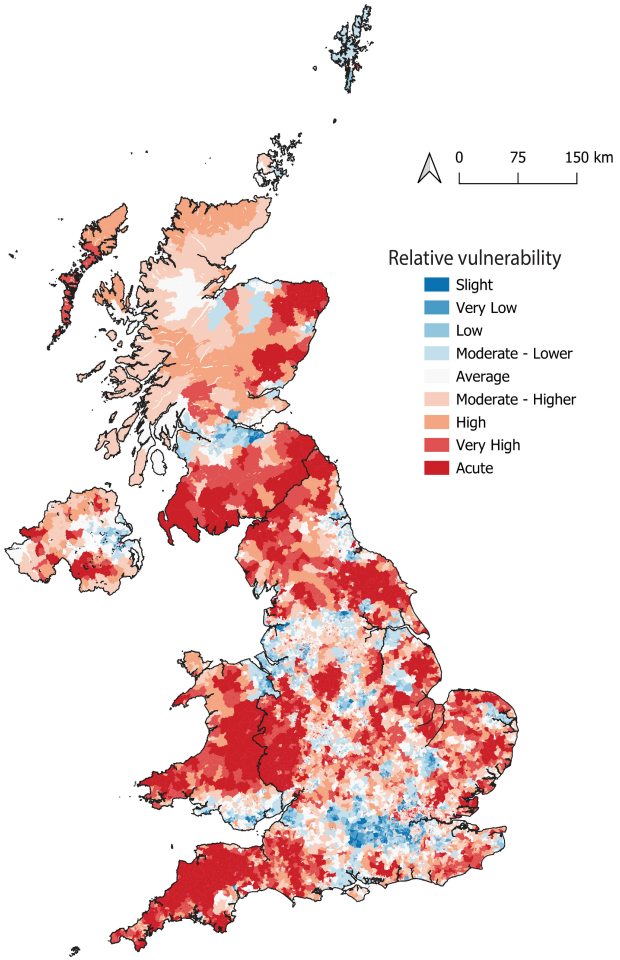
Data has been collated on each of these factors as detailed in the following tables:

- Adult skills (Appendix Table C-74)
- Employment sector diversity (Appendix Table C-75)
- Public sector employment (Appendix Table C-76)

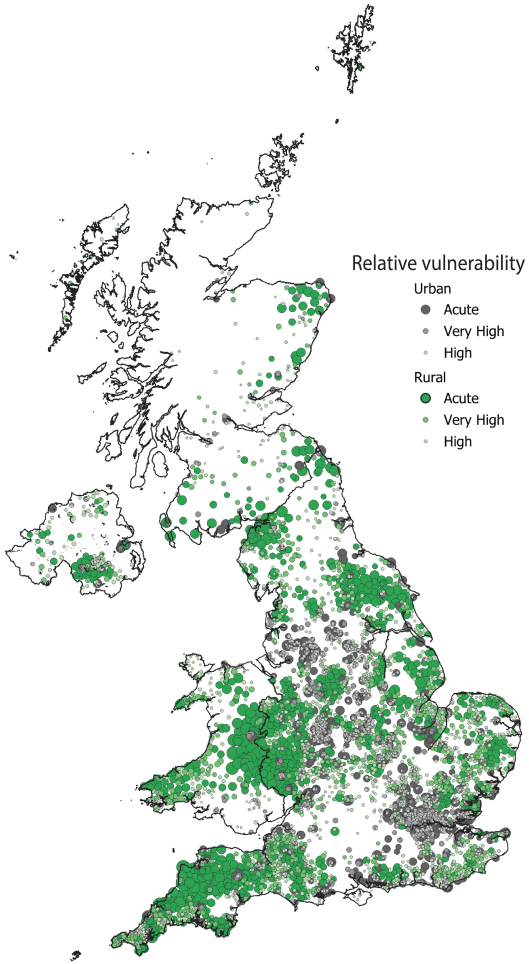
5.3 Aggregated index - Neighbourhood Business Vulnerability Index (NBVI)

A sub-set of the indicators gathered (as set out in previous section) are used to develop a single aggregated business vulnerability index: **Neighbourhood Business Vulnerability Index** (NBVI-CCRA4). The indicators used to support of this index have been selected based on the (limited) underlying research that supports its inclusion, discussion with the CCC team, and the experience of the project team gained since their initial development. As with the NFVI and NHVI, the business index has been developed at national-scale and UK-scale.

The national-scale analysis uses all available indicators considered relevant to the Index (as highlighted in Table 5-1). The spatial distributions of the NBVI based on the national-scale analysis is illustrated in Figure 5-1. Rural neighbourhoods appear highly vulnerable to business disruption. This is a function of the mapping structure (neighbourhoods are larger in rural areas) but also likely to be driven by the presence of *'outdoor workers'*. Incorporating a wider range of business indicators (if, and when, data becomes available) may change this pattern. The UK-scale assessment uses only those indicators consistently represented (in broad terms) in each nation (see Table 5-1). This restricts the number of indicators used. The spatial pattern of relative vulnerability changes when neighbourhoods are compared across the UK rather than within each nation (Figure 5-2). In many cases the change in category is limited (remaining the same or changing by one category). There are however many neighbourhoods where the assigned category of vulnerability varies significantly between the UK-scale and national-scale vulnerability assessment.

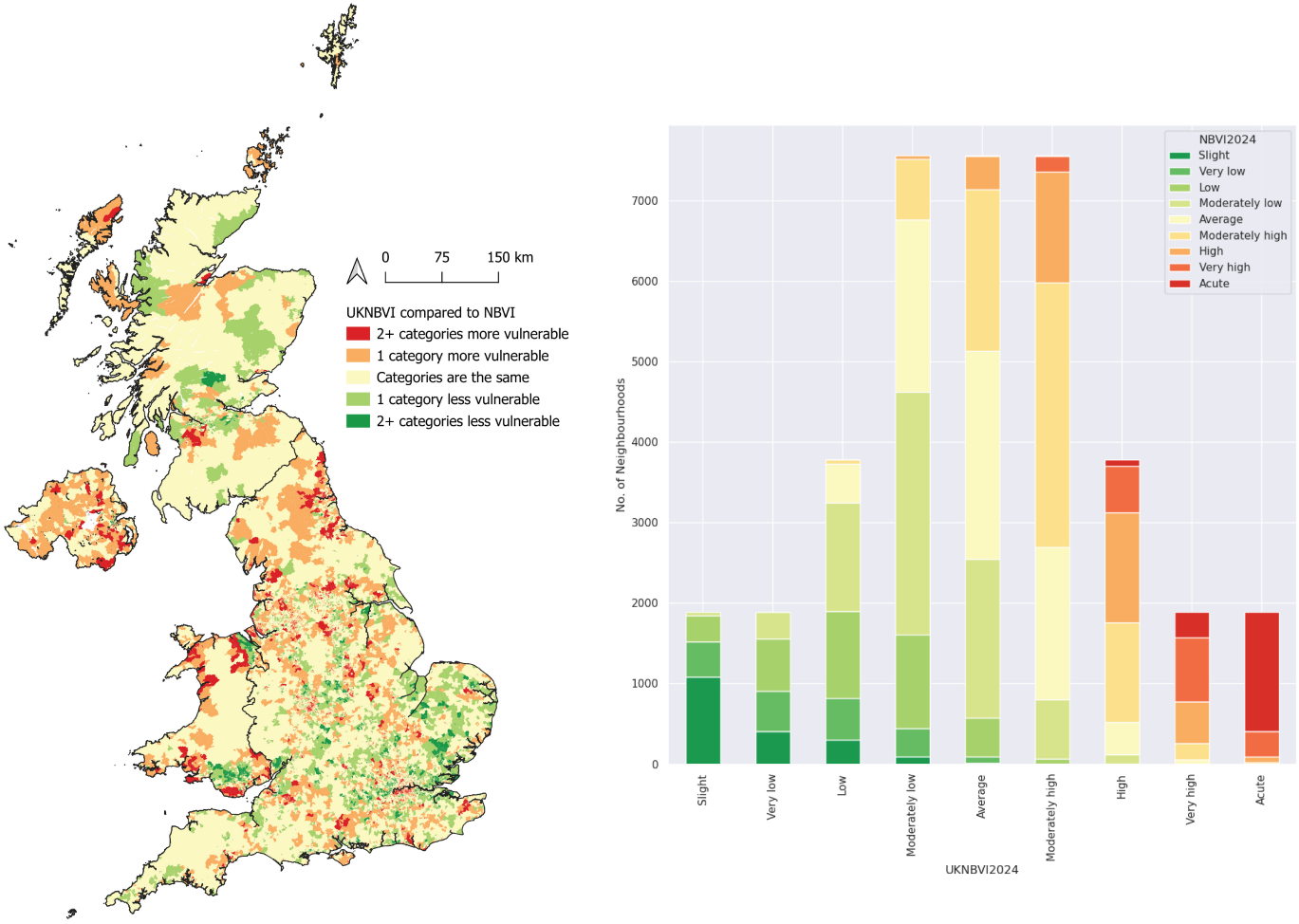


Left: *The relative social vulnerability of each neighbourhood by category*



Right: *The 20% most business vulnerable neighbourhoods. Coloured coded by rural (green) and urban (grey) neighbourhoods. The dark to light shading indicates the 5%, 10% and 20% most vulnerability neighbourhoods. The size of the dot reflects the absolute z-score (larger more vulnerable).*

Figure 5-1 NBVI (Business) – Spatial variation based on national-scale analysis



Left: *Spatial view of the difference in vulnerability category between the UK-scale and national-scale index.* ***Right:*** *Distribution view of the variation. X-axis represented the category assigned through country-scale analysis and y-axis the national-scale*

Figure 5-2 NBVI (Business) – Spatial variation based on UK-scale analysis

6.0 DISCUSSION AND RECOMMENDATIONS

This report collates a set of indicators and presents three integrated indices of vulnerability to support an understanding of this variation in a tractable and accessible way. The individual indicators are provided at a neighbourhood scale (defined by Lower layer Super Output Areas in England and Wales, Intermediate Zone Boundaries in Scotland, and Super Data Zones in Northern Ireland) as well as three indices that provide a relative measure of vulnerability:

- **Neighbourhood Flood Vulnerability Index** (NFVI-CCRA4, an evolution of Sayers *et al.,* 2017)
- **Neighbourhood (high temperature) Heat Vulnerability Index** (NHVI-CCRA4, an evolution of Sayers *et al.,* 2023)
- **Neighbourhood Business Vulnerability Index** (NBVI-CCRA4, developed here)

The results provide some important insights and suggestions for further development as outlined below.

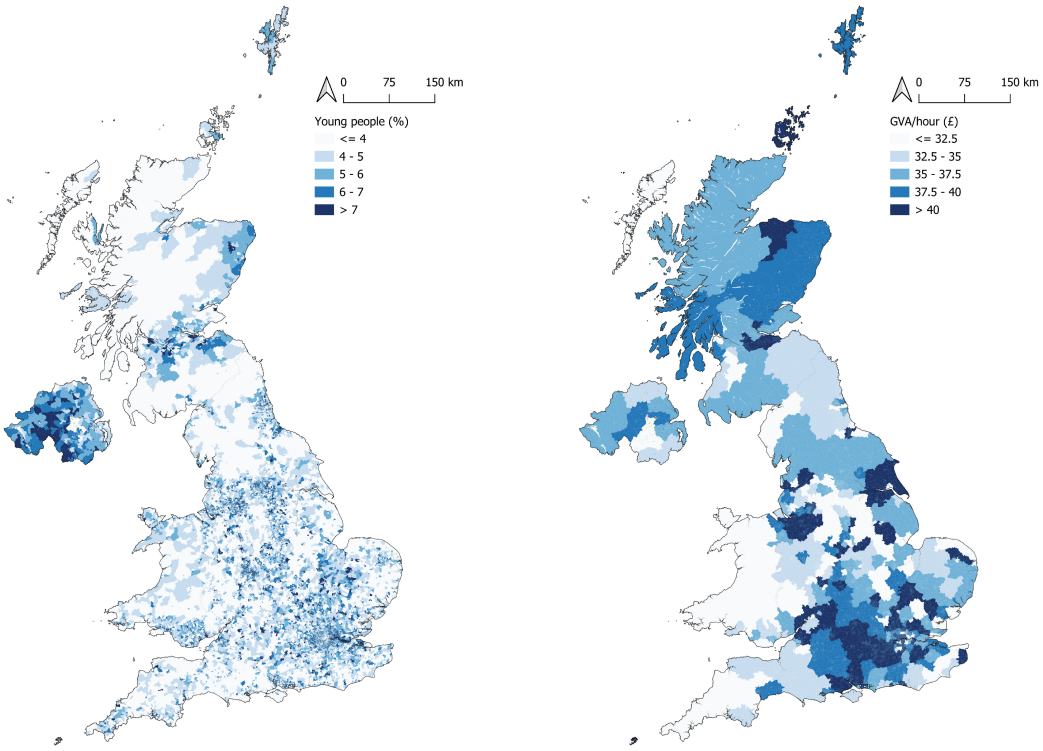
Note:

Links to download these indices and the individual indicators are provided in Appendix D.

6.1 Vulnerability exhibits significant heterogeneity

Significant spatial variation in both social and business vulnerability is evident across the UK as well as within England and each Devolved Administration (Wales, Scotland, and Northern Ireland).

This variation is evident in the individual indicators (as illustrated for *'Young People'* and *'Gross Value Added per hour'* in Figure 6-1). It is also evident in the distribution of each aggregated index, with a z-score for NFVI, NHVI, and NBVI all ranging from ~-4 to +4 (Figure 6-2). The largest skewness is present in the more exploratory business index. This is likely to reflect the greater sparsity and heterogeneity of the underlying indicators.



***Left**: Young people (%) available at a neighbourhood scale. **Right**: Gross Value Added (GVA) per hour (£), readily available at higher levels of aggregation only*

Figure 6-1 Summary distribution Young People and GVA/hour

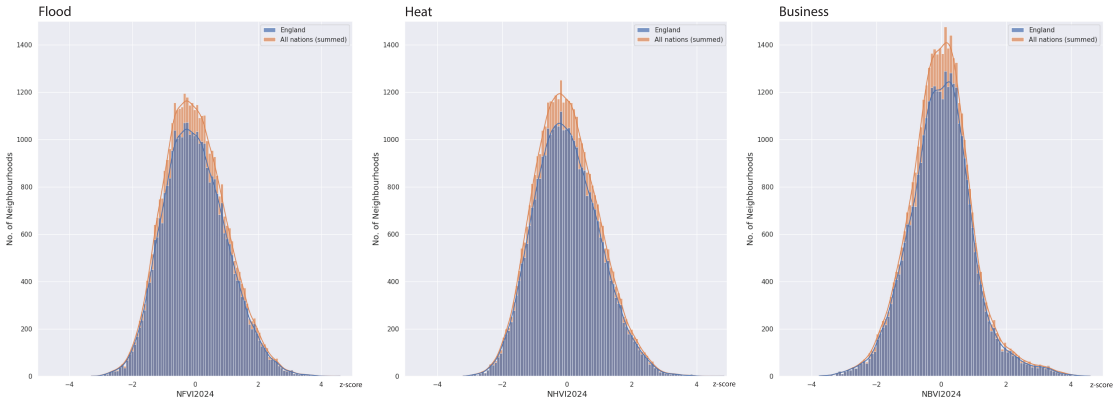
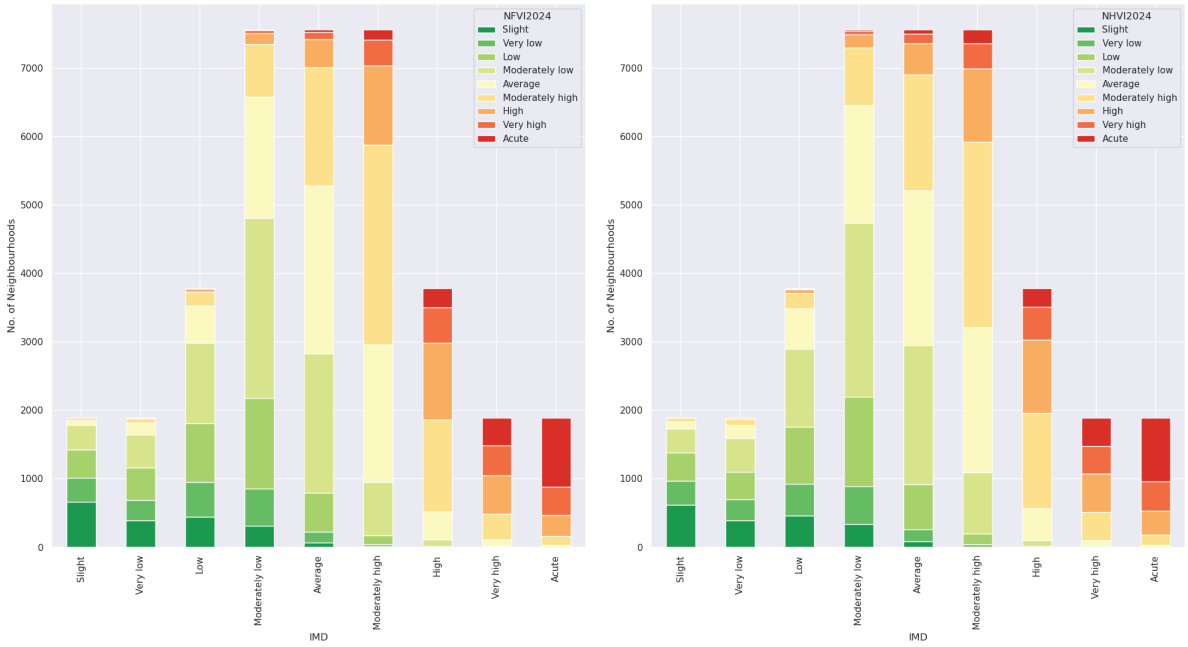


Figure 6-2 Summary distribution of the Flood, Heat, and Business indices

6.2 Understanding climate vulnerability is not the same as understanding deprivation

Many of the indicators of social vulnerability are shared by the indices of deprivation. There are however important differences. The Defra administered Flood Defence Grant in Aid (FDGiA) and other Treasury based investment process aim to provide and account for an equitable distribution of benefits but rely on an understanding of a location's relative deprivation (using the Indices of Multiple Deprivation, IMD) to direct investment. This approach is not tailored to the nuances of climate vulnerability. While some of these indicators presented in the NFVI and NHVI overlap with components of the IMD, the NFVI and the NHVI offer a purpose-built, evidence-based metric that directly quantify flood and heat vulnerability. This distinction is critical because climate vulnerability, and its persistence, is shaped by factors that the IMD does not fully quantify. For example, a lack of private transport, common in many flood-vulnerable households, impairs evacuation and recovery capabilities during or after flood events. Indicative research in the Humber region, encompassing Hull, the East Riding of Yorkshire, North Lincolnshire and Northeast Lincolnshire, underscores the persistence of flood vulnerability. Analysis using the NFVI over four consecutive epochs, 1991, 2001, 2011 and 2021, revealed that flood vulnerability remains geographically and socially static over time, with approximately 75% of the most flood-vulnerable neighbourhoods retaining their status between 2001 and 2021 (Ellmore, 2023). An extension to this study is ongoing to examine the persistence of flood vulnerability across England (Thomas *et al.,* in prep).

Vulnerability tends to link closely to issues of deprivation, but is not interchangeable. Low incomes affect the ability of people to purchase insurance to protect themselves from losses associated with flooding or adapt their homes. In some communities with elevated levels of transience and population change there may also be less local knowledge about the extent of flood problems. These differences lead to spatial differences in those locations considered most vulnerable. To illustrate these differences, the NFVI and NHVI are compared to the Index of Multiple Deprivation (based on assuming the ranking within the IMD is normally distributed and applying the same categorisation as used in the vulnerability index) in Figure 6-3.



Left: Flood: *Vulnerability categories of the NFVI-CCRA4 compared to the IMD*

Right: Heat: *Vulnerability categories of the NHVI-CCRA4 compared to the IMD*

Figure 6-3 Comparison of social vulnerability indices and the Indices of Multiple Deprivation in England

6.3 Recommendations for improvement

Practical steps in data consistency and access

- **Consistency of Census questions:** the Census questions across the UK appear to be unnecessarily variable. Greater consistency would significantly improve the ability for UK wide analysis.
- **Access to licenced data:** Various indicators cannot be shared directly due to licence constraints. This may be an area for future consideration, including, for example, providing open access to the data at aggregated scales.
- **Access to research outputs**: Some research data has been easy to access but others have involved a protracted exchange that has led to the data not being made available in time. Improved sharing arrangements for publicly funded data would aid future updates of the indices presented here.

Further research in vulnerability

- **Evolution through local level validation:** Validation at a local level to support the national scale analysis and associated findings presented here would help develop a more nuanced understanding of local characteristics and contexts that drive vulnerability.
- **Further longitudinal studies to explore the persistence of acute vulnerability:** Significant additional insight into issues of social and business vulnerability can be gained by adopting a longitudinal history and future projection perspective. Recent developments in this area have given important insights into issues of persistence (Thomas *et al.,* in press). These approaches could be broadened and projected forward using tools such as the Future Explorer suite and the methods and indices presented here.
- **Further development of the business index**: The approach presented here is very much a first step. Building upon this foundation provides an opportunity to make a step change in our understanding, and ability to assess, business vulnerability.

Further analysis of systemic disadvantage and fair investment

- **Significant insights not necessarily captured:** This project has focused on collating data. Through that process significant insights have been gained into what drives vulnerability that is not embedded within the data itself. Opportunities exist to explore the data to tease out the most important drivers in the most vulnerable neighbourhoods.
- **Explore systemic disadvantage:** The data gathered here presents the geographic vulnerability, but this is only part of the story. Understanding, and acting upon, systemic disadvantage is a central issue hindering progress to a well-adapted UK (Sayers *et al.,* 2017). This is being explored through the on-going analysis by SPL for the Environment Agency in England.

Provide easy access to explore and download the data

Various tools exist to host data in an accessible way. The Climate Just website has provided a home to the NFVI for several years and is the obvious long-term repository. In the short-term access and exploration of the CCRA4 could be facilitated through a simplified bespoke platform. Beyond CCRA4 this could provide a long-term archive store as well as easy the transition to a platform such as Climate Just.

