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Climate Change in Wales: Health Impact Assessment

Technical Report

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Contributors: Sumina Azam, Mark A Bellis, Katie Creswell, Christine Clar, Morganna Davies, Mark Drane, Michael Fletcher, Karen Hughes, Kristian James, Natasha Judd, Sue Toner, Phil Wheater, Sara Wood.

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Contents

Section 1 – Introduction

This Health Impact Assessment (HIA) is a concurrent and comprehensive assessment, and the first phase was undertaken between October 2019 and June 2020. It was then suspended whilst the Wales Health Impact Assessment Support Unit (WHIASU) team contributed to the COVID-19 pandemic response. The work was then restarted in mid-2021 which included the publication of a set of infographics to inform COP 26 in November 2021 and finalised during 2023.

This Technical Report provides background information on how the HIA was carried out, who was involved, and the methodological approach taken. It followed the 5-step process contained in Box 1.

This HIA was iterative and followed the systematic methodology described in the Welsh HIA guidance entitled 'Health Impact Assessment: A Practical Guide' (WHIASU, 2012).

The outputs of the HIA are:

- An evidence based HIA Summary report
- Individual chapters on the evidence of impact of climate change on the wider determinants of health and population groups in Wales
- A set of 4 infographics
- A PowerPoint slide deck
- A Technical Report (this report)

Section 2 – Health Impact Assessment

The European Centre for Health Policy Gothenburg Consensus (WHO, 1999) is widely accepted as the seminal definition of Health Impact Assessment (HIA), and defines it as:

> 'A combination of procedures, methods and tools by which a policy, programme or project may be judged as to its potential effects on the health of a population, and the distribution of those effects within the population.'

HIA is a process which supports organisations to assess the potential consequences of their decisions on people's health and well-being. The Public Health (Wales) Act 2017 has legislated for HIA to become statutory for public bodies in specific circumstances (as yet undefined) (UK Legislation, 2017).

HIA provides an evidence-based, systematic yet flexible and practical framework that can be used to consider the wider effects of local and national policies, scenarios or initiatives and how they, in turn, may affect people's health and well-being – in the present and in the future. A major objective or purpose of a HIA is to inform and influence decision-making or policy; however, it is not a decision-making tool per se.

HIA, as practised in Wales, is grounded in the World Health Organization (WHO) definition of health and well-being (WHO, 1948), which encompasses physical, mental and social health and well-being. HIA also views population impact through the lens and framework of the social determinants of health. This framework considers not just the biophysical and environmental health impacts which can be derived from policies, proposals and

plans, but also assesses the social factors that can have an impact and the population groups which are affected. These factors, such as environment, transport, housing, access to services and employment can all interact to a greater or lesser extent with an individual's lifestyle choices and genetic makeup to influence health and well-being. The diagram below summarises the relationship between these determinants.

Figure 1: A social determinants of health and well-being framework

Source: Dahlgren and Whitehead (1991)

HIA works best when it involves people and organisations who can contribute different kinds of relevant evidence, contextual knowledge and insight. The information is then used to identify