7.0 REFERENCES

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APPENDICES

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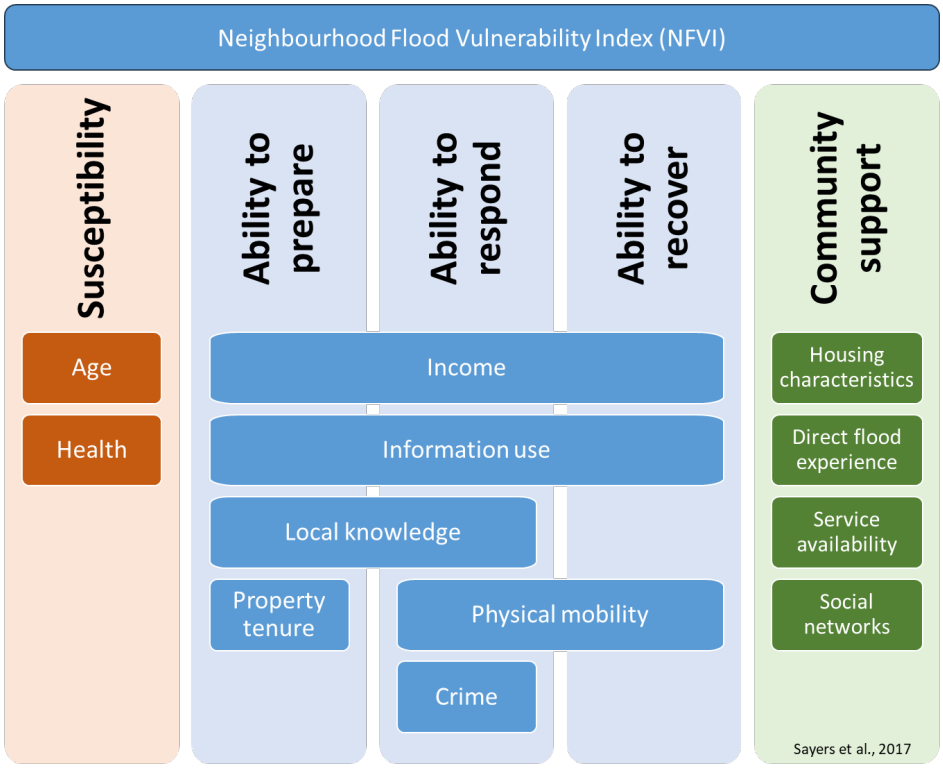
APPENDIX A. Approach to developing the aggregated indices: Example of the NFVI

A unique social vulnerability index has been derived for heat and flood hazards as well as a more general climate related business index:

- Neighbourhood Flood Vulnerability Index (NFVI)
- Neighbourhood Heat Vulnerability Index (NHVI)
- Neighbourhood Business Vulnerability Index (NBVI)

To calculate each index the associated indicators of social vulnerability are combined using a statistical process. This process is illustrated for the NFVI below (Appendix Figure A-1). Each other index follows a similar process of calculation. In all cases data are standardised and allocated no weights, *i.e.,* where there are multiple factors contributing to a particular vulnerability dimension, they are all given equal importance in the calculations.



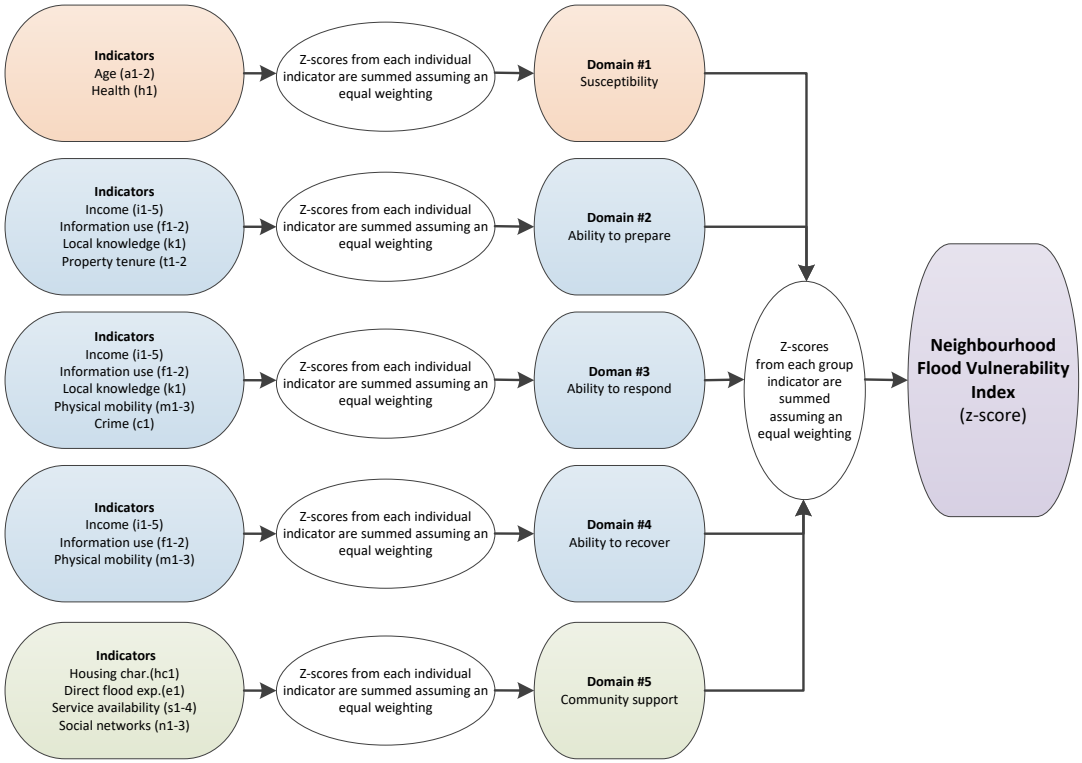
Appendix Figure A-1 A summary structure aggregating various domains in the NFVI (Sayers et al, 2017)

Note

The rationale for the inclusion of each dimension, domain, and indicator has been introduced in Chapter 4 and is not repeated here.

A.1 Approach to calculating the Neighbourhood Flood Vulnerability Index (NFVI)

The Neighbourhood Flood Vulnerability Index (NFVI) is determined through a three-stage process as outlined in Appendix Figure A-2 and described below.



Appendix Figure A-2 The process used to calculate the NFVI (Sayers et al, 2017)

A.2 Stage 1: Determine the z-score for individual Indicators

Each raw data collated for each indicator (*'young people' etc.*) is normalised to a z-score. The z-score is derived by subtracting the mean value and dividing by the standard deviation (see note below). If an indicator is already in the form of a rank (*e.g.,* as is the Index of Multiple Deprivation, IMD), the equivalent z-score is determined by assuming the rank is drawn from a normal distribution and calculating the number of standard deviations from the mean associated with that rank. This is done so that each indicator has the same numerical parameters, rather than its original numbers (which might be a %, a number, a rank, a fraction, etc.), and to enable them to be compared and combined on the *'same playing field'.*

Note

A z-score, also known as a standard score, relates the value of a given indicator within one neighbourhood to the mean value across all neighbourhoods. In doing so, the z-score enables the relative differences to be determined and is calculated as follows:

$$z = \frac{(X - \mu)}{\sigma}$$

Where:

- X is the value of the indicator within given neighbourhood.
- μ is the mean of value of the indicator across all neighbourhoods within the dataset.
- σ is the standard deviation of the indicator across all neighbourhoods within the dataset.

A z-score of:

- 0 means the value within a neighbourhood is exactly at the mean of all neighbourhoods.
- A positive z-score indicates the value is above the mean.
- A negative z-score indicates the value is below the mean.

In some instance the input data associated with a particular indicator is highly skewed or in complete in its cover across all neighbourhoods. The assumption of a normal distribution breaks down in these cases. To avoid an undue influence on the derivation of the index a cap is applied to the derived z-score for each indicator.

Note

The z-scores derived for each indicator have been capped as follows:

For **social data** (that is used to support the NFVI and NHVI set out in Chapter 4) a constraint of 4 times the standard deviation is applied.

For **business data** (that is used to support the NBVI set out in Chapter 5) a constraint of 3 times the standard deviation is applied. This reflects two related aspects. The first recognises that the census neighbourhoods include a similar number of people (at least in any one nation) but they are not constructed to reflect coherent 'businesses' units. The second recognises the highly skewed nature of the much of the business data (such as the SME loans) and strong spatial heterogeneity within much of the business data.

A.3 Stage 2: Determine the z-score for each Domain

Z-scores for the individual indicators that contribute to each domain (*'Age'*, *'Health'* etc) are combined based upon the assumption of equal weighting. The influence of the indicator reflects the direction of the relationship with vulnerability. In most cases an increase in the value of the underlying indicator (% or *young people*) acts to increase vulnerability. In some instances, the opposite can be true. For example, *'direct flood experience'* (e1) acts to reduce the relative vulnerability of one neighbourhood compared to another. This direction is given in the tables set out in Chapters 4 and 5.

The resulting values for each domain are then themselves transformed into a z score. In the case of the nation scale indices this is done at the scale of the nation. In the case of the UK scale index this is done at the scale of the UK.

A.4 Stage 3: Determine the z-score for each Dimension

Z-scores for the *domains* that contribute to each *dimension* (Susceptibility, Ability to Prepare, Respond and Recover, and Community Support) are combined based upon the assumption of equal weighting. The resulting values for each dimension are then themselves transformed into a z score. In the case of the nation scale indices this is done at the scale of the nation. In the case of the UK scale index this is done at the scale of the UK.

A.5 Stage 4: Determine the Index (e.g. NFVI)

For each neighbourhood, the z-scores derived for each dimension are summed with equal weighting. The final z-score is calculated based on these results and used as the NFVI. In the case of the nation scale indices this is done at the scale of the nation. In the case of the UK scale index this is done at the scale of the UK.

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APPENDIX B. Caveats and important notes

B.1 Local credibility

Various sources of data are used. Many have been collected at different times, by different organisations, and at different spatial scales. Although the data is presented here at the scale of the neighbourhood, not all data is credible at that scale. Equally, although all data is presented as representative of 2025 this may not be the case due to the variations in the collection period and the changes that may have occurred since collection.

B.2 Neighbourhood not individual vulnerability

For any individual, the relationship between climate related hazards (such as flooding and high temperatures), their physical and mental health, and the community surroundings is extremely complex. It is widely documented, for example, that heat can have a negative impact on health, with the very young, the elderly and those with pre-existing health conditions being particularly vulnerable. However, the impact can also be affected by multiple other factors – such as obesity, alcohol consumption, and genetics – the support networks available to that person, and particularly construction and conditions within their home. At an individual level neither these data or the way these factors (and others) is understood. Consequently, it is not possible to say with any certainty the impact a climate hazard may have on a specific individual. The data presented is best used when trends and insights are aggregated across multiple neighbourhoods to regional scales.

B.3 Influence of the COVID pandemic

The assessment presented here relies heavily on data from the 2021 Census. The COVID pandemic had a significant but unknown influence on employment, health, *etc.* during the period of the Census update. The degree to which data collected during this period is representative of today (or were unique to this period) is difficult to determine. Nonetheless, it is assumed that the Census 2021 data is relevant for today without modification.

B.4 Future change in socio-economic setting

No attempt is made to incorporate patterns of population growth or project changes to the underlying social characteristics that may influence the relative vulnerability between neighbourhoods.

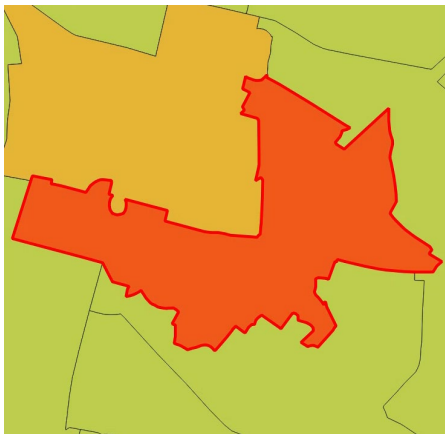
B.5 Linking between 2011 and 2021 Census boundaries

Not all-required data is available within the 2021 Census. In some instances, data from Census 2011 remains the latest insight. Unfortunately, the census geographies in 2011 and 2021 are markedly different due to local government reorganisation, population movement and other factors (a common issue recognised by Norman, 2006). For example, between 2011 and 2021, the number of LSOAs in England and Wales increased from 32,844 and 1,909 to 33,755 and 1,917 (ONS, 2022a; 2022b), the number of Data Zones and Intermediate Zones in Scotland increased from 6,796 and 1,279 to 7,385 and 1,328 (Scottish Government, 2024) and Northern Ireland retained the same number of 850 spatial units but the census geography was completely rederived (NISRA, 2023).

ONS provide a cross reference between 2011 and 2021 census area based on a point to polygon best fit process.[6] Given the complex shapes of many neighbourhoods however centroid points often lie

[6] LSOA (2011) to LSOA (2021) to Local Authority District (2022) Best Fit Lookup for EW (V2)

outside the boundary of the Census area (Appendix Figure B-1). To correct for this, a bespoke lookup is used based on maximum intersection area so that every 2021-census area links to the 2011-census area with the largest area within it. Although preferred to the ONS approach this remains a simplification (but reasonable for the context of the study here). The approach to assigning the indicator value after spatial reconciliation necessarily varies depending upon the type of indicator. In the case of indicators given as a percentage or native values, the 2011 value is used directly. In the case of ranks, the rank from the 2011-Census is assigned to Census-2021 and the full set of 2021 ranks reranked accordingly. In the case that two 2021-Census areas correspond to the same 2011-Census area they are given equal ranking.



The centroid of an LSOA often lies outside of the LSOA boundary. The centroid of LSOA-2011 E01003004 (red) lies outside its geometry and therefore would be linked to LSOA-2021 E01003002 (yellow) using a 'point to polygon' approach. A modified lookup is therefore used here based on maximum intersection area so that every 2021-LSOA links to the 2011-LSOA with the largest area within it. This method is repeated for each translatory lookup (e.g., MSOA-2011 to MSOA-2021 etc.).

Appendix Figure B-1 Reconciling 2011 and 2021 census boundaries

Note

Norman *et al.* (2024 and references therein) outlined a method by which the Office for National Statistics Postcode Directory (previously the All-Fields Postcode Directory) can be used to redistribute raw census data between epochs. The number of addresses within 'source' polygons and in the intersections of the 'source' (in this case LSOAs for 2011) and 'target' (LSOAs for 2021) polygons are estimated using the number of residential addresses in each postcode together with ArcGIS Pro's spatial join command and a point-in-polygon approach (Norman and Riva, 2012). The value from the 'source' is then allocated to 'targets' using the ratio of the addresses within the intersection and the total number of addresses in the 'source' polygon. Norman and Riva (2012) and Norman *et al.* (2024) provide examples of value allocation in this manner. However, the application of this approach is restricted to raw values, not rates, percentages, or other derived data such as deprivation index scores (Norman, 2006) and thus it is not applicable to ranks or z-scores. As a result, values were redistributed using areal weighting, assuming that underlying indicators are uniformly distributed within each 'source' spatial unit. For further developments this type of method could be considered to provide a more robust translation between census geographies.

B.6 Using data available at different spatial scales

In most cases Census data at the neighbourhood scale is used. This is not possible for all data. Various datasets are only available at larger Census scales or at regional scales, such as Local Authority, or even national scales. Where this is the case, the data is downscaled so that each 'neighbourhood' is consistent with the data from the more aggregated scale. In some instances, data from smaller Census areas has been used. In this case the data has been aggregated appropriately to the neighbourhood scale.

B.7 Assigning a distribution to ranked data

Many data inputs are provided as 'ranked' data. Where this is the case, ranked values have been converted to z-score by assuming the native data underlying the ranks are normally distributed within a default standard deviation of 1.

B.8 Using data provided as a z-score

Where possible, data has been collated in its native form. Some input data however is only readily available as a z-score. Where this is the case, it is assumed this has been calculated correctly at the stated spatial scale and is used directly here.

B.9 National and UK wide indices given comparable data across the UK is not always available

The data available varies across the UK. Some data is similar, but not the same (*e.g.,* often the Census questions are similar but vary in subtle ways) and in some case only applicable to a given nation (*e.g.,* ranks given within the IMD for England cannot be compared to ranks given in Scotland). This does not impact accuracy of data associated with an individual indicator but does impact the way it is used in developing the aggregated indices. To overcome this issue, the aggregated indices are developed at both a national-scale (in this case differences between countries can be ignored) and at a UK-scale using a sub-set of data that can be considered comparable. When an indicator is not available in given country it is assumed to be invariant. The national-scale assessment provides a more robust insight into the relative distribution of vulnerability within England, Scotland, Wales, or Northern Ireland (as it uses all available data), but does not enable UK wide comparison. The UK-scale indices therefore provide a useful lens, but care is needed in their use.

Note

The datasets used for each index at both the nation and the UK scale are detailed later in Chapters 4 and 5 together with a comparison to between the national-scale and UK-scale indices to help guide their appropriate use.

B.10 Validation, accuracy, and fitness for purpose

The input data sources used are set out in Appendix C. The accuracy of these data has not been checked (such as Census or other data). The process of extracting the indicators and developing the indices developed here has been independently reviewed to provide reassurance that the data chain is reasonable and uses the input data faithfully. These checks have been completed progressively by the core project team and the CCC and by a reviewer. Given the time and resource constraints of the project the validation process has been completed as a series of spot checks to confirm:

- The data sources recorded as those used
- The processing undertaken is as described
- The values of the raw data appear reasonable
- The distribution of the z-scores appear reasonable, including ensuring the mean values are zero (or very close) and the maximum and minimum values are reasonable given the underlying data inputs
- No effort has been made to validate the underlying data inputs (such as the data gather through the Census process).

This process of validation is consistent with the scale of the project and is not an exhaustive process. Care is still needed by the user to check that data is fit for purpose.

Note

Sayers and Partners do not accept any liability for inaccuracies. It is for the user to satisfy themselves the data provided here is 'fit for their purpose.'

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APPENDIX C. Indicator: Data sources, rationale, and processing metadata

Appendix Table C-1 Spatial units

Grouping	**Basics**								
Domain	**Basics**								
Indicator and ID	**bas1 - Spatial units**								
	Does this indicator contribute to an aggregated index?		**No**	**Business**		**Flood**		**Heat**	
Processing	England and Wales: Links indicators to appropriate LA (2019), MSOAs (2019 and 2011), LSOAs (2019 and 2011) Scotland: Intermediate Zones Boundaries remain in development, the 2011 IZBs are used as the spatial boundary Northern Ireland: Super Data Zones used from 2021 census								
Data used and resolution	**Source**	**Description**	**Scale**	**Owner**	**Download available**	**In data pack (raw)?**	**Units**	**Confidence**	**Date**
England	Census	BFC Full resolution - clipped to the coastline (Mean High Water mark)	LSOA	ONS	Yes	Yes	ID	High	2021
Wales	Census	BFC Full resolution - clipped to the coastline (Mean High Water mark)	LSOA	ONS	Yes	Yes	ID	High	2021
Scotland	Census	Intermediate Zone Boundaries	IZB	Scottish Government	Yes	No	N/A	Moderate	2011
Northern Ireland	Census	Super Data Zone	SDZ	NISRA	Yes	No	N/A	High	2021
Rationale	Enables the indicators to be linked to their location. The spatial data associated with the various neighbourhood definitions used, along with the field name used to link to neighbourhood code, can be found here. England and Wales: Lower Super Output Areas 2021 https://geoportal.statistics.gov.uk/datasets/2bbaef5230694f3abae4f9145a3a9800_0/explore fieldname: LSOA21CD Scotland: Intermediate Zones 2011 https://www.data.gov.uk/dataset/133d4983-c57d-4ded-bc59-390c962ea280/intermediate-zone-boundaries-2011 fieldname: InterZone Northern Ireland: Super Data Zones 2021 https://www.nisra.gov.uk/publications/super-data-zone-boundaries-gis-format field name: SDZ2021_cd								
Residual notes	Agreed with the CCC to focus on LSOA (in England and Wales), SDZ (NI), and IZBs (Scotland).								

Appendix Table C-2 Rural or urban setting

Grouping	**Basics**								
Domain	**Basics**								
Indicator and ID	**bas3 - Rural or urban setting**								
	Does this indicator contribute to an aggregated index?	**No**	**Business**		**Flood**		**Heat**		
Processing	England and Wales: Rural or Urban class taken from data processed by Sayers et al, 2017 Scotland: Rural or Urban class taken from data processed by Sayers et al, 2017 across the UK, aggregated to IZ using most common classification Northern Ireland: Rural or Urban class taken from data processed by Sayers et al, 2017 across the UK, aggregated to IZ using most common classification								
Data used and resolution	**Source**	**Description**	**Scale**	**Owner**	**Download available**	**In data pack (raw)?**	**Units**	**Confidence**	**Date**
England	CCRA2/SPL	Rural-urban classifications	LSOA	SPL	No	Yes	Class	Moderate	2011
Wales	CCRA2/SPL	Rural-urban classifications	LSOA	SPL	No	No	Class	High	2011
Scotland	CCRA2/SPL	Rural-urban classifications	-	SPL	No	No	Class	Moderate	2011
Northern Ireland	CCRA2/SPL	Rural-urban classifications	-	SPL	No	No	Class	Moderate	2011
Rationale	Useful for comparing vulnerabilities across urban and rural settings. Given on-going process of updates to the rural-urban criteria across the UK, a binary value of rural or urban is provided based on existing datasets.								
Residual notes	ONS is in the process of updating the rural-urban classifications but at the time of drafting these have not yet delivered. Similar updates are planned for Scotland. It has been agreed with the CCC to move ahead using the data processed by Sayers during the JRF analysis (Sayers et al., 2017) and used in CCRA2/3. Given the variation in rural-urban classes across the UK these classes as simplified here to be either 'rural' or 'urban'. This could be readily updated once updated classes are published by ONS and others.								

Appendix Table C-3 No. of people

Grouping	**Basics**								
Domain	**Basics**								
Indicator and ID	**bas4 - No. of people**								
	Does this indicator contribute to an aggregated index?	**No**	**Business**		**Flood**		**Heat**		
Processing	England and Wales: Sum of 'All usual residents' Scotland: Sum of 'All usual residents' Northern Ireland: Sum of residents by age								
Data used and resolution	**Source**	**Description**	**Scale**	**Owner**	**Download available**	**In data pack (raw)?**	**Units**	**Confidence**	**Date**
England	Census	TS007a	LSOA	ONS	Yes	Yes	No.	High	2021
Wales	Census	TS007a	LSOA	ONS	Yes	Yes	No.	High	2021
Scotland	Census	UV103 - Age by single year	OA	Scottish Government	Yes	No	No.	High	2022
Northern Ireland	Census	NISRA Age - 19 Categories	SDZ	NISRA	Yes	No	No.	High	2021
Rationale	Basic descriptor								
Residual notes	-								

Appendix Table C-4 Sex – Male

Grouping	**Population**								
Domain	**Sex**								
Indicator and ID	**sx1 - Male**								
	Does this indicator contribute to an aggregated index?		**No**	**Business**		**Flood**		**Heat**	
Processing	Number of 'males' divided by the total population, multiplied by 100.								
Data used and resolution	**Source**	**Description**	**Scale**	**Owner**	**Download available**	**In data pack (raw)?**	**Units**	**Confidence**	**Date**
England	Census	TS008	LSOA	ONS	Yes	Yes	%	High	2021
Wales	Census	TS008	LSOA	ONS	Yes	Yes	%	High	2021
Scotland	Census	UV101b - Usual resident population by sex by age (6)	OA	Scottish Government	Yes	No	%	high	2022
Northern Ireland	Census	NISRA Sex	SDZ	NISRA	Yes	No	%	High	2021
Rationale	Typically, there are small differences between male and female proportions within the population and climate hazards tend to impact each similarly. Gender differences may be reflected in activities – type and location of work and within the home.								
Residual notes	Included for information only - unlikely to be a signifcant (differential) spatial indicator								

Appendix Table C-5 Sex – Female

Grouping	**Population**								
Domain	**Sex**								
Indicator and ID	**sx2 - Female**								
	Does this indicator contribute to an aggregated index?	**No**	**Business**		**Flood**		**Heat**		
Processing	Number of 'females' divided by the total population, multiplied by 100.								
Data used and resolution	**Source**	**Description**	**Scale**	**Owner**	**Download available**	**In data pack (raw)?**	**Units**	**Confidence**	**Date**
England	Census	TS008	LSOA	ONS	Yes	Yes	%	High	2021
Wales	Census	TS008	LSOA	ONS	Yes	Yes	%	High	2021
Scotland	Census	UV101b - Usual resident population by sex by age (6)	OA	Scottish Government	Yes	No	%	high	2022
Northern Ireland	Census	NISRA Sex	SDZ	NISRA	Yes	No	%	High	2021
Rationale	Typically, there are small differences between male and female proportions within the population and climate hazards tend to impact each similarly. Gender differences may be reflected in activities – type and location of work and within the home.								
Residual notes	Included for information only - unlikely to be a signifcant (differential) spatial indicator								

Appendix Table C-6 Sex – Gender assigned

Grouping	**Population**								
Domain	**Sex**								
Indicator and ID	**sx3 - Gender assigned**								
	Does this indicator contribute to an aggregated index?	**No**	**Business**		**Flood**		**Heat**		
Processing	England and Wales: 100 minus % of people where gender identity the same as sex registered at birth minus % 'Not answered' Scotland: No. people 'Yes: Trans or has a trans history - Total' divided by 'All people aged 16 and over', multiplied by 100 Northern Ireland: No data								
Data used and resolution	**Source**	**Description**	**Scale**	**Owner**	**Download available**	**In data pack (raw)?**	**Units**	**Confidence**	**Date**
England	Census	TS078	MSOA	ONS	Yes	Yes	%	High	2021
Wales	Census	TS078	MSOA	ONS	Yes	Yes	%	High	2021
Scotland	Census	UV903a - Trans status or history (7 groups)	LA(2019)	Scottish Government	Yes	No	%	Mod	2022
Northern Ireland	-	-	-	-	No	No	-	-	-
Rationale	Little research focuses on the differential relationship between climate impacts and those within this group.								
Residual notes	Included for information only - unlikely to be a signifcant (differential) spatial indicator								

Appendix Table C-7 Household characteristics - Household size

Grouping	**Households**								
Domain	**Household characteristics**								
Indicator and ID	**hc1 - Household size**								
	Does this indicator contribute to an aggregated index?		**No**	**Business**		**Flood**		**Heat**	
Processing	(1 * 1 person in household + 2 * 2 people in household + 3 * 3 people in household.... 8 * 8 people in household) / Total households, multiplied by 100								
Data used and resolution	**Source**	**Description**	**Scale**	**Owner**	**Download available**	**In data pack (raw)?**	**Units**	**Confidence**	**Date**
England	Census	TS017	LSOA	ONS	Yes	Yes	No.	High	2021
Wales	Census	TS017	LSOA	ONS	Yes	No	No.	High	2021
Scotland	Census	UV406 - Household size	OA	Scottish Government	Yes	No	No.	Mod	2022
Northern Ireland	Census	NISRA Household Size	SDZ	NISRA	Yes	No	No.	High	2021
Rationale	Included to enables households and number of people to be interchanged								
Residual notes	-								

Appendix Table C-8 Age - Young Children

Grouping	**Population**								
Domain	**Age**								
Indicator and ID	**a1 - Young children**								
	Does this indicator contribute to an aggregated index?	**Yes**	**Business**		**Flood**	✓	**Heat**	✓	
Processing	Number of people aged 0-4 years divided by the total population and multiplied by 100.								
Data used and resolution	**Source**	**Description**	**Scale**	**Owner**	**Download available**	**In data pack (raw)?**	**Units**	**Confidence**	**Date**
England	Census	TS007a	LSOA	ONS	Yes	Yes	%	High	2021
Wales	Census	TS007a	LSOA	ONS	Yes	Yes	%	High	2021
Scotland	Census	UV103 - Age by single year	OA	Scottish Government	Yes	No	%	High	2022
Northern Ireland	Census	NISRA Age - 19 Categories	SDZ	NISRA	Yes	No	%	High	2021
Rationale	Young children are more susceptible to harms from a range of environmental hazards. Numerous studies have highlighted the association between flooding and increased mental health and behavioural problems in children. Young children are also more likely to be affected by hot weather because their bodies create more heat energy, they sweat less and dehydration affects them more quickly than in the case of healthy adults . Young children are also less able to adapt their own clothing and behaviour in response to over-heating. These are some of the reasons why there is evidence for increased hospital emergency admission rates for heat-related illness in children under five during hot weather Summary references: Mort M, Walker M, Williams AL, Bingley A, Howells V. Children, Young People and Flooding. Save the Children and Lancaster University; 2016. Knowlton K., Rotkin-Ellman M., King G., Margolis H.G., Smith D., Solomon G., Trent R. and English P. 2009. The 2006 California Heat Wave: Impacts on Hospitalizations and Emergency Department Visits. Environmental Health Perspectives. Volume 117. Number 1. pp 61-67. Kovats R. S., Hajat S. and Wilkinson P. 2004b. Contrasting Patterns of Mortality and Hospital Admissions During Hot Weather and Heat Waves in Greater London, UK. Occupational and Environmental Medicine. Volume 61. Number 11. pp 893-898. Sayers, P., Penning-Rowsell, E., Horritt, M. (2017). Flood vulnerability, risk and social disadvantage: Current and future patterns in the UK. Journal of Regional Environmental Change. DOI https://doi.org/10.1007/s10113-017-1252-z Climate Just website https://www.climatejust.org.uk/								
Residual notes	-								

Appendix Table C-9 Age - Older People

Grouping	**Population**								
Domain	**Age**								
Indicator and ID	**a2 - Older people**								
	Does this indicator contribute to an aggregated index?	**Yes**	**Business**		**Flood**	✓	**Heat**	✓	
Processing	Number of people aged 75 years or more divided by the total population and multiplied by 100.								
Data used and resolution	**Source**	**Description**	**Scale**	**Owner**	**Download available**	**In data pack (raw)?**	**Units**	**Confidence**	**Date**
England	Census	TS007a	LSOA	ONS	Yes	Yes	%	High	2021
Wales	Census	TS007a	LSOA	ONS	Yes	Yes	%	High	2021
Scotland	Census	UV103 - Age by single year	OA	Scottish Government	Yes	No	%	High	2022
Northern Ireland	Census	NISRA Age - 19 Categories	SDZ	NISRA	Yes	No	%	High	2021
Rationale	Not all older people are socially vulnerable, however, older people are more likely to experience detrimental impacts during climate events. Tapsell et al.looked in detail at six case studies from across the UK; these showed that those over the age of 75 were more vulnerable to flooding. Others have highlighted that high temperatures or poor air quality as we grow older due to inhibited ability for thermo-regulation and dehydration. There is conclusive evidence that when compared to other adults, older people - those over 65, but particularly people over 75 - consistently face more severe impacts as a result of flooding and heatwaves. Summary references: Tapsell, S.M., Penning-Rowsell, E.C., Tunstall, S.M. and Wilson, T.L., 2002. Vulnerability to flooding: health and social dimensions. Philosophical transactions of the royal society of London. Series A: Mathematical, Physical and Engineering Sciences, 360(1796), pp.1511-1525. Vardoulakis S & Heaviside C (2012), Health Effects of Climate Change in the UK 2012. Health Protection Agency. Hames, D and Vardoulakis S & Heaviside C (2012), Summary Report : Climate Change Risk Assessment Summary: Health Sayers, P., Penning-Rowsell, E., Horritt, M. (2017). Flood vulnerability, risk and social disadvantage: Current and future patterns in the UK. Journal of Regional Environmental Change. DOI https://doi.org/10.1007/s10113-017-1252-z Climate Just website https://www.climatejust.org.uk/								
Residual notes	-								

Appendix Table C-10 Age - Households with one child under 5 years

Grouping	**Population**								
Domain	**Age**								
Indicator and ID	**a7 - Households with one child under 5 years**								
	Does this indicator contribute to an aggregated index?	**No**	**Business**		**Flood**		**Heat**		
Processing	England and Wales: No. Households where: "Dependent children in household and their age (B) (6 categories)" is "Youngest dependent child: Aged 0 to 4 years" divided by the total households and multiplied by 100 Scotland: No data available at time of processing Northern Ireland: No. Households where: "Dependent children in household and their age (B) (6 categories)" is "Youngest dependent child: Aged 0 to 4 years" divided by the total households and multiplied by 100								
Data used and resolution	**Source**	**Description**	**Scale**	**Owner**	**Download available**	**In data pack (raw)?**	**Units**	**Confidence**	**Date**
England	Census	RM006	LSOA	ONS	Yes	Yes	%	High	2021
Wales	Census	RM006	LSOA	ONS	Yes	Yes	%	High	2021
Scotland	-	Still in review at time of data cut-off	-	-	No	No	-	-	-
Northern Ireland	Census	NISRA Classification of Household: Dependent Children	SDZ	NISRA	Yes	No	%	High	2021
Rationale	Numerous studies have highlighted the association between flooding and increased mental health and behavioural problems in children (e.g. Mort et al., 2016). It is likely these issues would have negative knock on effects for the rest of the household. Indeed, children's stories of the impacts of the floods in Hull reveal the range of impacts which can affect younger children, including physical and mental health, and the disruption to home-life and schooling (Mort et al., 2016). Mort M, Walker M, Williams AL, Bingley A, Howells V. Children, Young People and Flooding. Save the Children and Lancaster University; 2016.								
Residual notes	-								

Appendix Table C-11 Health - Disability / people in ill- health - A little

Grouping	**Population**								
Domain	**Health**								
Indicator and ID	**h1 - Disability / people in ill- health - A little**								
	Does this indicator contribute to an aggregated index?	**Yes**	**Business**		**Flood**	✓	**Heat**	✓	
Processing	Number of people where: "Disabled under the Equality Act: Day-to-day activities limited a little", divided by the total population, multiplied by 100.								
Data used and resolution	**Source**	**Description**	**Scale**	**Owner**	**Download available**	**In data pack (raw)?**	**Units**	**Confidence**	**Date**
England	Census	TS038	LSOA	ONS	Yes	Yes	%	High	2021
Wales	Census	TS038	LSOA	ONS	Yes	Yes	%	High	2021
Scotland	Census	UV303 - Disability - 'Day-to-day activities limited a lot'	DZ(2011)	Scottish Government	Yes	No	%	High	2022
Northern Ireland	Census	NISRA Health Problem or Disability (Long-term)	SDZ	NISRA	Yes	No	%	High	2021
Rationale	Some conditions and illnesses (or the medicine used to treat them) make people more sensitive to the effects of air pollution and high temperatures, e.g. dehydration, ability to sweat and exacerbate symptoms, e.g. cardiovascular disease. Some illnesses are associated with acute symptoms and hospital admissions, while others chronic leading to a build up of symptoms over time. Medicines may also be less effective during hot weather, or might be lost or damaged in floods. Flooding, for example, may restrict an individual's access to medicine, e.g. due to loss or damage or it being left behind in the context of an emergency and may prevent the use of complex home-based health care systems, for example home dialysis, due to direct flood damage or to loss of power. Summary references with signposting to further references: Sayers, P., Penning-Rowsell, E., Horritt, M. (2017). Flood vulnerability, risk and social disadvantage: Current and future patterns in the UK. Journal of Regional Environmental Change. DOI https://doi.org/10.1007/s10113-017-1252-z Climate Just website https://www.climatejust.org.uk/								
Residual notes	It may be possible with further development to find additional data available on types of disability and health conditions for Northern Ireland and on household adaptations. Beyond scope here.								

Appendix Table C-12 Health - Disability / people in ill- health - A lot

Grouping	**Population**								
Domain	**Health**								
Indicator and ID	**h2 - Disability / people in ill- health - A lot**								
	Does this indicator contribute to an aggregated index?	**Yes**	**Business**		**Flood**	✓	**Heat**	✓	
Processing	Number of people where 'Disabled under the Equality Act: Day-to-day activities limited a lot', divided by the total population, multiplied by 100.								
Data used and resolution	**Source**	**Description**	**Scale**	**Owner**	**Download available**	**In data pack (raw)?**	**Units**	**Confidence**	**Date**
England	Census	TS038	LSOA	ONS	Yes	Yes	%	High	2021
Wales	Census	TS038	LSOA	ONS	Yes	Yes	%	High	2021
Scotland	Census	UV303 - Disability - 'Day-to-day activities limited a little'	DZ(2011)	Scottish Government	Yes	No	%	High	2022
Northern Ireland	Census	NISRA Health Problem or Disability (Long-term)	SDZ	NISRA	Yes	No	%	High	2021
Rationale	Some conditions and illnesses (or the medicine used to treat them) make people more sensitive to the effects of air pollution and high temperatures, e.g. dehydration, ability to sweat and exacerbate symptoms, e.g. cardiovascular disease. Some illnesses are associated with acute symptoms and hospital admissions, while others chronic leading to a build up of symptoms over time. Medicines may also be less effective during hot weather, or might be lost or damaged in floods. Flooding, for example, may restrict an individual's access to medicine, e.g. due to loss or damage or it being left behind in the context of an emergency and may prevent the use of complex home-based health care systems, for example home dialysis, due to direct flood damage or to loss of power. Summary references with signposting to further references: Sayers, P., Penning-Rowsell, E., Horritt, M. (2017). Flood vulnerability, risk and social disadvantage: Current and future patterns in the UK. Journal of Regional Environmental Change. DOI https://doi.org/10.1007/s10113-017-1252-z Climate Just website https://www.climatejust.org.uk/								
Residual notes	It may be possible with further development to find additional data available on types of disability and health conditions for Northern Ireland and on household adaptations. Beyond scope here.								

Appendix Table C-13 Health - People receiving home-based care

Grouping	**Population**								
Domain	**Health**								
Indicator and ID	**h9 - People receiving home based care**								
	Does this indicator contribute to an aggregated index?	**Yes**	**Business**		**Flood**	✓	**Heat**	✓	
Processing	England and Wales: Unpaid carers (from census) plus paid carers (from DWP) divided by the total population, multiplied by 100 Scotland: No. people 'All unpaid carers' divided by No people 'All people aged 3 and over', multiplied by 100 Northern Ireland: Paid carers (from Domiciliary care services) + Unpaid carers (from census MS-D17) divided by all usual residents over 5 years old (from MS-D17), multiplied by 100								
Data used and resolution	**Source**	**Description**	**Scale**	**Owner**	**Download available**	**In data pack (raw)?**	**Units**	**Confidence**	**Date**
England	DWP + Census	TS039	LSOA	ONS	Yes	Yes	%	Moderate	2021
Wales	DWP + Census	TS039	LSOA	ONS	Yes	No	%	Moderate	2021
Scotland	Census	UV301 - Provision of unpaid care (all unpaid carers)	DZ(2011)	Scottish Government	Yes	No	%	-	2022
Northern Ireland	Census AND NSIRA	MS-D17 AND Domiciliary care services for adults in Northern Ireland	LDG/HSC Trust	NISRA	Yes	No	%	Moderate	2021 and 2023
Rationale	More complex health care is now being delivered at home rather than in hospitals and medical centres often using more sophisticated and power-reliant equipment . Flooding may prevent the use of complex home-based health care systems, for example home dialysis, due to direct flood damage or to loss of power. People requiring care have a range of dependencies which intersect with other vulnerability factors. Flooding may prevent the use of complex home-based health care systems, for example home dialysis, due to direct flood damage or to loss of power. Flooding may also restrict an individual's access to medicine, e.g. due to loss or damage or it being left behind in the context of an emergency. Telephone connectivity and transport routes are often disrupted during flood events making it difficult for carers to contact and reach their patients that are receiving care at home; a problem recgonised in Lancashire during the flooding in 2015 caused by Storm Desmond. Summary references with links to further supproting evidence: Sayers, P., Penning-Rowsell, E., Horritt, M. (2017). Flood vulnerability, risk and social disadvantage: Current and future patterns in the UK. Journal of Regional Environmental Change. DOI https://doi.org/10.1007/s10113-017-1252-z Climate Just website https://www.climatejust.org.uk/								
Residual notes	Rfurther refinements may be possible as part of further developments								

Appendix Table C-14 Health - Households with at least one person in long-term ill-health

Grouping	**Population**								
Domain	**Health**								
Indicator and ID	**h10 - Households with at least one person in long-term ill-health**								
	Does this indicator contribute to an aggregated index?	**Yes**	**Business**		**Flood**	✓	**Heat**	✓	
Processing	England and Wales: Sum of (1 person with a non-limiting long-term physical or mental health condition in household + 2 or more people with a non-limiting long-term physical or mental health condition in household) divided by the total number of households and multiplied by 100 Scotland: Long-term illness, disease or condition / total people multiplied by 100 Northern Ireland: Sum of (1 person with a non-limiting long-term physical or mental health condition in household + 2 or more people with a non-limiting long-term physical or mental health condition in household) divided by the total number of households and multiplied by 100								
Data used and resolution	**Source**	**Description**	**Scale**	**Owner**	**Download available**	**In data pack (raw)?**	**Units**	**Confidence**	**Date**
England	Census	Manual query	LSOA	ONS	No	Yes	%	High	2021
Wales	Census	Manual query	LSOA	ONS	No	No	%	High	2021
Scotland	Census	UV304 - Long-term health conditions 'Long-term illness, disease or condition'	DZ (2011)	Scottish Government	Yes	No	%	-	2022
Northern Ireland	NSIRA	MS-D03 - Number of residents in household with a limiting long-term health problem or disability	SDZ	NSIRA	Yes	No	%	-	2021
Rationale	More complex health care is now being delivered at home rather than in hospitals and medical centres often using more sophisticated and power-reliant equipment . Flooding may prevent the use of complex home-based health care systems, for example home dialysis, due to direct flood damage or to loss of power. People requiring care have a range of dependencies which intersect with other vulnerability factors. Flooding may prevent the use of complex home-based health care systems, for example home dialysis, due to direct flood damage or to loss of power. Flooding may also restrict an individual's access to medicine, e.g. due to loss or damage or it being left behind in the context of an emergency. Telephone connectivity and transport routes are often disrupted during flood events making it difficult for carers to contact and reach their patients that are receiving care at home; a problem recgonised in Lancashire during the flooding in 2015 caused by Storm Desmond. Summary references with links to further supproting evidence: Sayers, P., Penning-Rowsell, E., Horritt, M. (2017). Flood vulnerability, risk and social disadvantage: Current and future patterns in the UK. Journal of Regional Environmental Change. DOI https://doi.org/10.1007/s10113-017-1252-z Climate Just website https://www.climatejust.org.uk/								
Residual notes	The number of people in the household who assessed themselves as having long-term physical or mental health conditions or illnesses that do not limit their day-to-day activities. These people are not regarded as disabled in line with the Equality Act (2010) definition of disability. 4 Categories; No people with a non-limiting long-term physical or mental health condition in household; 1 person with a non-limiting long-term physical or mental health condition in household; 2 or more people with a non-limiting long-term physical or mental health condition in household; Does not apply. Care needed when using.								

Appendix Table C-15 Health - Mood and Anxiety Disorders

Grouping	**Population**								
Domain	**Health**								
Indicator and ID	**h12 - Mood and Anxiety Disorders**								
	Does this indicator contribute to an aggregated index?	**Yes**	**Business**		**Flood**	✓	**Heat**	✓	
Processing	England: IMD Health domain: Mood and anxiety disorders indicator direct (z-score) Wales: GP-recorded mental health condition (rate per 100) Scotland: Direct: Has a mental health condition: Percentage Northern Ireland: Number of 'All usual residents with an emotional, psychological or mental health condition' divided by # 'All usual residents', multiplied by 100								
Data used and resolution	**Source**	**Description**	**Scale**	**Owner**	**Download available**	**In data pack (raw)?**	**Units**	**Confidence**	**Date**
England	Ministry of Housing, Communities & Local Government	English IoD	LSOA(2011)	ONS	Yes	Yes	Z-Score	Moderate	2019
Wales	WIMD	Wales IMD	LSOA(2011)	StatsWales	Yes	No	No.	Moderate	2019
Scotland	Census	Report: Scotland's Census 2022 - Health, disability and unpaid care	LA	Scottish Government	Yes	No	No.	Moderate	2022
Northern Ireland	Census	MS-D12: Type of long-term condition: Emotional, psychological or mental health condition	LDG	NISRA	Yes	No	No.	Moderate	2021
Rationale	Some mental health disorders affect people's ability to self-regulate to avoid environmental hazards or recognise and take effective precautions against symptoms caused or aggravated by environmental hazards. Also, In some cases, medicines used may also increase susceptibility to effects, e.g. of heat stress. Being flooded is stressful and mental health impacts can be serious. Recorded psychological stresses caused by flooding in the UK and OECD include: post-traumatic stress disorder, depression, anxiety and domestic violence. A delayed increase in suicide rates has been observed following natural disasters, although the evidence of this after flood events is very limited. Many of these psychological effects last much longer (2+ years) than any adverse physical health effects. While post-event stress is likely to affect everyone, those with existing mental health conditions are likely to suffer the most. Some mental health disorders affect people's ability to self-regulate to avoid environmental hazards or recognise and take effective precautions against symptoms caused or aggravated by environmental hazards. Summary references with links to further supporting references: Sayers, P., Penning-Rowsell, E., Horritt, M. (2017). Flood vulnerability, risk and social disadvantage: Current and future patterns in the UK. Journal of Regional Environmental Change. DOI https://doi.org/10.1007/s10113-017-1252-z Climate Just website https://www.climatejust.org.uk/								
Residual notes	-								

Appendix Table C-16 Income - Unemployment (amongst economically active)

Grouping	**Households**								
Domain	**Income**								
Indicator and ID	**i1 - Unemployed (economically active)**								
	Does this indicator contribute to an aggregated index?	**Yes**	**Business**		**Flood**	✓	**Heat**	✓	
Processing	England and Wales: Economically active (excluding full-time students): Unemployed' divided by (All usual residents aged 16 years and over - Economically inactive: Retired) multiplied by 100 Scotland: Economically Active (excluding full-time students) - Unemployed - Available for work' divided by 'Economically Inactive - Total', 'Economically Active (excluding full time students) - Total', 'Economically Active full-time students - Total' minus 'Economically inactive - Retired') multiplied by 100 Northern Ireland: Economically active: Economically active (excluding full-time students): Unemployed' divided by all except ('Economically inactive: Retired' and 'No code required') multiplied by 100								
Data used and resolution	**Source**	**Description**	**Scale**	**Owner**	**Download available**	**In data pack (raw)?**	**Units**	**Confidence**	**Date**
England	Census	TS066	LSOA	ONS	Yes	Yes	%	Moderate	2021
Wales	Census	TS066	LSOA	ONS	Yes	Yes	%	Moderate	2021
Scotland	Census	UV601 - Economic activity	OA	Scottish Government	Yes	No	%	Mod	2022
Northern Ireland	Census	Economic Activity - 12 Categories	SDZ	NISRA	Yes	No	%	Moderate	2021
Rationale	Unemployment is commonly used as a measure of vulnerability. To take the example of flooding, unemployment or irregular employment may reduce the opportunities for obtaining insurance. People in this group are more likely have negative impacts on their health and wellbeing in the aftermath of flooding. Analysis of past events demonstrated that the perception of negative financial implications increased the potential for anxiety, depression and PTSD and these mental health symptoms were significantly higher in unemployed people . Poor mental health has implications for other health-related outcomes and health and care services. Income is also important for heat-related vulnerabilities, for example as low-income households may be less able to adapt buildings. There may be more reluctance to take advice to open windows if uninsured or with poorer security measures thus increasing the potential for heat stress. It should be noted that unemployment does reduce vulnerability in some circumstances, e.g. higher ability to respond to flood events. However, this – on balance – is outweighed by the lower adaptive capacity potential due to associations with low income. Summary references with links to further information: Twigger-Ross, C and Orr, P (2012) The UK Climate Change Risk Assessment 2012 Evidence Report Project D.4.2.1 Release 7 Annex B: Social Vulnerability to Climate Change Impacts Paranjothy S, Gallacher J, Amlôt R, Rubin GJ, Page L, Baxter T, Wight J, Kirrage D, McNaught R, Palmer SR BMC (2011) Psychosocial impact of the summer 2007 floods in England. Public Health. 3;11:145 Tilley, N., Tseloni, A and Farrrell, G (2011) Income disparities of burglary risk: Security availability during the crime drop BRIT. J. CRIMINOL. (2011) Sayers, P., Penning-Rowsell, E., Horritt, M. (2017). Flood vulnerability, risk and social disadvantage: Current and future patterns in the UK. Journal of Regional Environmental Change. DOI https://doi.org/10.1007/s10113-017-1252-z Climate Just website https://www.climatejust.org.uk/								
Residual notes	-								

Appendix Table C-17 Income - Long-term unemployed

Grouping	**Households**								
Domain	**Income**								
Indicator and ID	**i2 - Long-term unemployed**								
	Does this indicator contribute to an aggregated index?	**No**	**Business**		**Flood**		**Heat**		
Processing	England and Wales: 100 * ('Not in employment: Not worked in the last 12 months' + 'Not in employment: Never worked') divided by divided by (All usual residents aged 16 years and over - Economically inactive: Retired) multiplied by 100 Scotland: ('Economically inactive - Looking after home/ family' plus 'Economically inactive - Long term sick or disabled' plus 'Economically inactive - Other') divided by (All usual residents aged 16 years and over - Economically inactive: Retired) multiplied by 100 Northern Ireland: ('Economically inactive: Long-term sick or disabled' plus 'Economically inactive: Looking after home or family' plus 'Economically inactive: Other') divided by all except ('Economically inactive: Retired' and 'No code required') multiplied by 100								
Data used and resolution	**Source**	**Description**	**Scale**	**Owner**	**Download available**	**In data pack (raw)?**	**Units**	**Confidence**	**Date**
England	Census	TS065	LSOA	ONS	Yes	Yes	%	Moderate	2021
Wales	Census	TS065	LSOA	ONS	Yes	Yes	%	Moderate	2021
Scotland	Census	Long term sick or disabled - inactive in UV601	OA	Scottish Government	Yes	No	%	Mod	2022
Northern Ireland	Census	Economic Activity - 12 Categories	SDZ	NISRA	Yes	No	%	Moderate	2021
Rationale	Higher proportions of people in an area who are long-term unemployed or who have never worked indicate a higher vulnerability because of their likelihood to be on lower incomes relative to other people. Average levels of wealth for households headed by people who are long-term unemployed or who have never worked are just 3% of those of working in employment classified as 'large employer or higher managerial' . Summary references with links to further detail: Vardoulakis S & Heaviside C (2012), Health Effects of Climate Change in the UK 2012. Health Protection Agency Sayers, P., Penning-Rowsell, E., Horritt, M. (2017). Flood vulnerability, risk and social disadvantage: Current and future patterns in the UK. Journal of Regional Environmental Change. DOI https://doi.org/10.1007/s10113-017-1252-z Climate Just website https://www.climatejust.org.uk/								
Residual notes	-								

Appendix Table C-18 Income - Low-income occupations

Grouping	**Households**								
Domain	**Income**								
Indicator and ID	**i3 - Low income occupations**								
	Does this indicator contribute to an aggregated index?	**No**	**Business**		**Flood**		**Heat**		
Processing	England and Wales: 100 * (No. people in L12 Semi-routine occupations' plus No. people in 'L13 Routine occupations') / (All usual residents aged 16 years and over - Economically inactive: Retired) Scotland: 100 * (No. people in L12 Semi-routine occupations' plus No. people in 'L13 Routine occupations') / (All usual residents aged 16 years and over - Economically inactive: Retired) Northern Ireland: People in '9 Elementary occupations' divided by number of people without a code required (i.e. Over 16) multiplied by 100								
Data used and resolution	**Source**	**Description**	**Scale**	**Owner**	**Download available**	**In data pack (raw)?**	**Units**	**Confidence**	**Date**
England	Census	TS062	LSOA	ONS	Yes	Yes	%	Moderate	2021
Wales	Census	TS062	LSOA	ONS	Yes	Yes	%	Moderate	2021
Scotland	Census	UV607 - Socioeconomic classification	OA	Scottish Government	Yes	No	%	Mod	2022
Northern Ireland	Census	NISRA Occupation (Current) - 10 Categories	SDZ	NISRA	Yes	No	%	Moderate	2021
Rationale	Several studies shave shown low income households to be more vulnerable to flooding (and other shocks) across the UK. The main reason for this is the lack of savings that could be used immediately to spend on repairs and replacements that would kick-start a recovery process. Low income households are less likely to have the capacity to fully prepare for future floods (through insurance and property level measures). Summary references: Sayers, P., Penning-Rowsell, E., Horritt, M. (2017). Flood vulnerability, risk and social disadvantage: Current and future patterns in the UK. Journal of Regional Environmental Change. DOI https://doi.org/10.1007/s10113-017-1252-z Climate Just website https://www.climatejust.org.uk/								
Residual notes	-								

Appendix Table C-19 Income - Households with dependent children and no adults in employment

Grouping	**Households**								
Domain	**Income**								
Indicator and ID	**i4 - Households with dependent children and no adults in employment**								
	Does this indicator contribute to an aggregated index?	**No**	**Business**		**Flood**		**Heat**		
Processing	England and Wales: Number of households 'No adults in employment in household: With dependent children' divided by the total number of households and multiplied by 100. Infill supressed for missing data Scotland: No data available at time of processing Northern Ireland: Number of households 'No adults in employment in household: With dependent children' divided by the total number of households and multiplied by 100. Infill supressed for missing data								
Data used and resolution	**Source**	**Description**	**Scale**	**Owner**	**Download available**	**In data pack (raw)?**	**Units**	**Confidence**	**Date**
England	Census	KS106	LSOA	ONS	Yes	Yes	%	Moderate	2021
Wales	Census	KS106	LSOA	ONS	Yes	Yes	%	Moderate	2021
Scotland	-	Still in review at time of data cut-off	-	-	No	No	-	-	-
Northern Ireland	Census	Derived - see notes	SDZ	NISRA	Yes	No	%	Moderate	2021
Rationale	Households with dependent children and no adults in employment are likely have Lower disposal incomes. Several studies have shown low income households to be more vulnerable to flooding (and other shocks) across the UK. The main reason for this is the lack of savings that could be used immediately to spend on repairs and replacements that would kick-start a recovery process. Low income households are less likely to have the capacity to fully prepare for future floods (through insurance and property level measures). Summary references: Sayers, P., Penning-Rowsell, E., Horritt, M. (2017). Flood vulnerability, risk and social disadvantage: Current and future patterns in the UK. Journal of Regional Environmental Change. DOI https://doi.org/10.1007/s10113-017-1252-z Climate Just website https://www.climatejust.org.uk/								
Residual notes	Note: Suppressed LSOAs due to data privacy. Where this has been done the word 'suppressed' is added to the data								

Appendix Table C-20 Income - Income deprivation

Grouping	**Households**								
Domain	**Income**								
Indicator and ID	**i5 - Income deprivation**								
	Does this indicator contribute to an aggregated index?	**Yes**	**Business**		**Flood**	✓	**Heat**	✓	
Processing	England: Income Rank (where 1 is most deprived)' assigned to best 2021 LSOA's, then reranked where matching scores both bome the highest value Wales: WIMD Income index, i.e. "percentage of people income deprived" Scotland: SIMD 2020 Income index, attributed to OAs and reranked. 1 is the most deprived. Max where values are equal Northern Ireland: Income Rank (where 1 is most deprived)' from the Supoer Output Areas assigned to best 2021 SDZ's, then reranked where matching scores both bome the highest value								
Data used and resolution	**Source**	**Description**	**Scale**	**Owner**	**Download available**	**In data pack (raw)?**	**Units**	**Confidence**	**Date**
England	Ministry of Housing, Communities & Local Government	Report	MSOA	ONS	Yes	Yes	Rank	Moderate	2019
Wales	StatWales	WalesIMD Income Index	LSOA	StatWales	No	No	%	Moderate	2019
Scotland	SIMD	Scottish Index of Multiple Deprivation 2020	DZ(2011)	Scottish Government	Yes	No	Rank	Mod	2020
Northern Ireland	NI	NIMDM2017	SOA (2001)	NISRA	Yes	No	Rank	Moderate	2017
Rationale	Low income is important because a lack of financial resources restricts people's ability to prepare for, respond to and recover from hazard events. As well a reduced choice in terms of goods and services, there is also evidence of lower self-esteem and higher levels of stress and anxiety. The Income Deprivation domain of the Index of Multiple Deprivation (IMD) measures deprivation at the household level. It considers the proportion of the population experiencing deprivation related to low income, including both individuals in households receiving income support and those in households with low earnings. Income deprived households are likely to have the less capacity to fully prepare for and recovery from climate events. Several studies shave shown low income households to be more vulnerable to flooding (and other shocks) across the UK. The main reason for this is the lack of savings that could be used immediately to spend on repairs and replacements that would kick-start a recovery process. Low income households are less likely to have the capacity to fully prepare for future floods (through insurance and property level measures). Summary references with links to further information: Sayers, P., Penning-Rowsell, E., Horritt, M. (2017). Flood vulnerability, risk and social disadvantage: Current and future patterns in the UK. Journal of Regional Environmental Change. DOI https://doi.org/10.1007/s10113-017-1252-z Climate Just website https://www.climatejust.org.uk/								
Residual notes	In England The Income Deprivation Domain measures the proportion of the population experiencing deprivation relating to low income. The definition of low income used includes both those people that are out-of-doors, and those that are in work but who have low earnings (and who satisfy the respective means tests). In NI - Proportion of the population living in households whose equivalised income is below 60 per cent of the NI median								

Appendix Table C-21 Income - Average Household Income

Grouping	**Households**								
Domain	**Income**								
Indicator and ID	**i6 - Average Household Income**								
	Does this indicator contribute to an aggregated index?	**No**	**Business**		**Flood**		**Heat**		
Processing	England and Wales: 'Net annual income after housing costs (£) Scotland: Mean Gross Household Income per week'. Values are research based and exclude housing costs. Average DZ value across IZ Northern Ireland: Direct: Table 3: GDHI local authority by ITL1 region: TLN Northern Ireland: GDHI per head of population at current basic prices, pounds								
Data used and resolution	**Source**	**Description**	**Scale**	**Owner**	**Download available**	**In data pack (raw)?**	**Units**	**Confidence**	**Date**
England	ONS	Online	MSOA	ONS	Yes	Yes	£	Moderate	2020
Wales	ONS	Online	MSOA	ONS	Yes	Yes	£	Moderate	2020
Scotland	Research	Banded income statistics: 2018	DZ(2011)	Scottish Government	Yes	No	£	Low	2018
Northern Ireland	ONS	Regional gross disposable household income	LGD	ONS	Yes	Yes	£	Moderate	2022
Rationale	Average household income (after housing costs) provides a measure of resources that households may have to support adaptation and recovery from climate events.								
Residual notes	-								

Appendix Table C-22 Information use and local knowledge - Recent arrivals to the UK

Grouping	**Households**								
Domain	**Information use and local knowledge**								
Indicator and ID	**f1 - Recent arrivals to the UK**								
	Does this indicator contribute to an aggregated index?	**Yes**	**Business**		**Flood**	✓	**Heat**	✓	
Processing	England and Wales: Number of people arriving in UK less than 1 year before the census date divided by the total population and multiplied by 100 Scotland: No. people arrived between 2020 and 2022 inclusive, divided by total no. people, multiplied by 100 Northern Ireland: No. people ('Lived elsewhere one year ago; outside Northern Ireland - within the Republic of Ireland' plus 'Lived elsewhere one year ago; outside the UK and Republic of Ireland') divided by total population, multiplied by 100								
Data used and resolution	**Source**	**Description**	**Scale**	**Owner**	**Download available**	**In data pack (raw)?**	**Units**	**Confidence**	**Date**
England	Census	Ts015	LSOA	ONS	Yes	Yes	%	High	2021
Wales	Census	Ts015	LSOA	ONS	Yes	Yes	%	High	2021
Scotland	Census	UV801 - Year of arrival in UK - arriving 2020 - 2022	OA	Scottish Government	Yes	No	%	High	2022
Northern Ireland	Census	NISRA Address One Year Ago	SDZ	NISRA	Yes	No	%	High	2021
Rationale	Higher proportions of people recently arrived from outside an area indicate a higher vulnerability as they are more likely to have difficulty obtaining and using information and guidance provided to the general public. Recent arrivals to the UK may be unfamiliar with the data sources (flood maps), services (warnings), and mechanisms (rights, support) than others. This lack of information and local knowledge is considered to influence vulnerability. Summary references: Sayers, P., Penning-Rowsell, E., Horritt, M. (2017). Flood vulnerability, risk and social disadvantage: Current and future patterns in the UK. Journal of Regional Environmental Change. DOI https://doi.org/10.1007/s10113-017-1252-z Climate Just website https://www.climatejust.org.uk/								
Residual notes	Note: Query in Scotland, the download file is named table 801 but online is referenced as 802. Reason unknown.								

Appendix Table C-23 Information use and local knowledge - Level of proficiency in English language

Grouping	**Households**								
Domain	**Information use and local knowledge**								
Indicator and ID	**f2 - Level of proficiency in English language**								
	Does this indicator contribute to an aggregated index?	**Yes**	**Business**		**Flood**	✓	**Heat**	✓	
Processing	England and Wales: (No, people where 'Main language is not English (English or Welsh in Wales): Cannot speak English well' + No. people where 'Main language is not English (English or Welsh in Wales): Cannot speak English'), divided by the total number of people (over 3) and multiplied by 100. Scotland: Limited English skills' +'No skills in English' divided by total population over 3, multiplied by 100 Northern Ireland: No people ('Main Language is not English: Cannot speak English well' plus 'Main Language is not English: Cannot speak English') divided by total # people over 3, multiplied by 100								
Data used and resolution	**Source**	**Description**	**Scale**	**Owner**	**Download available**	**In data pack (raw)?**	**Units**	**Confidence**	**Date**
England	Census	Ts029	LSOA	ONS	Yes	Yes	%	High	2021
Wales	Census	Ts029	LSOA	ONS	Yes	Yes	%	High	2021
Scotland	Census	Table UV210 - English language skills - Limited or no	OA	Scottish Government	Yes	No	%	High	2022
Northern Ireland	Census	NISRA English Language Proficiency	SDZ	NISRA	Yes	No	%	High	2021
Rationale	Non-English speakers (or may also find it difficult to access flood and heat warnings if they are not immediately available in languages other than English. Relatively poor proficiency in English therefore can restrict people's ability to prepare for, respond to and recover from events with the capacity to cause harm because it restricts knowledge of and access to information and support services. Summary references linking to further references and evidence: Sayers, P., Penning-Rowsell, E., Horritt, M. (2017). Flood vulnerability, risk and social disadvantage: Current and future patterns in the UK. Journal of Regional Environmental Change. DOI https://doi.org/10.1007/s10113-017-1252-z Climate Just wesbite								
Residual notes	Note: This is a simplification and may misrepresents those that speak Welsh in Wales, Galeac in Scotland or NI but not English. This should be explored in a future update								

Appendix Table C-24 Information use and local knowledge - Internet access (not superfast)

Grouping	**Households**								
Domain	**Information use and local knowledge**								
Indicator and ID	**f7 - Internet access (not SFBB)**								
	Does this indicator contribute to an aggregated index?	**No**	**Business**		**Flood**		**Heat**		
Processing	100 - % of premises with access to SFBB								
Data used and resolution	**Source**	**Description**	**Scale**	**Owner**	**Download available**	**In data pack (raw)?**	**Units**	**Confidence**	**Date**
England	Ofcom	Coverage	LSOA	Ofcom	Yes	Yes	%	High	2023
Wales	Ofcom	Coverage	LSOA	Ofcom	Yes	Yes	%	High	2023
Scotland	Ofcom	Coverage	OA(2011)	Ofcom	Yes	No	%	High	2023
Northern Ireland	Ofcom	Coverage	DZ (2021)	Ofcom	Yes	No	%	High	2023
Rationale	The internet is an increasingly important means of supplying and receiving information about public authorities and services, for obtaining goods and services and for communicating with others. The Super Fast Broadband and Ultrafast Broadband relate to download speeds >100Mbps. Better connection speeds allows more rapid access to information, goods and services and social networks. This is important given the increasing reliance on online information, especially during periods where demand is high. Internet accessibility is also important to business sectors and for employees working from home. Summary references and links to further references: Climate Just website https://www.climatejust.org.uk/								
Residual notes	Downloaded data by Manchester from Ofcom.								

Appendix Table C-25 Information use and local knowledge - Internet access (below USO)

Grouping	**Households**								
Domain	**Information use and local knowledge**								
Indicator and ID	**f8 - Internet access (below USO)**								
	Does this indicator contribute to an aggregated index?	**Yes**	**Business**		**Flood**	✓	**Heat**	✓	
Processing	England: Number of premises below USO divided by 'All Premises', multiplied by 100 Wales: Number of premises below USO divided by 'All Matched Premises', multiplied by 100 Scotland: Number of premises below USO divided by 'All Matched Premises', multiplied by 100 Northern Ireland: Number of premises below USO divided by 'All Matched Premises', multiplied by 100								
Data used and resolution	**Source**	**Description**	**Scale**	**Owner**	**Download available**	**In data pack (raw)?**	**Units**	**Confidence**	**Date**
England	Ofcom	Coverage	LSOA	Ofcom	Yes	Yes	%	High	2023
Wales	Ofcom	Coverage	LSOA	Ofcom	Yes	Yes	%	High	2023
Scotland	Ofcom	Coverage	OA(2011)	Ofcom	Yes	No	%	High	2023
Northern Ireland	Ofcom	Coverage	DZ (2021)	Ofcom	Yes	No	%	High	2023
Rationale	The internet is an increasingly important means of supplying and receiving information about public authorities and services, for obtaining goods and services and for communicating with others . However, its availability, reliability and accessibility varies considerably across Scotland. Furthermore, the internet, like other critical infrastructure, can also be impacted by some events, like high temperatures or extreme weather . The Universal Service Obligation relates to average household requirements, assumed to be download speeds >10Mbps and upload speeds of 1Mbps. Areas with poorer internet may also have less well-developed infrastructure for other key sectors, e.g., mobile communications, transport and energy. Summary references and links to further references: Climate Just website https://www.climatejust.org.uk/								
Residual notes	Downloaded data by Manchester from Ofcom.								

Appendix Table C-26 Information use and local knowledge - New migrants from outside the local area

Grouping	**Households**								
Domain	**Information use and local knowledge**								
Indicator and ID	**k1 - New migrants from outside the local area**								
	Does this indicator contribute to an aggregated index?	**Yes**	**Business**		**Flood**	✓	**Heat**		
Processing	England and Wales: 100 - percentage of people where address one year ago is the same as the address of enumeration Scotland: Direct: 'Less than one year' * 100 (comes as a decimal) Northern Ireland: (No people over 1 yr old minus no people: 'Lived at same address one year ago') divided by no people over 1 year old multiplied by 100								
Data used and resolution	**Source**	**Description**	**Scale**	**Owner**	**Download available**	**In data pack (raw)?**	**Units**	**Confidence**	**Date**
England	Census	Ts019	LSOA	ONS	Yes	Yes	%	High	2021
Wales	Census	Ts019	LSOA	ONS	Yes	Yes	%	High	2021
Scotland	SHS	SHS 2022 annual report: Table 1 housing: 1_26: Adult characteristics by tenure - Length of time at current address, 2022	LA	Scottish Government	Yes	No	%	-	-
Northern Ireland	Census	NISRA Address One Year Ago - 4 Categories	SDZ	NISRA	Yes	No	%	High	2021
Rationale	People who have recently moved into an area may also lack awareness of local flood risk provided through family and community clues. Communities where population turnover (population transience) is high may be less aware of the likelihood of being affected by events like floods, how to respond and where to seek support. In places with high amounts of population turnover there is the potential for higher vulnerability due to lack of knowledge of hazards, health and support services and social networks. Such areas are more likely to be characterised by rented accommodation and in some cases insecure employment. These factors affect the capacity for preparing for, responding to and recovering from environmental hazards like heat waves.This lack of local support, difficulty in accessing information and limited familiarity with local climate hazards are all important underlying reasons for vulnerability. Summary references: Sayers, P., Penning-Rowsell, E., Horritt, M. (2017). Flood vulnerability, risk and social disadvantage: Current and future patterns in the UK. Journal of Regional Environmental Change. DOI https://doi.org/10.1007/s10113-017-1252-z Climate Just website https://www.climatejust.org.uk/								
Residual notes	-								

Appendix Table C-27 Physical Mobility - Living in medical and care establishments

Grouping	**Households**								
Domain	**Physical Mobility**								
Indicator and ID	**m1 - Living in medical and care establishments**								
	Does this indicator contribute to an aggregated index?	**Yes**	**Business**		**Flood**	✓	**Heat**	✓	
Processing	England and Wales: Number of people Total: All usual residents in communal establishments' divided by total number of residence and multiplied by 100. Scotland: Number of Long Stay Residents Complete Length of Stay 3 Months' or greater divided by total population, multiplied by 100 Northern Ireland: All usual residents in communal establishments' divided by (A1 plus A2), multiplied by 100								
Data used and resolution	**Source**	**Description**	**Scale**	**Owner**	**Download available**	**In data pack (raw)?**	**Units**	**Confidence**	**Date**
England	Census	Ts048	MSOA	ONS	Yes	Yes	%	Moderate	2021
Wales	Census	Ts048	MSOA	ONS	Yes	Yes	%	Moderate	2021
Scotland	Care Home Census	Number of Long Stay Residents By Length of Stay	LA	NHS Scotland	Yes	No	%	-	-
Northern Ireland	Census	MS-F03 Communal establishment residents and long-term health problem or disability	LDG (2014)	NISRA	Yes	No	%	Moderate	2021
Rationale	People living in medical and care establishments may have greater dependencies as a result of health-related factors. As well as making people generally more susceptible to negative effects, there are also more likely to be low mobility and additional needs in relation to responding to and recovering from environmental stresses like high temperatures and poor air quality. During times of flood, people with reduced mobility may be more reliant on others to assist them for example during evacuation either from their own homes or from serviced accommodation such as care homes. Disruption caused by a flood may prevent carers reaching those they care for and may leave assistance tools such as electronic lifts unusable. Neighbourhoods with higher proportions of medical and care residents may have more needs for support before, during and after events and residents may be more susceptible to hazard effects due to biophysical reasons or reliance on infrastructure (e.g. power supply, equipment etc). Summary references with links to further details: Sayers, P., Penning-Rowsell, E., Horritt, M. (2017). Flood vulnerability, risk and social disadvantage: Current and future patterns in the UK. Journal of Regional Environmental Change. DOI https://doi.org/10.1007/s10113-017-1252-z Climate Just website https://www.climatejust.org.uk/- People with low personal mobility								
Residual notes	-								

Appendix Table C-28 Physical Mobility - Lack of private transport

Grouping	**Households**								
Domain	**Physical Mobility**								
Indicator and ID	**m2 - Lack of private transport**								
	Does this indicator contribute to an aggregated index?	**Yes**	**Business**		**Flood**	✓	**Heat**	✓	
Processing	England and Wales: Direct: 'No cars or vans in household - %' Scotland: Number of cars or vans in household: No cars or vans divided by 'All occupied households, multiplied by 100 Northern Ireland: Car or Van Availability Label' : 'No cars or vans available' divided by total number of included households, multiplied by 100								
Data used and resolution	**Source**	**Description**	**Scale**	**Owner**	**Download available**	**In data pack (raw)?**	**Units**	**Confidence**	**Date**
England	Census	Ts045	LSOA	ONS	Yes	Yes	%	High	2021
Wales	Census	Ts045	LSOA	ONS	Yes	Yes	%	High	2021
Scotland	Census	UV405 - Car or van availability	OA	Scottish Government	Yes	No	%	Mod	2022
Northern Ireland	Census	NISRA Car or Van Availability	SDZ	NISRA	Yes	No	%	Moderate	2021
Rationale	People with access to private transport have increased adaptive capacity as they have more flexibility to cope with impacts which may result from extreme events and environmental hazards, for instance helping immediate family or the local community access health or other support services, or handling changes due to transport problems during periods of extreme heat or flooding. Households without access to private transport are therefore more likely to experience mobility problems compared to others. Summary references with links to further details: Sayers, P., Penning-Rowsell, E., Horritt, M. (2017). Flood vulnerability, risk and social disadvantage: Current and future patterns in the UK. Journal of Regional Environmental Change. DOI https://doi.org/10.1007/s10113-017-1252-z Climate Just website https://www.climatejust.org.uk/								
Residual notes	-								

Appendix Table C-29 Physical Mobility - Limited access to employment opportunities by public transport

Grouping	**Households**								
Domain	**Physical Mobility**								
Indicator and ID	**m3 - Limited access to employment opportunities by public transport**								
	Does this indicator contribute to an aggregated index?	**No**	**Business**		**Flood**		**Heat**		
Processing	England and Wales: Ranked number of employment opportunities via public transport within 1 hour, where 1 is most deprived - max rank where equal Scotland: Average number of opportunities for each OA within IDZ, Ranked via public transport within 1 hour, where 1 is most deprived - max rank where equal Northern Ireland: Ranked average distance to work travelled where 1 is the furthest average distance to work. Capped at 60km. 'Work within Northern Ireland: 60km and over' * 60 plus 'Work outside Northern Ireland: England, Scotland or Wales' multiplied by 60 plus 'Work outside Northern Ireland: Republic of Ireland',5 'Work outside the United Kingdom and Ireland' multiplied by 60 plus Work within Northern Ireland: 40km to less than 60km' multiplied by 50 etc. divided by 'All usual residents aged 16 and over (excluding full-time students) in employment'. Ranked, with duplicate values having the highest								
Data used and resolution	**Source**	**Description**	**Scale**	**Owner**	**Download available**	**In data pack (raw)?**	**Units**	**Confidence**	**Date**
England	Urban Big Data Centre	Yes	LSOA(2011)	Urban Big Data Centre	Yes	Yes	Rank	High	2022
Wales	Urban Big Data Centre	Yes	LSOA(2011)	Urban Big Data Centre	Yes	No	Rank	High	2022
Scotland	Urban Big Data Centre	Yes	IDZ(2011)	Urban Big Data Centre	Yes	No	Rank	High	2022
Northern Ireland	Census	MS-103: Distance travelled to work	LDG (2014)	NISRA	Yes	No	Rank	Moderate	2021
Rationale	Limited access to public transport to travel to work may result in more limited opportunities to continue to work during a heat or flood event that impacts those routes. Limited evidence is avaiable and although included here care is needed in its use.								
Residual notes	Urban Big Data Centre requires acknowledge of licence before use								

Appendix Table C-30 Physical Mobility - Extended public transport journey times

Grouping	**Households**								
Domain	**Physical Mobility**								
Indicator and ID	**m4 - Extended public transport journey times**								
	Does this indicator contribute to an aggregated index?	**No**	**Business**		**Flood**		**Heat**		
Processing	England and Wales: Time to nearest hospital + time to nearest GP + time to nearest primary school + time to nearest supermarket (all average times in minutes via public transport) Scotland: Time to nearest hospital + time to nearest GP + time to nearest primary school + time to nearest supermarket (all average times in minutes via public transport) Northern Ireland: No data								
Data used and resolution	**Source**	**Description**	**Scale**	**Owner**	**Download available**	**In data pack (raw)?**	**Units**	**Confidence**	**Date**
England	Urban Big Data Centre	Yes	LSOA(2011)	Urban Big Data Centre	Yes	Yes	Minutes	High	2022
Wales	Urban Big Data Centre	Yes	LSOA(2011)	Urban Big Data Centre	Yes	No	Minutes	High	2022
Scotland	Urban Big Data Centre	Yes	IDZ(2011)	Urban Big Data Centre	Yes	No	Minutes	High	2022
Northern Ireland	-	-	-	-	No	No	-	-	-
Rationale	In areas with low public transport provision it may be more difficult for people to cope during and after events like heat waves, or if immediate family is affected by symptoms aggravated by poor air quality. More physically isolated areas may also be associated with other factors which increase vulnerability.								
Residual notes	Urban Big Data Centre requires acknowledge of licence before use								

Appendix Table C-31 Physical Mobility – People with a disability that live in medical and care establishment

Grouping	**Households**								
Domain	**Physical Mobility**								
Indicator and ID	**m5 - People living in medical and care establishment with a disability**								
	Does this indicator contribute to an aggregated index?	**Yes**	**Business**		**Flood**	✓	**Heat**		
Processing	England and Wales: No. medical and care establishment residents who are registered disabled divided by (those that are registered disabled + those that are not registered disabled + does not apply) multiplied by 100. Scotland: No data available at time of processing Northern Ireland: ('Medical and care establishments: Day-to-day activities limited a lot') divided by (All usual residents in communal establishments), multiplied by 100. Nb.this excludes "other establishments"								
Data used and resolution	**Source**	**Description**	**Scale**	**Owner**	**Download available**	**In data pack (raw)?**	**Units**	**Confidence**	**Date**
England	Census	Manual query	MSOA	ONS	Yes	Yes	%	High	2021
Wales	Census	Manual query	MSOA	ONS	Yes	No	%	High	2021
Scotland	-	Still in review at time of data cut-off	-	-	No	No	-	-	-
Northern Ireland	Census	MS-F03 Communal establishment residents and long-term health problem or disability	LA (2014)	NISRA	Yes	0	%	High	2021
Rationale	People living in medical and care establishments may have greater dependencies as a result of health-related factors. As well as making people generally more susceptible to negative effects, there are also more likely to be low mobility and additional needs in relation to responding to and recovering from environmental stresses like high temperatures and poor air quality. During times of flood, people with reduced mobility may be more reliant on others to assist them for example during evacuation either from their own homes or from serviced accommodation such as care homes. Disruption caused by a flood may prevent carers reaching those they care for and may leave assistance tools such as electronic lifts unusable. Neighbourhoods with higher proportions of medical and care residents may have more needs for support before, during and after events and residents may be more susceptible to hazard effects due to biophysical reasons or reliance on infrastructure (e.g. power supply, equipment etc). Summary references with links to further details: Sayers, P., Penning-Rowsell, E., Horritt, M. (2017). Flood vulnerability, risk and social disadvantage: Current and future patterns in the UK. Journal of Regional Environmental Change. DOI https://doi.org/10.1007/s10113-017-1252-z Climate Just website https://www.climatejust.org.uk/- People with low personal mobility								
Residual notes	-								

Appendix Table C-32 Physical Mobility - High levels of registered disability

Grouping	**Households**								
Domain	**Physical Mobility**								
Indicator and ID	**m7 - High levels of registered disability**								
	Does this indicator contribute to an aggregated index?	**Yes**	**Business**		**Flood**	✓	**Heat**	✓	
Processing	All residents registered under the act - minus those in Care establishments registered disabled over all usual residents								
Data used and resolution	**Source**	**Description**	**Scale**	**Owner**	**Download available**	**In data pack (raw)?**	**Units**	**Confidence**	**Date**
England	Census	TS038 - Disability	LSOA	ONS	Yes	Yes	%	Moderate	2021
Wales	Census	TS038 - Disability	LSOA	ONS	Yes	Yes	%	Moderate	2021
Scotland	Census	UV303 - Long-term health problem or disability	OA	Scottish Government	Yes	No	%	Mod	2022
Northern Ireland	Census	MS-D02: Long-term health problem or disability	LGD	NISRA	Yes	No	%	Moderate	2021
Rationale	People with disabilities or poor health are more likely to have reduced mobility and/or be reliant on others to assist them during extreme events, e.g. if they have symptoms of heat stress or acute adverse effects due to poor air quality. Even if people are relatively independent in normal times, there may be additional pressures if infrastructure is impacted, e.g. power cuts, internet or mobile networks. Summary references with links to further details: Sayers, P., Penning-Rowsell, E., Horritt, M. (2017). Flood vulnerability, risk and social disadvantage: Current and future patterns in the UK. Journal of Regional Environmental Change. DOI https://doi.org/10.1007/s10113-017-1252-z Climate Just website https://www.climatejust.org.uk/- People with low personal mobility								
Residual notes	-								

Appendix Table C-33 Housing type - Caravan or other mobile or temporary structures

Grouping	**Households**								
Domain	**Housing type**								
Indicator and ID	**ht1 - Caravan or other mobile or temporary structures**								
	Does this indicator contribute to an aggregated index?	**Yes**	**Business**		**Flood**	✓	**Heat**		
Processing	England and Wales: Direct: 'All household spaces: Caravan or other mobile or temporary structure - %' Scotland: No. Households: 'Caravan or other mobile or temporary structure' divided by No. Households: 'All occupied households', multiplied by 100. Nb census totals wrong; recalculated from individual parts Northern Ireland: No. Households: 'Caravan or other mobile or temporary structure' divided by No. Households: 'All occupied households', multiplied by 100								
Data used and resolution	**Source**	**Description**	**Scale**	**Owner**	**Download available**	**In data pack (raw)?**	**Units**	**Confidence**	**Date**
England	Census	TS044	LSOA	ONS	Yes	Yes	%	High	2021
Wales	Census	TS044	LSOA	ONS	Yes	No	%	High	2021
Scotland	Census	UV402 - Accommodation type - Household	OA	Scottish Government	Yes	No	%	Mod	2022
Northern Ireland	Census	NISRA Accommodation Type	SDZ	NISRA	Yes	No	%	High	2021
Rationale	Residents of caravans are also more likely to have a limited knowledge of the local area (see above, local knowledge). Those living in mobile or temporary structures tend to more limited ability to take action to reduce the impact of climate event (access shaded rooms, or move to other unaffected rooms). Summary references and links to further discussions: Sayers, P., Penning-Rowsell, E., Horritt, M. (2017). Flood vulnerability, risk and social disadvantage: Current and future patterns in the UK. Journal of Regional Environmental Change. DOI https://doi.org/10.1007/s10113-017-1252-z Climate Just website https://www.climatejust.org.uk/								
Residual notes	-								

Appendix Table C-34 Housing type - Detached properties

Grouping	**Households**								
Domain	**Housing type**								
Indicator and ID	**ht2 - Detached properties**								
	Does this indicator contribute to an aggregated index?	**No**	**Business**		**Flood**		**Heat**		
Processing	England and Wales: Direct: 'All household spaces: detached - %' Scotland: No. Households: 'Whole house or bungalow: Detached' divided by No. Households: 'All occupied households', multiplied by 100. Nb census totals wrong; recalculated from individual parts Northern Ireland: No. Households: 'Whole house or bungalow: Detached' divided by No. Households: 'All occupied households', multiplied by 100								
Data used and resolution	**Source**	**Description**	**Scale**	**Owner**	**Download available**	**In data pack (raw)?**	**Units**	**Confidence**	**Date**
England	Census	TS044	LSOA	ONS	Yes	Yes	%	High	2021
Wales	Census	TS044	LSOA	ONS	Yes	No	%	High	2021
Scotland	Census	UV402 - Accommodation type - Household	OA	Scottish Government	Yes	No	%	Mod	2022
Northern Ireland	Census	NISRA Accommodation Type	SDZ	NISRA	Yes	No	%	High	2021
Rationale	Those living in detached homes are more likely to have the space and autonomy to adapt the house and the space to avoid limit the impact of a hazard. This actions reflect an overall reduction in vulnerability								
Residual notes	-								

Appendix Table C-35 Housing type - Semi-detached properties

Grouping	**Households**								
Domain	**Housing type**								
Indicator and ID	**ht3 - Semi-detached properties**								
	Does this indicator contribute to an aggregated index?	**No**	**Business**		**Flood**		**Heat**		
Processing	England and Wales: Direct: 'All household spaces: semi-detached - %' Scotland: No. Households: 'Whole house or bungalow: Semi-detached' divided by No. Households: 'All occupied households', multiplied by 100. Nb census totals wrong; recalculated from individual parts Northern Ireland: No. Households: 'Whole house or bungalow: Semi-detached' divided by No. Households: 'All occupied households', multiplied by 100								
Data used and resolution	**Source**	**Description**	**Scale**	**Owner**	**Download available**	**In data pack (raw)?**	**Units**	**Confidence**	**Date**
England	Census	TS044	LSOA	ONS	Yes	Yes	%	High	2021
Wales	Census	TS044	LSOA	ONS	Yes	No	%	High	2021
Scotland	Census	UV402 - Accommodation type - Household	OA	Scottish Government	Yes	No	%	Mod	2022
Northern Ireland	Census	NISRA Accommodation Type	SDZ	NISRA	Yes	No	%	High	2021
Rationale	Those living in detached homes are more likely to have the space and autonomy to adapt the house and the space to avoid limit the impact of a hazard. This actions reflect an overall reduction in vulnerability								
Residual notes	-								

Appendix Table C-36 Housing type - Terraced properties

Grouping	**Households**								
Domain	**Housing type**								
Indicator and ID	**ht4 - Terraced properties**								
	Does this indicator contribute to an aggregated index?	**No**	**Business**		**Flood**		**Heat**		
Processing	England and Wales: Direct 'All household spaces: terraced - %' Scotland: No. Households: Whole house or bungalow: Terraced (including end-terrace)' divided by No. Households: 'All occupied households', multiplied by 100. Nb census totals wrong; recalculated from individual parts Northern Ireland: No. Households: Whole house or bungalow: Terraced (including end-terrace)' divided by No. Households: 'All occupied households', multiplied by 100								
Data used and resolution	**Source**	**Description**	**Scale**	**Owner**	**Download available**	**In data pack (raw)?**	**Units**	**Confidence**	**Date**
England	Census	TS044	LSOA	ONS	Yes	Yes	%	High	2021
Wales	Census	TS044	LSOA	ONS	Yes	No	%	High	2021
Scotland	Census	UV402 - Accommodation type - Household	OA	Scottish Government	Yes	No	%	Mod	2022
Northern Ireland	Census	NISRA Accommodation Type	SDZ	NISRA	Yes	No	%	High	2021
Rationale	Autonomous adaptations (particularly relating to flooding) may be difficult, relying upon collective action for success. See related issues of 'tenure'								
Residual notes	-								

Appendix Table C-37 Housing type - Purpose-built block of flats or tenement

Grouping	**Households**								
Domain	**Housing type**								
Indicator and ID	**ht5 - Purpose-built block of flats or tenement**								
	Does this indicator contribute to an aggregated index?	**Yes**	**Business**		**Flood**		**Heat**	✓	
Processing	England and Wales: Direct: 'All household spaces: flats or tenements - %' Scotland: No. Households: 'Flat, maisonette or apartment: Purpose-built block of flats or tenement' divided by No. Households: 'All occupied households', multiplied by 100. Nb census totals wrong; recalculated from individual parts Northern Ireland: No. Households: 'Flat, maisonette or apartment: Purpose-built block of flats' divided by No. Households: 'All occupied households', multiplied by 100								
Data used and resolution	**Source**	**Description**	**Scale**	**Owner**	**Download available**	**In data pack (raw)?**	**Units**	**Confidence**	**Date**
England	Census	TS044	LSOA	ONS	Yes	Yes	%	High	2021
Wales	Census	TS044	LSOA	ONS	Yes	No	%	High	2021
Scotland	Census	UV402 - Accommodation type - Household	OA	Scottish Government	Yes	No	%	Mod	2022
Northern Ireland	Census	NISRA Accommodation Type	SDZ	NISRA	Yes	No	%	High	2021
Rationale	Autonomous adaptations (particularly relating to flooding) may be difficult, relying upon collective action for success. See related issues of 'tenure'								
Residual notes	-								

Appendix Table C-38 Housing type - Converted or shared house, including bedsits

Grouping	**Households**								
Domain	**Housing type**								
Indicator and ID	**ht6 - Converted or shared house, including bedsits**								
	Does this indicator contribute to an aggregated index?	**No**	**Business**		**Flood**		**Heat**		
Processing	England and Wales: Direct: 'Part of a converted or shared house, including bedsits - %' Scotland: No. Households: 'Flat, maisonette or apartment: Part of a converted or shared house (including bed-sits)' divided by No. Households: 'All occupied households', multiplied by 100. Nb census totals wrong; recalculated from individual parts Northern Ireland: No. Households: 'Flat, maisonette or apartment: Part of a converted or shared house (including bed-sits)' divided by No. Households: 'All occupied households', multiplied by 100								
Data used and resolution	**Source**	**Description**	**Scale**	**Owner**	**Download available**	**In data pack (raw)?**	**Units**	**Confidence**	**Date**
England	Census	TS044	LSOA	ONS	Yes	Yes	%	High	2021
Wales	Census	TS044	LSOA	ONS	Yes	No	%	High	2021
Scotland	Census	UV402 - Accommodation type - Household	OA	Scottish Government	Yes	No	%	Mod	2022
Northern Ireland	Census	NISRA Accommodation Type	SDZ	NISRA	Yes	No	%	High	2021
Rationale	Autonomous adaptations (particularly relating to flooding) may be difficult, relying upon collective action for success. See related issues of 'tenure'								
Residual notes	-								

Appendix Table C-39 Housing type – Basements

Grouping	**Households**								
Domain	**Housing type**								
Indicator and ID	**ht9 - Basements**								
	Does this indicator contribute to an aggregated index?	**Yes**	**Business**		**Flood**	✓	**Heat**		
Processing	England and Wales: No basement households (classified as dB) divided by all households multiplied by 100 Scotland: No basement households (classified as dB) divided by all households multiplied by 100 Northern Ireland: No data								
Data used and resolution	**Source**	**Description**	**Scale**	**Owner**	**Download available**	**In data pack (raw)?**	**Units**	**Confidence**	**Date**
England	Defra	Basements (dB) within the National Receptor Dataset	LSOA	Defra	No	No	%	Low	2023
Wales	NRD	Basements (dB) within the national receptor dataset	LSOA	National Resources Wales	No	No	%	Moderate	2018
Scotland	OSNI	NAFRA2 NRD	IZ	NAFRA	No	No	%	Moderate	2018
Northern Ireland	-	-	-	-	No	No	-	-	-
Rationale	Basement flooding can be rapid and more difficult to warn. Autonomous adaptations and actions (particularly relating to flooding) may be difficult, relying on others. This can be influential on the differential vulnerability experienced by those living in a basement.								
Residual notes	Not public data - determined via the licenced NRD dataset. For use only as Z-score wihtin the integrated index. Access to similar datasets in Wales, NI and Scotland not provided for use here.								

Appendix Table C-40 Housing type – High rise flats

Grouping	**Households**								
Domain	**Housing type**								
Indicator and ID	**ht11 - High rise flats**								
	Does this indicator contribute to an aggregated index?	**Yes**	**Business**		**Flood**		**Heat**	✓	
Processing	England and Wales: 100 - (100 * No. Flats: with private outdoor space / All addresses: total count) Scotland: 100 - (100 * No. Flats: with private outdoor space / All addresses: total count) Northern Ireland: No data								
Data used and resolution	**Source**	**Description**	**Scale**	**Owner**	**Download available**	**In data pack (raw)?**	**Units**	**Confidence**	**Date**
England	OS	Data on access to private gardens, public parks and playing fields in Great Britain	MSOA	OS	Yes	No	%	Low	2020
Wales	OS	Data on access to private gardens, public parks and playing fields in Great Britain	MSOA	OS	Yes	Yes	%	Low	2020
Scotland	OS	Data on access to private gardens, public parks and playing fields in Great Britain	MSOA	OS	Yes	Yes	%	Low	2020
Northern Ireland	-	-	-	-	No	No	-	-	-
Rationale	High rise flats are well known to be associated with elevated temperatures during heat-wave events. Analyses of past events demonstrate increased mortality in these building types. Modelling suggests that the degree of enhanced exposure depends on a range of factors such as building orientation, insulation, ventilation and building use. High rise flats can also highlight areas where the number of households indirectly impacted by a flood are likely to be higher than the number directly impacted. Summary references: Climate Just website https://www.climatejust.org.uk/								
Residual notes	Not an open licence as sign up to the OS platforms needed. Note: The CCC are also looking into modelling this as part of our CB7 building stock model and this may be updated with those results in a future update. Equally further interrogation of property EPC data could be used in a future update								

Appendix Table C-41 Housing type – Homelessness

Grouping	**Households**								
Domain	**Housing type**								
Indicator and ID	**ht12 - Homelessness**								
	Does this indicator contribute to an aggregated index?	**Yes**	**Business**		**Flood**	✓	**Heat**	✓	
Processing	England: Direct: IMD Barriers domain: Homelessness indicator (rate per 1000 households) Wales: Direct :Households assessed as homeless and owed duty to secure – Rate per 10,000 households (Section 73). Divided by 10 to make Rate per 1,000 households Scotland: Direct: Households assessed as homeless\n - Rate per 10,000 households. Divided by 10 to make Rate per 1,000 households Northern Ireland: Direct; Sheet 1_3, Homeless presenters by local government district - Presenters per 1,000 populationDirect: IMD Barriers domain: Homelessness indicator (rate per 1000 households) All standardised to per 1,000 households								
Data used and resolution	**Source**	**Description**	**Scale**	**Owner**	**Download available**	**In data pack (raw)?**	**Units**	**Confidence**	**Date**
England	Ministry of Housing, Communities & Local Government	English IoD	LSOA(2011)	ONS	Yes	Yes	per 1,000 households	Moderate	2019
Wales	StatWales	Relief of Homelessness by Area and Measure (Section 73)	LA	StatsWales	Yes	No	per 1,000 households	Moderate	2024
Scotland	Cabinet Secretary for Social Justice	Homelessness in Scotland: 2023-24	LA	Scottish Government	Yes	No	per 1,000 households	Moderate	2024
Northern Ireland	Department for Communities	Northern Ireland Homelessness Bulletin October 2023 - March 2024	LDG	Northern Ireland Government	Yes	No	per 1,000 households	High	2024
Rationale	If someone becomes homeless they may find it difficult to care for and protect themselves and cope with existing life challenges. Lacking safety, security, privacy and the support networks of friends and family, they may become particularly vulnerable to violence, abuse, crime and exploitation - these issues can be exacerbated during climate events.								
Residual notes	-								

Appendix Table C-42 Tenure – Private renters

Grouping	**Households**								
Domain	**Tenure**								
Indicator and ID	**t1 - Private renters**								
	Does this indicator contribute to an aggregated index?	**Yes**	**Business**		**Flood**	✓	**Heat**	✓	
Processing	England and Wales: Direct: 'Private rented - %' Scotland: No. Households: 'Private rented: Total' divided by No households: 'All occupied households', multiplied by 100. NB. Census totals are wrong; recalculated from core data Northern Ireland: No households: 'Private rented: Private landlord or letting agency' plus 'Private rented: Other private rented' divided by all households, multiplied by 100								
Data used and resolution	**Source**	**Description**	**Scale**	**Owner**	**Download available**	**In data pack (raw)?**	**Units**	**Confidence**	**Date**
England	Census	TS054	LSOA	ONS	Yes	Yes	%	High	2021
Wales	Census	TS054	LSOA	ONS	Yes	No	%	High	2021
Scotland	Census	UV404 - Household Tenure - household	OA	Scottish Government	Yes	No	%	Mod	2022
Northern Ireland	Census	NISRA Tenure - 7 Categories	SDZ	NISRA	Yes	No	%	High	2021
Rationale	Private renters represent a very broad group and not all are equally socially vulnerable. However, on average private renters are less able to prepare for extreme weather events, for example due to inability to modify their homes to prepare for heatwaves or account for poor air quality. Property maintenance and adaptation such as insultation and ventilation is normally the responsibility of the property owner. They may also be more transient and therefore less familiar with local neighbourhoods, environmental hazards, and sources of support Tenants are often not allowed to make physical alterations to their properties, and leaseholders may be disinclined to as they may not feel the additional expense of making those changes is worthwhile given that they do not own the freehold. Landlords of social housing may be more inclined to make these alterations, but little quantified evidence exists. Where tenants are permitted to make physical alterations to their dwellings, there is little incentive to do so. Tenants are generally less well-off than homeowners (The Poverty Site, 2014), and therefore cannot afford to install meaningful physical risk reducing measures. Tenants are less likely than homeowners to speak English as their first language (for example, in Boston, Lincolnshire, there are more than 10,000 migrant workers the majority of whom live in rented accommodation), and so may not be easily able to access information on flood risk and preparedness. Summary references and links to further discussions: Sayers, P., Penning-Rowsell, E., Horritt, M. (2017). Flood vulnerability, risk and social disadvantage: Current and future patterns in the UK. Journal of Regional Environmental Change. DOI https://doi.org/10.1007/s10113-017-1252-z Climate Just website https://www.climatejust.org.uk/ - Tenants in social or private rented housing: who are we concerned about?								
Residual notes	-								

Appendix Table C-43 Tenure – Social renters

Grouping	**Households**								
Domain	**Tenure**								
Indicator and ID	**t2 - Social renters**								
	Does this indicator contribute to an aggregated index?	**Yes**	**Business**		**Flood**	✓	**Heat**	✓	
Processing	England and Wales: Direct: 'Social rented - %' Scotland: No. Households: 'Social Rented: Council (LA) or Housing Association/ Registered Social Landlord' divided by No households: 'All occupied households', multiplied by 100. NB. Census totals are wrong; recalculated from core data Northern Ireland: No households: 'Social rented: Northern Ireland Housing Executive' plus 'Social rented: Housing association or charitable trust' divided by all households, multiplied by 100								
Data used and resolution	**Source**	**Description**	**Scale**	**Owner**	**Download available**	**In data pack (raw)?**	**Units**	**Confidence**	**Date**
England	Census	TS054	LSOA	ONS	Yes	Yes	%	High	2021
Wales	Census	TS054	LSOA	ONS	Yes	No	%	High	2021
Scotland	Census	UV404 - Household Tenure - household	OA	Scottish Government	Yes	No	%	Mod	2022
Northern Ireland	Census	NISRA Tenure - 7 Categories	SDZ	NISRA	Yes	No	%	High	2021
Rationale	Social renters are less able to prepare for extreme weather events, for example due to inability to modify their homes to prepare for heatwaves or account for poor air quality. Property maintenance and adaptation is normally the responsibility of the property owner though in the case of some social tenants social renting may also provide opportunities for adaptation. Tenants in social housing are likely to have a range of other characteristics which increase vulnerability enants are often not allowed to make physical alterations to their properties, and leaseholders may be disinclined to as they may not feel the additional expense of making those changes is worthwhile given that they do not own the freehold. Landlords of social housing may be more inclined to make these alterations, but little quantified evidence exists. Where tenants are permitted to make physical alterations to their dwellings, there is little incentive to do so. Summary references and links to further discussions: Sayers, P., Penning-Rowsell, E., Horritt, M. (2017). Flood vulnerability, risk and social disadvantage: Current and future patterns in the UK. Journal of Regional Environmental Change. DOI https://doi.org/10.1007/s10113-017-1252-z Climate Just website https://www.climatejust.org.uk/ - Tenants in social or private rented housing: who are we concerned about?								
Residual notes	-								

Appendix Table C-44 Tenure – Owners occupied

Grouping	**Households**								
Domain	**Tenure**								
Indicator and ID	**t3 - Owner occupied**								
	Does this indicator contribute to an aggregated index?	**No**	**Business**		**Flood**		**Heat**		
Processing	England and Wales: % 100 - t1 - t2 Scotland: No. Households: 'Owned: Total' divided by No households: 'All occupied households', multiplied by 100. NB. Census totals are wrong; recalculated from core data Northern Ireland: No households: 'Owner occupied: Owns outright' plus 'Owner occupied: Owns with a mortgage or loan or shared ownership' divided by all households, multiplied by 100								
Data used and resolution	**Source**	**Description**	**Scale**	**Owner**	**Download available**	**In data pack (raw)?**	**Units**	**Confidence**	**Date**
England	Inferred from T1 and T2	TS054	LSOA	ONS	Yes	Yes	%	High	2021
Wales	Inferred from T1 and T2	TS054	LSOA	ONS	Yes	No	%	High	2021
Scotland	Census	UV404 - Household Tenure - household	OA	Scottish Government	Yes	No	%	Mod	2022
Northern Ireland	Census	NISRA Tenure - 7 Categories	SDZ	NISRA	Yes	No	%	High	2021
Rationale	Home owners are greater autonomy and often capacity to act to adapt their homes. Included here for information and is not specifically related to vulnerability								
Residual notes	-								

Appendix Table C-45 Insurance - Insurance take-up

Grouping	**Households**								
Domain	**Insurance**								
Indicator and ID	**pi3 - Insurance take-up**								
	Does this indicator contribute to an aggregated index?		**No**	**Business**		**Flood**		**Heat**	
Processing	Processing undertaken by Sayers in support of JRF research (Sayers et al, 2017) based on acombination evidence including the ABI data on take up by income decile (I6 as a decile).								
Data used and resolution	**Source**	**Description**	**Scale**	**Owner**	**Download available**	**In data pack (raw)?**	**Units**	**Confidence**	**Date**
England	Sayers	Likelihood of insurance given household income	UK	SPL	No	No	%	Low	2017
Wales	Sayers	Likelihood of insurance given household income	UK	SPL	No	Yes	%	Low	2017
Scotland	Sayers	Likelihood of insurance given household income	UK	SPL	No	Yes	%	Low	2017
Northern Ireland	Sayers	Likelihood of insurance given household income	LDG	SPL	No	Yes	%	Low	2017
Rationale	Insurance is a significant contribution to both recovery, and through incentives, preparation. The impact of climate event, such as flood, on those without insurance is likely to much greater than those with access to appropriate insurance (as reflected by the metric of Relative Economic Pain that describes the ratio of uninsured loss to income, Sayers et al., 2017). The most socially vulnerable are less likely to have insurance than others as low incomes and living in social and private rented accommodation are both important barriers to the take of insurance (as reported by Flood Re, Sayers et al., 2020). Insurance can be a powerful motivator of adaptation. The Flood Re 'building back better' incentive for example that encourages flood damaged properties to the repaired to higher flood resilience standards post events. A neighbourhood scale assessment of insurance take up is provided in data collated. Given the commercial sensitives and the lack of published data at this scale this is based on the inferred values derived by Sayers et al., 2017.								
Residual notes	Hazard specific insights are possible (such as for flooding, Sayers et al., 2017) but these use multiple evidence streams and hence are not included here. Disaggregation by peril, tender etc may also be possible but consideed too detailed for here; could be done if taken forward in a future study. Access to the ABI Living Standards Reporting may be required to access absolute numbers hence need for licence constraint, and hence not included inthe pack here.								

Appendix Table C-46 Previous experience of climate events

Grouping	**Area**								
Domain	**Direct previous experience of climate events (reduces vulnerability)**								
Indicator and ID	**e1 - Previous experience of climate events**								
	Does this indicator contribute to an aggregated index?	**Yes**	**Business**		**Flood**	✓	**Heat**		
Processing	Focused on flooding only. Number of properties within historical flood boundary, based on query of property datasets and flood outlines as available in 2015; limited to past 50 years when date information available. Data updated to link to the 2021 census boundaries (Z-score only due to licence constraints).								
Data used and resolution	**Source**	**Description**	**Scale**	**Owner**	**Download available**	**In data pack (raw)?**	**Units**	**Confidence**	**Date**
England	Sayers et al, 2017	Direct from previous study to support the NFVI update only	LSOA (2011)	SPL	No	No	Z-Score	Low	2017
Wales	Sayers et al, 2017	Direct from previous study to support the NFVI update only	LSOA (2011)	SPL	No	Yes	Z-Score	Low	2017
Scotland	Sayers et al, 2017	Direct from previous study to support the NFVI update only	DZ (2011)	SPL	No	Yes	Z-Score	Moderate	2017
Northern Ireland	Sayers et al, 2017	Direct from previous study to support the NFVI update only	SDZ (2011)	SPL	No	Yes	Z-Score	Moderate	2017
Rationale	Several studies show that those with previous experience of a climate event are more likely to take action or adopt particular strategies to reduce the impact of a future event compared to others. Those without experience are likely to be less able to cope. Previous experience of a flood, for example, has been shown to be a key factor in level of willingness to take preventative action against future floods, and respond seriously to warnings. Summary references: Sayers, P., Penning-Rowsell, E., Horritt, M. (2017). Flood vulnerability, risk and social disadvantage: Current and future patterns in the UK. Journal of Regional Environmental Change. DOI https://doi.org/10.1007/s10113-017-1252-z Climate Just webiste								
Residual notes	As agreed with CCC not needed as a raw indicator due to licence restrcitions. It is also noted these values will have been updated significantly through Nafra2 in England and similar inittaivies elsewheer since CCRA3. This data is therefore only used to update the NFVI using SPL internal dataset (from 2017). Only a z-score is readily available and provided as an output.								

Appendix Table C-47 Crime - High levels of crime

Grouping	**Area**								
Domain	**Crime**								
Indicator and ID	**c1 - High levels of crime**								
	Does this indicator contribute to an aggregated index?	**Yes**	**Business**		**Flood**	✓	**Heat**	✓	
Processing	England: English Indices of Deprivation 2019: Crime Domain: Crime Rank Wales: Welsh Indices of Deprivation 2019: Sum of ('Police recorded criminal damage (rate per 100) ', 'Police recorded violent crime (rate per 100) ', 'Anti-Social Behaviour (rate per 100) ', 'Police recorded burglary (rate per 100) ', 'Police recorded theft (rate per 100) ') - ranked. 1 has highest crime. Max where equal Scotland: SIMD Crime Rank 1: most deprived Northern Ireland: NIMDM Crime Rank - 2017, aggregated to SDZ and re-ranked. 1 is most deprived, max value when duplicates								
Data used and resolution	**Source**	**Description**	**Scale**	**Owner**	**Download available**	**In data pack (raw)?**	**Units**	**Confidence**	**Date**
England	MHCLG	IMD Crime Rank	LSOA(2011)	ONS	Yes	Yes	Rank	Moderate	2019
Wales	StatWales	Wales IMD	LSOA(2011)	StatWales	Yes	No	Rate	Moderate	2019
Scotland	SIMD	Scottish Index of Multiple Deprivation - Crime Indicators	DZ	Scottish Government	Yes	No	Rate	Moderate	High
Northern Ireland	NI	NIMDM2017	SOA (2001)	NISRA	Yes	No	Rank	Moderate	2017
Rationale	People living in areas with higher rates of crime (or perceived high crime) may be more reluctant to take preventative measures in reaction to flood warnings or heat wave events. Where crime rates are high, residents may hesitate to evacuate properties during floods for fear of looting and may have reduced adaptive capacity during heat wave events due to an unwillingness to leave windows open at night. Where dwelling-related crime levels are highest, residents are more likely to have extra security mechanisms on their houses such as multiple locks on doors and windows; this can cause delays in evacuation and rescue attempts. Fear of crime may also influence whether residents deploy flood gates while away from home. During the 2014 floods on the Somerset Levels, for example, it was reported that empty houses were being targeted by thieves taking domestic heating oil. Summary references: Sayers, P., Penning-Rowsell, E., Horritt, M. (2017). Flood vulnerability, risk and social disadvantage: Current and future patterns in the UK. Journal of Regional Environmental Change. DOI https://doi.org/10.1007/s10113-017-1252-z Who are we concerned about? | Climate Just								
Residual notes	-								

Appendix Table C-48 Air pollution - Indoor sources (smoking behaviour)

Grouping	**Area**								
Domain	**Air pollution**								
Indicator and ID	**pol4 - Indoor sources (smoking behaviour)**								
	Does this indicator contribute to an aggregated index?	**No**	**Business**		**Flood**		**Heat**		
Processing	Direct: "2023 Current smokers %"								
Data used and resolution	**Source**	**Description**	**Scale**	**Owner**	**Download available**	**In data pack (raw)?**	**Units**	**Confidence**	**Date**
England	ONS	Smoking habits in the UK and its constituent countries	LA	ONS	Yes	Yes	%	Moderate	2023
Wales	ONS	Smoking habits in the UK and its constituent countries	LA	ONS	Yes	Yes	%	Moderate	2023
Scotland	ONS	Smoking habits in the UK and its constituent countries	LA	ONS	Yes	Yes	%	Moderate	2023
Northern Ireland	ONS	Smoking habits in the UK and its constituent countries	LA	ONS	Yes	Yes	%	Moderate	2023
Rationale	High temperature events are frequently associated with episodic air pollution. Sources of indoor air pollution, such as smoking and solid fuel burning, can exacerbate the impact of poor air quality during climate events and elevate air pollution within the home and hence potential impacts. The evidence however remains largely anecdotal.								
Residual notes	Research provided by Robinson et al uses the LA scale information provided by ONS. Robinsons et al provides a useful first step in exploring the impact of smoking and other indoor pollutants on vulnerability								

Appendix Table C-49 Air pollution - Indoor sources (fuel use)

Grouping	**Area**								
Domain	**Air pollution**								
Indicator and ID	**pol5 - Indoor sources (fuel use)**								
	Does this indicator contribute to an aggregated index?	**No**	**Business**		**Flood**		**Heat**		
Processing	England and Wales: No households where Type of central heating in household is in 'Wood only' or 'Solid fuel only', divided by no households, multiplied by 100 Scotland: No of households where type of cental heading is 'Solid Fuel (excluding wood)' OR 'Wood or Biomass (including logs, pellets, chippings) central heating' divided by All occupied households, and miltiplied by 100 Northern Ireland: No of households where type of cental heading is 'Solid Fuel (excluding wood)' OR 'Wood (for example logs or waste wood)' divided by All households, and miltiplied by 100								
Data used and resolution	**Source**	**Description**	**Scale**	**Owner**	**Download available**	**In data pack (raw)?**	**Units**	**Confidence**	**Date**
England	Census	TS046: Central heating	LSOA	ONS	Yes	Yes	%	High	2021
Wales	Census	TS046: Central heating	LSOA	ONS	Yes	Yes	%	High	2021
Scotland	Census	UV407 - Central heating	OA	Scottish Government	Yes	No	%	Moderate	2022
Northern Ireland	Census	MS-E11 Central heating (household based)	SDZ	NISRA	Yes	No	%	Mod	-
Rationale	Sources of indoor air pollution, such as solid fuel burning, can give rise to elevated air pollution within the home. Domestic and commercial black carbon emissions are taken as a proxy indicator of a range of air pollutants associated with solid fuel use. Sarah...								
Residual notes	Research provided by Robinson et al uses the LA scale information provided by ONS. Robinsons et al provides a useful first step in exploring the impact of smoking and other indoor pollutants on vulnerability								

Appendix Table C-50 Service access times - Journey times to health services - GP surgeries

Grouping	**Area**								
Domain	**Service access times**								
Indicator and ID	**ast1 - Journey times to health services - GP surgeries**								
	Does this indicator contribute to an aggregated index?	**Yes**	**Business**		**Flood**		**Heat**	✓	
Processing	England: Travel time in minutes to nearest GP surgery by public transport. Wales: Direct: 'nearest_gp' Scotland: Direct: 'nearest_gp' Northern Ireland: Direct: 'Service-weighted fastest travel time by public transport (rank)'								
Data used and resolution	**Source**	**Description**	**Scale**	**Owner**	**Download available**	**In data pack (raw)?**	**Units**	**Confidence**	**Date**
England	Department for Transport	Journey time statistics England 2019	LSOA(2011)	Department for Transport	JTS0505	Yes	Minutes	High	2019
Wales	Urban Big Data Centre	Access GP PT	LSOA(2011)	Urban Big Data Centre	Yes	Yes	Minutes	High	2022
Scotland	Urban Big Data Centre	Access GP PT	IDZ(2011)	Urban Big Data Centre	Yes	Yes	Minutes	High	2022
Northern Ireland	NI	NIMDM2017	SOA(2001)	NISRA	Yes	No	Rank	Very low	2017
Rationale	People living in areas which are more physically isolated from health and other support services are less likely to be able to access those services than others. This places constraints on accessing medical help or medicines quickly if experiencing heat stress or accessing repeat prescribed in the aftermath of a flood. These difficulties manifest in an increase in vulnerable compared to other areas.								
Residual notes	-								

Appendix Table C-51 Service access times - Journey times to health services – Hospitals

Grouping	**Area**								
Domain	**Service access times**								
Indicator and ID	**ast2 - Journey times to health services - Hospitals**								
	Does this indicator contribute to an aggregated index?	**Yes**	**Business**		**Flood**		**Heat**	✓	
Processing	England: Travel time in minutes to nearest hospital by public transport. Wales: Direct: 'nearest_hosp' Scotland: Direct: 'nearest_hosp' Northern Ireland: Direct: 'Service-weighted fastest travel time by public transport (rank)'								
Data used and resolution	**Source**	**Description**	**Scale**	**Owner**	**Download available**	**In data pack (raw)?**	**Units**	**Confidence**	**Date**
England	Department for Transport	NTS01 Average no of trips made and distance travelled	LSOA(2011)	Department for Transport	JTS0506	Yes	Minutes	High	2019
Wales	Urban Big Data Centre	Access Hospital PT	LSOA(2011)	Urban Big Data Centre	Yes	Yes	Minutes	High	2022
Scotland	Urban Big Data Centre	Access Hospital PT	IDZ(2011)	Urban Big Data Centre	Yes	Yes	Minutes	High	2022
Northern Ireland	NI	NIMDM2017	SOA(2001)	NISRA	Yes	No	Rank	Very low	2017
Rationale	People living in areas which are more physically isolated from health and other support services are less likely to be able to access those services than others. This places constraints on accessing medical help or medicines quickly if experiencing heat stress or accessing repeat prescribed in the aftermath of a flood. These difficulties manifest in an increase in vulnerable compared to other areas.								
Residual notes	Various opportuntiies exist to improve this data through further review of The National Travel Survey 2021 (part of the Analysis Function Reproducible Analytical Pipeline Strategy). It is understood this will also include breakdowns by rural and urban setting and disability in future updates.								

Appendix Table C-52 Distance to green space

Grouping	**Area**								
Domain	**Access to green space**								
Indicator and ID	**ags1 - Access to green space**								
	Does this indicator contribute to an aggregated index?	**Yes**	**Business**		**Flood**		**Heat**	✓	
Processing	England and Wales: Average distance to nearest park or public garden or playing field (m). If neighborhood is rural, force NaN so ignored from z-score Scotland: Average distance to nearest park or public garden or playing field (m). If neighborhood is rural, force NaN so ignored from z-score Northern Ireland: Distane from the centroid of neighbourhood to nearest greenspace access point								
Data used and resolution	**Source**	**Description**	**Scale**	**Owner**	**Download available**	**In data pack (raw)?**	**Units**	**Confidence**	**Date**
England	ONS	ONS access to public green space in Great Britain	LSOA	ONS	Yes	Yes	metres	High	2021
Wales	ONS	ONS access to public green space in Great Britain	LSOA	ONS	Yes	Yes	metres	High	2021
Scotland	ONS	ONS access to public green space in Great Britain	LSOA	ONS	Yes	Yes	metres	High	2021
Northern Ireland	NI Greenspace Layer	NI Greenspace access points]	N/A	Outscape	Yes	Yes	metres	Moderate	2024
Rationale	Proximity to greenspace provides opportunities for people to access cooler areas during heat waves (urban parks have been shown to be on average 1ºC cooler than the surrounding built-up areas due to shading and evapotranspiration, Bowler et al., 2010) and provide broader well-being benefits. Urban neighbourhoods with fewer opportunities to access green space are likely to experience greater impact during heat waves (although the evidence is largely hypothesis rather than observation). Summary references see: Neighbourhoods without much greenspace | Climate Just								
Residual notes	-								

Appendix Table C-53 Size of local green space

Grouping	**Area**								
Domain	**Access to green space**								
Indicator and ID	**ags2 - Size of local green space**								
	Does this indicator contribute to an aggregated index?		**Yes**	**Business**		**Flood**		**Heat**	✓
Processing	England and Wales: Average combined size of parks and public gardens and playing fields within 1,000 m radius (m2). . If neighborhood is rural, force NaN so ignored from z-score Scotland: Average combined size of parks and public gardens and playing fields within 1,000 m radius (m2). . If neighborhood is rural, force NaN so ignored from z-score Northern Ireland: Sum of HA space for all access points within 1KM of neighbourhood centroid								
Data used and resolution	**Source**	**Description**	**Scale**	**Owner**	**Download available**	**In data pack (raw)?**	**Units**	**Confidence**	**Date**
England	ONS	ONS access to public green space in Great Britain	LSOA	ONS	Yes	Yes	m2	High	2021
Wales	ONS	ONS access to public green space in Great Britain	LSOA	ONS	Yes	Yes	m2	High	2021
Scotland	ONS	ONS access to public green space in Great Britain	LSOA	ONS	Yes	Yes	M2	High	2021
Northern Ireland	NI Greenspace Layer	NI Greenspace access points]	N/A	Outscape	Yes	Yes	metres	Moderate	2024
Rationale	Proximity to greenspace provides opportunities for people to access cooler areas during heat waves (urban parks have been shown to be on average 1ºC cooler than the surrounding built-up areas due to shading and evapotranspiration, Bowler et al., 2010) and provide broader well-being benefits. Urban neighbourhoods with fewer opportunities to access green space are likely to experience greater impact during heat waves (although the evidence is largely hypothesis rather than observation). Summary references see: Neighbourhoods without much greenspace | Climate Just								
Residual notes	-								

Appendix Table C-54 Service availability - Emergency services exposed to flooding

Grouping	**Area**								
Domain	**Service availability**								
Indicator and ID	**s1 - Emergency services exposed to flooding**								
	Does this indicator contribute to an aggregated index?	**Yes**	**Business**		**Flood**	✓	**Heat**		
Processing	Reused direct from CCRA3 (Sayers et al., 2020)								
Data used and resolution	**Source**	**Description**	**Scale**	**Owner**	**Download available**	**In data pack (raw)?**	**Units**	**Confidence**	**Date**
England	Sayers et al, 2017	Direct from previous study to support the NFVI update only	LSOA (2011)	SPL	No	No	Count	Moderate	2017
Wales	Sayers et al, 2017	Direct from previous study to support the NFVI update only	LSOA (2011)	SPL	No	No	Count	Moderate	2017
Scotland	Sayers et al, 2017	Direct from previous study to support the NFVI update only	DZ (2011)	SPL	No	Yes	Count	Moderate	2017
Northern Ireland	Sayers et al, 2017	Direct from previous study to support the NFVI update only	SDZ (2011)	SPL	No	Yes	Count	Moderate	2017
Rationale	Various studies highlight the link between the degree of institutional support (such as the police, the fire brigade, ambulances and local authority social care) and community support networks and the vulnerability of the individuals in those communities. Research by the National Flood Forum confirms this to be the case and shows that higher levels of post-flood institutional support (in this case from a charity) accelerates the pace of recovery. Emergency services aim to target the most vulnerable households in assistance efforts but the ability to do this effectively relies on the flood resilience of these services themselves. If a police station, ambulance station, GP surgery or hospital floods the ability to service the community at time of need is severely impacted. Similarly, if a school floods, children are often temporarily transferred to other schools which may be some distance away while the original school is restored. This adds to family disruption and dislocation, increasing their vulnerability. If care or nursing homes are flooded, highly vulnerable residents must be evacuated and suitable placements for them have to be found. Care homes will also often take in vulnerable residents who have been evacuated from their own homes. This system is severely hampered if the care home itself is flooded. Summary references with links to supporting evidence: Sayers, P., Penning-Rowsell, E., Horritt, M. (2017). Flood vulnerability, risk and social disadvantage: Current and future patterns in the UK. Journal of Regional Environmental Change. DOI https://doi.org/10.1007/s10113-017-1252-z								
Residual notes	Various advances are now possible through recent extensive updates to the flood hazard data (such as through Nafra2 in England and elsewhere since CCRA3) but using this data is beyond scope here. As agreed with CCC the native indicator is not needed due to a combination of licence restrcitions and these recent updates. This data is therefore only provided as a Z-score based on the CCRA3 Sayers analysis and used as part of the update to the NFVI. Only a z-score is readily available and provided as an output. This data is already avaiable on the Climate Just website.								

Appendix Table C-55 Service availability – Care homes exposed to flooding

Grouping	**Area**								
Domain	**Service availability**								
Indicator and ID	**s2 - Care homes exposed to flooding**								
	Does this indicator contribute to an aggregated index?	**Yes**	**Business**		**Flood**	✓	**Heat**		
Processing	Reused direct from CCRA3 (Sayers et al., 2020)								
Data used and resolution	**Source**	**Description**	**Scale**	**Owner**	**Download available**	**In data pack (raw)?**	**Units**	**Confidence**	**Date**
England	Sayers et al, 2017	Direct from previous study to support the NFVI update only	LSOA (2011)	SPL	No	No	Count	Moderate	2017
Wales	Sayers et al, 2017	Direct from previous study to support the NFVI update only	LSOA (2011)	SPL	No	No	Count	Moderate	2017
Scotland	Sayers et al, 2017	Direct from previous study to support the NFVI update only	DZ (2011)	SPL	No	Yes	Count	Moderate	2017
Northern Ireland	Sayers et al, 2017	Direct from previous study to support the NFVI update only	SDZ (2011)	SPL	No	Yes	Count	Moderate	2017
Rationale	Various studies highlight the link between the degree of institutional support (such as the police, the fire brigade, ambulances and local authority social care) and community support networks and the vulnerability of the individuals in those communities. Research by the National Flood Forum confirms this to be the case and shows that higher levels of post-flood institutional support (in this case from a charity) accelerates the pace of recovery. Emergency services aim to target the most vulnerable households in assistance efforts but the ability to do this effectively relies on the flood resilience of these services themselves. If a police station, ambulance station, GP surgery or hospital floods the ability to service the community at time of need is severely impacted. Similarly, if a school floods, children are often temporarily transferred to other schools which may be some distance away while the original school is restored. This adds to family disruption and dislocation, increasing their vulnerability. If care or nursing homes are flooded, highly vulnerable residents must be evacuated and suitable placements for them have to be found. Care homes will also often take in vulnerable residents who have been evacuated from their own homes. This system is severely hampered if the care home itself is flooded. Summary references with links to supporting evidence: Sayers, P., Penning-Rowsell, E., Horritt, M. (2017). Flood vulnerability, risk and social disadvantage: Current and future patterns in the UK. Journal of Regional Environmental Change. DOI https://doi.org/10.1007/s10113-017-1252-z								
Residual notes	Various advances are now possible through recent extensive updates to the flood hazard data (such as through Nafra2 in England and elsewhere since CCRA3) but using this data is beyond scope here. As agreed with CCC the native indicator is not needed due to a combination of licence restrcitions and these recent updates. This data is therefore only provided as a Z-score based on the CCRA3 Sayers analysis and used as part of the update to the NFVI. Only a z-score is readily available and provided as an output. This data is already avaiable on the Climate Just website.								

Appendix Table C-56 Service availability – GP surgeries exposed to flooding

Grouping	**Area**								
Domain	**Service availability**								
Indicator and ID	**s3 - GP surgeries exposed to flooding**								
	Does this indicator contribute to an aggregated index?	**Yes**	**Business**		**Flood**	✓	**Heat**		
Processing	Reused direct from CCRA3 (Sayers et al., 2020)								
Data used and resolution	**Source**	**Description**	**Scale**	**Owner**	**Download available**	**In data pack (raw)?**	**Units**	**Confidence**	**Date**
England	Sayers et al, 2017	Direct from previous study to support the NFVI update only	LSOA (2011)	SPL	No	No	Count	Moderate	2017
Wales	Sayers et al, 2017	Direct from previous study to support the NFVI update only	LSOA (2011)	SPL	No	No	Count	Moderate	2017
Scotland	Sayers et al, 2017	Direct from previous study to support the NFVI update only	DZ (2011)	SPL	No	Yes	Count	Moderate	2017
Northern Ireland	Sayers et al, 2017	Direct from previous study to support the NFVI update only	SDZ (2011)	SPL	No	Yes	Count	Moderate	2017
Rationale	Various studies highlight the link between the degree of institutional support (such as the police, the fire brigade, ambulances and local authority social care) and community support networks and the vulnerability of the individuals in those communities. Research by the National Flood Forum confirms this to be the case and shows that higher levels of post-flood institutional support (in this case from a charity) accelerates the pace of recovery. Emergency services aim to target the most vulnerable households in assistance efforts but the ability to do this effectively relies on the flood resilience of these services themselves. If a police station, ambulance station, GP surgery or hospital floods the ability to service the community at time of need is severely impacted. Similarly, if a school floods, children are often temporarily transferred to other schools which may be some distance away while the original school is restored. This adds to family disruption and dislocation, increasing their vulnerability. If care or nursing homes are flooded, highly vulnerable residents must be evacuated and suitable placements for them have to be found. Care homes will also often take in vulnerable residents who have been evacuated from their own homes. This system is severely hampered if the care home itself is flooded. Summary references with links to supporting evidence: Sayers, P., Penning-Rowsell, E., Horritt, M. (2017). Flood vulnerability, risk and social disadvantage: Current and future patterns in the UK. Journal of Regional Environmental Change. DOI https://doi.org/10.1007/s10113-017-1252-z								
Residual notes	Various advances are now possible through recent extensive updates to the flood hazard data (such as through Nafra2 in England and elsewhere since CCRA3) but using this data is beyond scope here. As agreed with CCC the native indicator is not needed due to a combination of licence restrcitions and these recent updates. This data is therefore only provided as a Z-score based on the CCRA3 Sayers analysis and used as part of the update to the NFVI. Only a z-score is readily available and provided as an output. This data is already avaiable on the Climate Just website.								

Appendix Table C-57 Service availability – Schools exposed to flooding

Grouping	**Area**								
Domain	**Service availability**								
Indicator and ID	**s4 - Schools exposed to flooding**								
	Does this indicator contribute to an aggregated index?		**Yes**	**Business**		**Flood**	✓	**Heat**	
Processing	Reused direct from CCRA3 (Sayers et al., 2020)								
Data used and resolution	**Source**	**Description**	**Scale**	**Owner**	**Download available**	**In data pack (raw)?**	**Units**	**Confidence**	**Date**
England	Sayers et al, 2017	Direct from previous study to support the NFVI update only	LSOA (2011)	SPL	No	No	Count	Moderate	2017
Wales	Sayers et al, 2017	Direct from previous study to support the NFVI update only	LSOA (2011)	SPL	No	No	Count	Moderate	2017
Scotland	Sayers et al, 2017	Direct from previous study to support the NFVI update only	DZ (2011)	SPL	No	Yes	Count	Moderate	2017
Northern Ireland	Sayers et al, 2017	Direct from previous study to support the NFVI update only	SDZ (2011)	SPL	No	Yes	Count	Moderate	2017
Rationale	Various studies highlight the link between the degree of institutional support (such as the police, the fire brigade, ambulances and local authority social care) and community support networks and the vulnerability of the individuals in those communities. Research by the National Flood Forum confirms this to be the case and shows that higher levels of post-flood institutional support (in this case from a charity) accelerates the pace of recovery. Emergency services aim to target the most vulnerable households in assistance efforts but the ability to do this effectively relies on the flood resilience of these services themselves. If a police station, ambulance station, GP surgery or hospital floods the ability to service the community at time of need is severely impacted. Similarly, if a school floods, children are often temporarily transferred to other schools which may be some distance away while the original school is restored. This adds to family disruption and dislocation, increasing their vulnerability. If care or nursing homes are flooded, highly vulnerable residents must be evacuated and suitable placements for them have to be found. Care homes will also often take in vulnerable residents who have been evacuated from their own homes. This system is severely hampered if the care home itself is flooded. Summary references with links to supporting evidence: Sayers, P., Penning-Rowsell, E., Horritt, M. (2017). Flood vulnerability, risk and social disadvantage: Current and future patterns in the UK. Journal of Regional Environmental Change. DOI https://doi.org/10.1007/s10113-017-1252-z								
Residual notes	Various advances are now possible through recent extensive updates to the flood hazard data (such as through Nafra2 in England and elsewhere since CCRA3) but using this data is beyond scope here. As agreed with CCC the native indicator is not needed due to a combination of licence restrcitions and these recent updates. This data is therefore only provided as a Z-score based on the CCRA3 Sayers analysis and used as part of the update to the NFVI. Only a z-score is readily available and provided as an output. This data is already avaiable on the Climate Just website.								

Appendix Table C-58 Social networks – Single-pensioner households

Grouping	**Area**								
Domain	**Social networks**								
Indicator and ID	**n1 - Single-pensioner households**								
	Does this indicator contribute to an aggregated index?	**Yes**	**Business**		**Flood**	✓	**Heat**	✓	
Processing	Number of households 'One person household: Aged 66 and over' divided by the total number of households and multiplied by 100.								
Data used and resolution	**Source**	**Description**	**Scale**	**Owner**	**Download available**	**In data pack (raw)?**	**Units**	**Confidence**	**Date**
England	Census	Ts003	LSOA	ONS	Yes	Yes	%	High	2021
Wales	Census	Ts003	LSOA	ONS	Yes	Yes	%	High	2021
Scotland	Census	UV113 - Household composition - Households	OA	Scottish Government	Yes	Yes	%	High	2022
Northern Ireland	Census	NISRA Household Composition - 9 Categories	SDZ	NISRA	Yes	Yes	%	High	2021
Rationale	Various studies have made the connections between a lack of social or community networks and levels of social deprivation in an area. Where social networks are relatively good there is evidence of a better response to emergency situations and quicker recovery. Individuals that are more likely to feel socially isolated include single parents, lone pensioners and new arrivals to an area may face practical difficulties in responding to a flood where children are dependent on them as there is less direct within-the-family support. Adults who live alone (including those with dependent children) are more likely to struggle to take action when receiving a flood warning, for example it may be physically impossible to move furniture or other items, and they will also feel more uncertain and anxious with no-one to confide in. With limited social networks people may face difficulties in accessing short-term alternative accommodation from family and friends, and so are more likely to need to use public shelters in the event of an evacuation, but also may be less likely to know about the existence and location of such services. Opportunities for informal networks (via school or community groups) are much reduced or even absent during a flood. Summary references with links to supporting references: Sayers, P., Penning-Rowsell, E., Horritt, M. (2017). Flood vulnerability, risk and social disadvantage: Current and future patterns in the UK. Journal of Regional Environmental Change. DOI https://doi.org/10.1007/s10113-017-1252-z								
Residual notes	-								

Appendix Table C-59 Social networks – Lone-parent households with dependent children

Grouping	**Area**								
Domain	**Social networks**								
Indicator and ID	**n2 - Lone-parent households with dependent children**								
	Does this indicator contribute to an aggregated index?	**Yes**	**Business**		**Flood**	✓	**Heat**		
Processing	Number of households 'Single family household: Lone parent family: With dependent children' divided by the total number of households and multiplied by 100.								
Data used and resolution	**Source**	**Description**	**Scale**	**Owner**	**Download available**	**In data pack (raw)?**	**Units**	**Confidence**	**Date**
England	Census	Ts003	LSOA	ONS	Yes	Yes	%	High	2021
Wales	Census	Ts003	LSOA	ONS	Yes	Yes	%	High	2021
Scotland	Census	UV113 - Household composition - Households	OA	Scottish Government	Yes	Yes	%	High	2022
Northern Ireland	Census	NISRA Household Composition - 9 Categories	SDZ	NISRA	Yes	Yes	%	High	2021
Rationale	Various studies have made the connections between a lack of social or community networks and levels of social deprivation in an area. Where social networks are relatively good there is evidence of a better response to emergency situations and quicker recovery. Individuals that are more likely to feel socially isolated include single parents, lone pensioners and new arrivals to an area may face practical difficulties in responding to a flood where children are dependent on them as there is less direct within-the-family support. Adults who live alone (including those with dependent children) are more likely to struggle to take action when receiving a flood warning, for example it may be physically impossible to move furniture or other items, and they will also feel more uncertain and anxious with no-one to confide in. With limited social networks people may face difficulties in accessing short-term alternative accommodation from family and friends, and so are more likely to need to use public shelters in the event of an evacuation, but also may be less likely to know about the existence and location of such services. Opportunities for informal networks (via school or community groups) are much reduced or even absent during a flood. Summary references with links to supporting references: Sayers, P., Penning-Rowsell, E., Horritt, M. (2017). Flood vulnerability, risk and social disadvantage: Current and future patterns in the UK. Journal of Regional Environmental Change. DOI https://doi.org/10.1007/s10113-017-1252-z								
Residual notes	-								

Appendix Table C-60 Social networks – Lack of school-related networks

Grouping	**Area**								
Domain	**Social networks**								
Indicator and ID	**n3 - Lack of school-related networks**								
	Does this indicator contribute to an aggregated index?	**Yes**	**Business**		**Flood**	✓	**Heat**	✓	
Processing	(1 - (sum of number of people aged 4-11 divided by the total usual residents)) and multiplied by 100								
Data used and resolution	**Source**	**Description**	**Scale**	**Owner**	**Download available**	**In data pack (raw)?**	**Units**	**Confidence**	**Date**
England	ONS	Mid-year pop est	MSOA	ONS	Yes	Yes	%	High	2021
Wales	ONS	Mid-year pop est	MSOA	ONS	Yes	Yes	%	High	2021
Scotland	Census	UV103 - Age by single year	OA	Scottish Government	Yes	Yes	%	High	2022
Northern Ireland	Census	NISRA all ages	SDZ	NISRA	Yes	Yes	%	High	2021
Rationale	Various studies have made the connections between a lack of social or community networks and levels of social deprivation in an area. Where social networks are relatively good there is evidence of a better response to emergency situations and quicker recovery. Individuals that are more likely to feel socially isolated include single parents, lone pensioners and new arrivals to an area may face practical difficulties in responding to a flood where children are dependent on them as there is less direct within-the-family support. Adults who live alone (including those with dependent children) are more likely to struggle to take action when receiving a flood warning, for example it may be physically impossible to move furniture or other items, and they will also feel more uncertain and anxious with no-one to confide in. With limited social networks people may face difficulties in accessing short-term alternative accommodation from family and friends, and so are more likely to need to use public shelters in the event of an evacuation, but also may be less likely to know about the existence and location of such services. Opportunities for informal networks (via school or community groups) are much reduced or even absent during a flood. Summary references with links to supporting references: Sayers, P., Penning-Rowsell, E., Horritt, M. (2017). Flood vulnerability, risk and social disadvantage: Current and future patterns in the UK. Journal of Regional Environmental Change. DOI https://doi.org/10.1007/s10113-017-1252-z								
Residual notes	The NFVI (2107) this was written from the prespective of 'reducing vulnerability' so recast here to reflect heightening vulnerability.								

Appendix Table C-61 Business presence - Non-residential properties

Grouping	**Business**								
Domain	**Business presence**								
Indicator and ID	**bb1 - Non-residential properties**								
	Does this indicator contribute to an aggregated index?	**No**	**Business**		**Flood**		**Heat**		
Processing	England: Sumary statistics taken from the NRD Non-residential properties, spatially joined with LSOAs Wales: Summary statistics taken from the NRD Non-residential properties processed in CCRA3, spatially joined with LSOAs Scotland: Summary statistics taken from the NRD Non-residential properties processed in CCRA3, spatially joined with IZBs Northern Ireland: summary statistics taken from the NRD Non-residential properties data set provided under licence, spatially joined with SDZs								
Data used and resolution	**Source**	**Description**	**Scale**	**Owner**	**Download available**	**In data pack (raw)?**	**Units**	**Confidence**	**Date**
England	Defra	National Receptor Dataset	LSOA	Defra	No	No	Count	Moderate	2022
Wales	NRD and CCRA3	National Receptor Dataset as procssed in CCRA3	LSOA	National Resources Wales	No	No	Count	Low	2018
Scotland	NRD and CCRA3	National Receptor Dataset as procssed in CCRA3	IZB	Scottish Government	No	No	Count	Low	2018
Northern Ireland	Fusion Largescale Buildings	POINTER dataset	SDZ	OSNI	No	No	Count	Moderate	2018
Rationale	Provides a (basic) indication of the scale of business activity within an area								
Residual notes	All data provided under licence. Therefore Z-score only to provided								

Appendix Table C-62 Operational flexibility - Outdoor workers (working in the area)

Grouping	**Business**								
Domain	**Operational flexibility**								
Indicator and ID	**bt2 - Outdoor workers (working in the area)**								
	Does this indicator contribute to an aggregated index?	**Yes**	**Business**	✓	**Flood**		**Heat**		
Processing	England and Wales: Sum of workers in 511 Agricultural and related trades; 631 Community and civil enforcement occupations; 822 Mobile machine drivers and operatives; 911 Elementary agricultural occupations, 531 Construction and building trades and 912 Elementary construction occupations divided by sum of all categories (indoors and outdoors) Scotland: No data available at time of processing Northern Ireland: No data available at time of processing								
Data used and resolution	**Source**	**Description**	**Scale**	**Owner**	**Download available**	**In data pack (raw)?**	**Units**	**Confidence**	**Date**
England	Census	Workday populations	MSOA	ONS	Yes	Yes	%	Low	2021
Wales	Census	Workday populations	MSOA	ONS	Yes	No	%	Low	2021
Scotland	-	Still in review at time of data cut-off	-	-	No	No	-	-	-
Northern Ireland	-	Still in review at time of data cut-off	-	-	No	No	-	-	-
Rationale	Workers in the area and in jobs that expose them directly to the weather, and activities are often disturbed by the weather, heightening vulnerable to climate change. For a business vulnerability prespective the workplace environment can significantly influence a business's vulnerability to climate change (e.g., Cox et al., 2022). This is particular the case if a business relies upon outdoor workers. Climate events such as heat and flood events can disrupt operations as in more extreme cases pose significant safety risks. Outdoor works are more likely to suffer heat-related illnesses, reducing worker productivity and increasing absenteeism. Outdoor work often involves supply chain activities that can be disrupted by climate-related events, affecting the timely delivery of goods and services. Climate events can also damage infrastructure that may be critical to outdoor work, such as roads, bridges, and equipment, leading to increased repair costs and operational delays. Implement strategies to mitigate these risks relies about organisation capacity financial resources to identify and invest in climate-resilient infrastructure, developing adequate training, and providing protective equipped and spaces, as well as developing contingency plans for extreme weather events.								
Residual notes	-								

Appendix Table C-63 Operational flexibility - Share of outdoor workers in permanent activities (working in the area)

Grouping	**Business**								
Domain	**Operational flexibility**								
Indicator and ID	**bt3 - Share of outdoor workers in permanent activities (working in the area)**								
	Does this indicator contribute to an aggregated index?	**No**	**Business**		**Flood**		**Heat**		
Processing	England and Wales: Sum of workers in 511 Agricultural and related trades; 631 Community and civil enforcement occupations; 822 Mobile machine drivers and operatives; 911 Elementary agricultural occupations divided by sum of all categories of outdoor workers (as defined by Bt3 and Bt4) and multiplied by 100. Scotland: No data available at time of processing Northern Ireland: No data available at time of processing								
Data used and resolution	**Source**	**Description**	**Scale**	**Owner**	**Download available**	**In data pack (raw)?**	**Units**	**Confidence**	**Date**
England	Census	Workday populations	MSOA	ONS	Yes	Yes	%	Low	2021
Wales	Census	Workday populations	MSOA	ONS	Yes	No	%	Low	2021
Scotland	-	Still in review at time of data cut-off	-	-	No	No	-	-	-
Northern Ireland	-	Still in review at time of data cut-off	-	-	No	No	-	-	-
Rationale	Permanent workers exposed directly to the weather, and activities are often disturbed by the weather, heightening vulnerablility to climate change. For a business vulnerability prespective the workplace environment can significantly influence a business's vulnerability to climate change (e.g., Cox et al., 2022). This is particular the case if a business relies upon outdoor workers. Climate events such as heat and flood events can disrupt operations as in more extreme cases pose significant safety risks. Outdoor works are more likely to suffer heat-related illnesses, reducing worker productivity and increasing absenteeism. Outdoor work often involves supply chain activities that can be disrupted by climate-related events, affecting the timely delivery of goods and services. Climate events can also damage infrastructure that may be critical to outdoor work, such as roads, bridges, and equipment, leading to increased repair costs and operational delays. Implement strategies to mitigate these risks relies about organisation capacity financial resources to identify and invest in climate-resilient infrastructure, developing adequate training, and providing protective equipped and spaces, as well as developing contingency plans for extreme weather events.								
Residual notes	-								

Appendix Table C-64 Operational flexibility - Share of outdoor workers in transient activities (working in the area)

Grouping	**Business**								
Domain	**Operational flexibility**								
Indicator and ID	**bt4 - Share of outdoor workers in transient activities (working in the area)**								
	Does this indicator contribute to an aggregated index?	**Yes**	**Business**	✓	**Flood**		**Heat**		
Processing	England and Wales: :Sum of workers in 531 Construction and building trades and 912 Elementary construction occupations divided by sum of all categories of outdoor workers (as defined by Bt3 and Bt4) and multiplied by 100. Scotland: No data available at time of processing Northern Ireland: No data available at time of processing								
Data used and resolution	**Source**	**Description**	**Scale**	**Owner**	**Download available**	**In data pack (raw)?**	**Units**	**Confidence**	**Date**
England	Census	Workday populations	MSOA	ONS	Yes	Yes	%	Low	2021
Wales	Census	Workday populations	MSOA	ONS	Yes	No	%	Low	2021
Scotland	-	Still in review at time of data cut-off	-	-	No	No	-	-	-
Northern Ireland	-	Still in review at time of data cut-off	-	-	No	No	-	-	-
Rationale	transient workers exposed directly to the weather, and activities are often disturbed by the weather, heightening vulnerable to climate change. For a business vulnerability prespective the workplace environment can significantly influence a business's vulnerability to climate change (e.g., Cox et al., 2022). This is particular the case if a business relies upon outdoor workers. Climate events such as heat and flood events can disrupt operations as in more extreme cases pose significant safety risks. Outdoor works are more likely to suffer heat-related illnesses, reducing worker productivity and increasing absenteeism. Outdoor work often involves supply chain activities that can be disrupted by climate-related events, affecting the timely delivery of goods and services. Climate events can also damage infrastructure that may be critical to outdoor work, such as roads, bridges, and equipment, leading to increased repair costs and operational delays. Implement strategies to mitigate these risks relies about organisation capacity financial resources to identify and invest in climate-resilient infrastructure, developing adequate training, and providing protective equipped and spaces, as well as developing contingency plans for extreme weather events.								
Residual notes	-								

Appendix Table C-65 Operational flexibility - Outdoor workers (living within the area)

Grouping	**Business**								
Domain	**Operational flexibility**								
Indicator and ID	**bt1 - Outdoor workers (living within the area)**								
	Does this indicator contribute to an aggregated index?	**No**	**Business**		**Flood**		**Heat**		
Processing	England and Wales: Sum of workers in A: Agriculture, Forestry and fishing, plus 41 Construction of buildings plus 93 Sports activities and amusement and recreation activities divided by all people with a code (i.e. In work) multiplied by 100. Scotland: Sum of workers in 'Agriculture; Forestry; Fishing' plus 'Construction' divided by working age population in employment multiplied by 100 Northern Ireland: ('51 Skilled agricultural and related trades' plus '53 Skilled construction and building trades' plus '91 Elementary trades and related occupations') divided by no people with a code (i.e. in work), multiplied by 100								
Data used and resolution	**Source**	**Description**	**Scale**	**Owner**	**Download available**	**In data pack (raw)?**	**Units**	**Confidence**	**Date**
England	Census	ts060	MSOA	ONS	Yes	Yes	%	Low	2021
Wales	Census	ts060	MSOA	ONS	Yes	No	%	Low	2021
Scotland	Census	UV605 - Industry	OA	Scottish Government	Yes	No	%	Mod	2022
Northern Ireland	Census	MS-H10 - Occupation - minor groups (2-digit)	SDZ	NISRA	Yes	No	%	Low	2021
Rationale	People living in the area and in jobs that expose them directly to the weather, and activities are often disturbed by the weather, heightening vulnerable to climate change								
Residual notes	-								

Appendix Table C-66 Operational flexibility - Home workers

Grouping	**Business**								
Domain	**Operational flexibility**								
Indicator and ID	**bt6 - Home workers**								
	Does this indicator contribute to an aggregated index?	**No**	**Business**		**Flood**		**Heat**		
Processing	England and Wales: No. of people 'Mainly working at or from home' divided by the working age population and multiplied by 100 Scotland: No. of people 'Mainly working at or from home' divided by the working age population and multiplied by 100 Northern Ireland: No people mainly working from home, divided by all residents over 16, multiplied by 100								
Data used and resolution	**Source**	**Description**	**Scale**	**Owner**	**Download available**	**In data pack (raw)?**	**Units**	**Confidence**	**Date**
England	Census	Bespoke query	MSOA	ONS	Bespoke query	Yes	%	Low	2021
Wales	Census	Bespoke query	MSOA	ONS	Bespoke query	No	%	Low	2021
Scotland	Census	UV703 - Distance travelled to work	OA	Scottish Government	Yes	No	%	High	2022
Northern Ireland	Census	NISRA Distance travelled to work	SDZ	NISRA	Yes	No	%	Low	2021
Rationale	Home workers are less likely to have access to commercial quality climate controls, and may be less able to continue to work if their home is subject to a climate event. No used here as part of the aggregated indices by included to support the differenitaion of adaptation measures.								
Residual notes	Measure used as a proxy for likelihood of home working. Suggestions for assessment of reliability (a) compare to 2011 or (b) derive by employment type to exclude job roles which are normally place-based, e.g. teachers. Note: the Census says: At the time of Census 2021, UK government guidance and lockdown restrictions resulted in unprecedented changes to travel behaviour and patterns. It is not clear if furloughed respondents followed guidance as intended.								

Appendix Table C-67 Organisational capacity - Micro companies

Grouping	**Business**								
Domain	**Organisational capacity**								
Indicator and ID	**bb2 - Micro companies**								
	Does this indicator contribute to an aggregated index?	**Yes**	**Business**	✓	**Flood**		**Heat**		
Processing	England and Wales: Companies with 0-9 employees divided by the total number of companies, multiplied by 100 Scotland: Companies with 0-9 employees divided by the total number of companies, multiplied by 100 Northern Ireland: ('Companies with 0 employees' plus 'Companies with 1-9 employees') divided by the total number of companies, multiplied by 100								
Data used and resolution	**Source**	**Description**	**Scale**	**Owner**	**Download available**	**In data pack (raw)?**	**Units**	**Confidence**	**Date**
England	ONS	Business size	LA	HMRC	Yes	Yes	%	Low	2022
Wales	ONS	Business size	LA	HMRC	Yes	No	%	Low	2022
Scotland	ONS	Business size	LA	HMRC	Yes	No	%	High	2023
Northern Ireland	Inter-departmental Businessregister	Northern Ireland business: activity, size and location, 2024	LDG	NISRA	Yes	No	%	High	2024
Rationale	Organisation capacity to prepare for and respond to climate events can be significantly influenced by company size. Larger companies often have more financial and human resources to invest in climate adaptation measures, such as upgrading infrastructure, and developing resilience strategies as well as the expertise to develop and implement more comprehensive plans. With more resources and expertise, larger companies can invest in practice and innovative solutions to mitigate climate risks, and develop partnerships with other organizations to share the risk. Larger companies typically have more robust risk management frameworks, which can help them identify, assess, and address climate-related risks more effectively, as well as greater influence over their supply chains, allowing them to work with suppliers to reduce the risk. As regulation continues to develop larger business often have more capacity to navigate complex regulatory environments and ensure compliance with climate-related regulations, and hence delivery the desired regulatory outcomes of greater resilience. Company resilience may vary with company size and available resources to prepare and recover although little evidence exists								
Residual notes									

Appendix Table C-68 Organisational capacity - Small companies

Grouping	**Business**								
Domain	**Organisational capacity**								
Indicator and ID	**bb3 - Small companies**								
	Does this indicator contribute to an aggregated index?	**Yes**	**Business**	✓	**Flood**		**Heat**		
Processing	Companies with 10-49 employees divided by the total number of companies, multiplied by 100								
Data used and resolution	**Source**	**Description**	**Scale**	**Owner**	**Download available**	**In data pack (raw)?**	**Units**	**Confidence**	**Date**
England	ONS	Business size	LA	HMRC	Yes	Yes	%	Low	2022
Wales	ONS	Business size	LA	HMRC	Yes	No	%	Low	2022
Scotland	ONS	Business size	LA	HMRC	Yes	No	%	Low	2022
Northern Ireland	Inter-departmental Businessregister	Northern Ireland business: activity, size and location, 2024	LDG	NISRA	Yes	No	%	High	2024
Rationale	Organisation capacity to prepare for and respond to climate events can be significantly influenced by company size. Larger companies often have more financial and human resources to invest in climate adaptation measures, such as upgrading infrastructure, and developing resilience strategies as well as the expertise to develop and implement more comprehensive plans. With more resources and expertise, larger companies can invest in practice and innovative solutions to mitigate climate risks, and develop partnerships with other organizations to share the risk. Larger companies typically have more robust risk management frameworks, which can help them identify, assess, and address climate-related risks more effectively, as well as greater influence over their supply chains, allowing them to work with suppliers to reduce the risk. As regulation continues to develop larger business often have more capacity to navigate complex regulatory environments and ensure compliance with climate-related regulations, and hence delivery the desired regulatory outcomes of greater resilience. Company resilience may vary with company size and available resources to prepare and recover although little evidence exists								
Residual notes									

Appendix Table C-69 Organisational capacity - Medium companies

Grouping	**Business**								
Domain	**Organisational capacity**								
Indicator and ID	**bb4 - Medium companies**								
	Does this indicator contribute to an aggregated index?	**No**	**Business**		**Flood**		**Heat**		
Processing	Companies with 50-249 employees divided by the total number of companies, multiplied by 100								
Data used and resolution	**Source**	**Description**	**Scale**	**Owner**	**Download available**	**In data pack (raw)?**	**Units**	**Confidence**	**Date**
England	ONS	Business size	LA	HMRC	Yes	Yes	%	Low	2022
Wales	ONS	Business size	LA	HMRC	Yes	No	%	Low	2022
Scotland	ONS	Business size	LA	HMRC	Yes	No	%	Low	2022
Northern Ireland	Inter-departmental Businessregister	Northern Ireland business: activity, size and location, 2024	LDG	NISRA	Yes	No	%	High	2024
Rationale	Organisation capacity to prepare for and respond to climate events can be significantly influenced by company size. Larger companies often have more financial and human resources to invest in climate adaptation measures, such as upgrading infrastructure, and developing resilience strategies as well as the expertise to develop and implement more comprehensive plans. With more resources and expertise, larger companies can invest in practice and innovative solutions to mitigate climate risks, and develop partnerships with other organizations to share the risk. Larger companies typically have more robust risk management frameworks, which can help them identify, assess, and address climate-related risks more effectively, as well as greater influence over their supply chains, allowing them to work with suppliers to reduce the risk. As regulation continues to develop larger business often have more capacity to navigate complex regulatory environments and ensure compliance with climate-related regulations, and hence delivery the desired regulatory outcomes of greater resilience. Company resilience may vary with company size and available resources to prepare and recover although little evidence exists								
Residual notes									

Appendix Table C-70 Organisational capacity – Large companies

Grouping	**Business**								
Domain	**Organisational capacity**								
Indicator and ID	**bb5 - Large companies**								
	Does this indicator contribute to an aggregated index?	**No**	**Business**		**Flood**		**Heat**		
Processing	Companies with 250+ employees divided by the total number of companies, multiplied by 100								
Data used and resolution	**Source**	**Description**	**Scale**	**Owner**	**Download available**	**In data pack (raw)?**	**Units**	**Confidence**	**Date**
England	ONS	Business size	LA	HMRC	Yes	Yes	%	Low	2022
Wales	ONS	Business size	LA	HMRC	Yes	No	%	Low	2022
Scotland	ONS	Business size	LA	HMRC	Yes	No	%	Low	2022
Northern Ireland	Inter-departmental Businessregister	Northern Ireland business: activity, size and location, 2024	LDG	NISRA	Yes	No	%	High	2024
Rationale	Organisation capacity to prepare for and respond to climate events can be significantly influenced by company size. Larger companies often have more financial and human resources to invest in climate adaptation measures, such as upgrading infrastructure, and developing resilience strategies as well as the expertise to develop and implement more comprehensive plans. With more resources and expertise, larger companies can invest in practice and innovative solutions to mitigate climate risks, and develop partnerships with other organizations to share the risk. Larger companies typically have more robust risk management frameworks, which can help them identify, assess, and address climate-related risks more effectively, as well as greater influence over their supply chains, allowing them to work with suppliers to reduce the risk. As regulation continues to develop larger business often have more capacity to navigate complex regulatory environments and ensure compliance with climate-related regulations, and hence delivery the desired regulatory outcomes of greater resilience. Company resilience may vary with company size and available resources to prepare and recover although little evidence exists								
Residual notes	-								

Appendix Table C-71 Financial resources - SME loans

Grouping	**Business**								
Domain	**Financial resources**								
Indicator and ID	**bb8 - SME loans**								
	Does this indicator contribute to an aggregated index?	**Yes**	**Business**	✓	**Flood**		**Heat**		
Processing	Determine ratio of postcodes within a postcode sector to OA21. Take the total borrowing in H2 2023 in each postcode sector and divide between the OAs that the comprising postcodes belong to using each postcode as equal weight. Sum up to LSOA scale								
Data used and resolution	**Source**	**Description**	**Scale**	**Owner**	**Download available**	**In data pack (raw)?**	**Units**	**Confidence**	**Date**
England	SME Lending	SME Lending within UK postcodes (H2: 2023)	Postcode sector	UK Finance	Yes	Yes	£	Low	2023
Wales	SME Lending	SME Lending within UK postcodes (H2: 2023)	Postcode sector	UK Finance	Yes	Yes	£	Low	2023
Scotland	SME Lending	SME Lending within UK postcodes (H2: 2023)	Postcode sector	UK Finance	Yes	Yes	£	Low	2023
Northern Ireland	SME Lending	SME Lending within UK postcodes (H2: 2023)	Postcode sector	UK Finance	Yes	Yes	£	Low	2023
Rationale	Financial resources provide the buffer and flexibility needed to navigate the uncertainties and challenges posed by climate events and to survive a climate shock. Sufficient liquidity allows businesses to cover immediate expenses and maintain operations during disruptions, whilst health financial resources enable businesses to invest in climate adaptation and resilience, and direct effort towards opportunities that may emerge through new market conditions.								
Residual notes	-								

Appendix Table C-72 Financial resources - Gross value added per hour

Grouping	**Business**								
Domain	**Financial resources**								
Indicator and ID	**bb9 - Gross value added per hour**								
	Does this indicator contribute to an aggregated index?	**Yes**	**Business**	✓	**Flood**		**Heat**		
Processing	Direct: Table A3: Current Price (smoothed) GVA (B) per hour worked (£); 2022								
Data used and resolution	**Source**	**Description**	**Scale**	**Owner**	**Download available**	**In data pack (raw)?**	**Units**	**Confidence**	**Date**
England	ONS Labour productivity	Subregional productivity: labour productivity indices by local authority district	LA(2023)	ONS	Yes	Yes	£	Moderate	2022
Wales	ONS Labour productivity	Subregional productivity: labour productivity indices by local authority district	LA(2023)	ONS	Yes	Yes	£	Moderate	2022
Scotland	ONS Labour productivity	Subregional productivity: labour productivity indices by local authority district	LA(2023)	ONS	Yes	Yes	£	Moderate	2022
Northern Ireland	ONS Labour productivity	Subregional productivity: labour productivity indices by local authority district	LA (2023)	ONS	Yes	Yes	£	Moderate	2022
Rationale	Financial resources provide the buffer and flexibility needed to navigate the uncertainties and challenges posed by climate events and to survive a climate shock. Sufficient liquidity allows businesses to cover immediate expenses and maintain operations during disruptions, whilst health financial resources enable businesses to invest in climate adaptation and resilience, and direct effort towards opportunities that may emerge through new market conditions.								
Residual notes	-								

Appendix Table C-73 Financial resources - Productive hours

Grouping	**Business**								
Domain	**Financial resources**								
Indicator and ID	**bb10 - Productive hours**								
	Does this indicator contribute to an aggregated index?	**Yes**	**Business**	✓	**Flood**		**Heat**		
Processing	Direct: Table Productive Hours: Productivity Hours Worked per Week by Local Authority District (constrained to ITL1), 2022								
Data used and resolution	**Source**	**Description**	**Scale**	**Owner**	**Download available**	**In data pack (raw)?**	**Units**	**Confidence**	**Date**
England	ONS Labour productivity	Subregional productivity: labour productivity indices by local authority district	LA(2023)	ONS	Yes	Yes	Count	Moderate	2022
Wales	ONS Labour productivity	Subregional productivity: labour productivity indices by local authority district	LA(2023)	ONS	Yes	Yes	Count	Moderate	2022
Scotland	ONS Labour productivity	Subregional productivity: labour productivity indices by local authority district	LA(2023)	ONS	Yes	Yes	Count	Moderate	2022
Northern Ireland	ONS Labour productivity	Subregional productivity: labour productivity indices by local authority district	LA(2023)	ONS	Yes	Yes	Count	Moderate	2022
Rationale	Financial resources provide the buffer and flexibility needed to navigate the uncertainties and challenges posed by climate events and to survive a climate shock. Sufficient liquidity allows businesses to cover immediate expenses and maintain operations during disruptions, whilst health financial resources enable businesses to invest in climate adaptation and resilience, and direct effort towards opportunities that may emerge through new market conditions.								
Residual notes	-								

Appendix Table C-74 Other influences - Adult skills

Grouping	**Business**								
Domain	**Other influences**								
Indicator and ID	**be4 - Adult skills**								
	Does this indicator contribute to an aggregated index?	**Yes**	**Business**	✓	**Flood**		**Heat**		
Processing	England and Wales: Turn codes into a score: 0: 0, 1: 1, 2: 1, 3: 3, 4: 2, 5: 5, 6: 3. Then find the average score for each LSoA. 1 is least educated Scotland: No people: ('Lower school qualifications + 'Upper school qualifications' * 2 + 'Apprenticeship qualifications' * 3 + 'Further Education and sub-degree Higher Education qualifications' * 4 + 'Degree level qualifications or above' * 5) divided by total population over 16, multiplied by 100 Northern Ireland: No people: ('Lower school qualifications + 'Upper school qualifications' * 2 + 'Apprenticeship qualifications' * 3 + 'Further Education and sub-degree Higher Education qualifications' * 4 + 'Degree level qualifications or above' * 5) divided by total population over 16, multiplied by 100								
Data used and resolution	**Source**	**Description**	**Scale**	**Owner**	**Download available**	**In data pack (raw)?**	**Units**	**Confidence**	**Date**
England	Census	TS067 - Highest level of qualification	LSOA	ONS	Yes	Yes	Score	Moderate	2021
Wales	Census	TS067 - Highest level of qualification	LSOA	ONS	Yes	No	Score	Moderate	2021
Scotland	Census	UV501 - Highest level of qualification	OA	Scottish Government	Yes	No	Score	High	2022
Northern Ireland	Census	MS-G01 - Highest qualification	SDZ	NISRA	Yes	No	Score	High	2021
Rationale	A well-qualified adult work force provides flexible emplyment opportunities and is likely to be more able to response and recovery automonously from a climate shock. From a business prespective a workforce with strong adult skills, including technical and soft skills, is better equipped to adapt to new challenges posed by climate change. Continuous learning and upskilling can help employees innovate and support their organisation in implementing effective climate adaptation strategies.								
Residual notes	-								

Appendix Table C-75 Other influences - Employment sector diversity

Grouping	**Business**								
Domain	**Other influences**								
Indicator and ID	**bt7 - Employment sector diversity**								
	Does this indicator contribute to an aggregated index?	**Yes**	**Business**	✓	**Flood**		**Heat**		
Processing	England: Direct: ind_rpc. N.b. London is missing and replaced with NaNs Wales: No data available at time of processing Scotland: calculate the standard deviation for number of people working in each industry by IZB. Compute the z-score for this across the country and multiply by -1 (as low varience between # people in each industry means high diversity) Northern Ireland: calculate the standard deviation for number of people working in each industry by IZB. Compute the z-score for this across the country and multiply by -1 (as low varience between # people in each industry means high diversity)								
Data used and resolution	**Source**	**Description**	**Scale**	**Owner**	**Download available**	**In data pack (raw)?**	**Units**	**Confidence**	**Date**
England	Camacho et al	Still in review at time of data cut-off	LA	Camacho et al	Yes	Yes	Percentile	Low	2024
Wales	-	Still in review at time of data cut-off	-	-	No	No	-	-	2024
Scotland	Census	UV605 - Industry	OA	Scottish Government	Yes	No	Z-Score	Mod	2022
Northern Ireland	Census	MS-H10 - Occupation - minor groups (2-digit)	SDZ	NISRA	Yes	No	Z-Score	Low	2021
Rationale	A diversity of emplyment sectors provides altnernative opportunities if one sector is impacted by a climate related event. This is little quantified supporting research but this remains an inituative indicator. From a national economic perspective, diverse employment sectors can reduce vulnerability to climate events by spreading risk across different industries. At the scale of a single business (the focus here) diversity in the employment market can help support business to access skills need to adapt.								
Residual notes	-								

Appendix Table C-76 Other influences - Public sector employment

Grouping	**Business**								
Domain	**Other influences**								
Indicator and ID	**bb12 - Public sector employment**								
	Does this indicator contribute to an aggregated index?		**Yes**	**Business**	✓	**Flood**		**Heat**	
Processing	England and Wales: 100 * 'Total Emplyment: Public' divided by 'Total Employment: All' Scotland: 100 * 'Total Emplyment: Public' divided by 'Total Employment: All' Northern Ireland:								
Data used and resolution	**Source**	**Description**	**Scale**	**Owner**	**Download available**	**In data pack (raw)?**	**Units**	**Confidence**	**Date**
England	Local authority county – Business Register and Employment	Table 5 - Employment (thousands) by Local Authority County within Region (full-time/part/time and public/private sector split)	County/LA	ONS	Yes	Yes	%	Low	2022
Wales	Local authority county – Business Register and Employment	Table 5 - Employment (thousands) by Local Authority County within Region (full-time/part/time and public/private sector split)	County/LA	ONS	Yes	Yes	%	Low	2022
Scotland	Local authority county – Business Register and Employment	Table 5 - Employment (thousands) by Local Authority County within Region (full-time/part/time and public/private sector split)	County/LA	ONS	Yes	Yes	%	Low	2022
Northern Ireland	-	-	-	-	No	No	-	-	-
Rationale	Private sector may be less secure in the short term to climate shocks, whereas public sector workers are more likely to be supported with continued job security. From a national economic perspective, public-private partnerships can help leverage resources, expertise, and innovation to promote resilience and develop and implement effective climate adaptation measures. The business vulnerability of an area (the focus of this issue here) is however likely to be reduce where public sector employment is higher. This reflects the financial and organisational resources associated with public sector activities and may or may not the available within the private sector.								
Residual notes	Annual employee and employment estimates for the UK split by local authority county. Results given by full-time or part-time and public or private splits.								

APPENDIX D. Output datasets

D.1 Geo-package

Sayers-ClimateVulnerabilityIndicators_Neighbourhoods_06March2025-Submitted.gpkg

This provides the spatial data and associated unique IDs for each Neighbourhoods across the UK. For ease, the aggregated indices determined at the national scale (NFVI-CCRA4, NHVI-CCRA4, and NBVI-CCRA4) are included. The IDs can be used to link to the individual indicators (and the aggregated national and UK indices) provided in the supporting Excel file (see below).

D.2 Excel file of indicators

Sayers-ClimateVulnerabilityIndicators_Neighbourhoods_06March2025-Submitted.xls

This provides individual indicator values (where this is possible to do so given licencing or other constraints) and the integrated indices. Some data records, for example, are highlighted as 'suppressed'. This reflects suppression in the input data sources.

The integrated indices are presented as two versions.

- **England and DA scale indices:** In this case the NFVI-CCRA4, NHVI-CCRA4, and NBVI-CCRA4 are based on the data and the statistical distribution of that data within each nation. This data is likely to be most appropriate when assessing outcomes at the scale of England or DA.
- **UK scale indices:** In this case indices are based on those indicators that can be considered reasonably comparable across the UK. The statistical distributions of the data are determined at a UK scale. Care is needed when using this data due to the limited inputs but may be most appropriate when assessing the variation in vulnerability across the UK.

Note

Care is needed when using the data. The individual indicator values are complex, with varying methods used between countries and often varying units (as highlighted in the Tables provided in Appendix C). Extreme care is needed in using these data correctly. We encourage users to use the integrated indices.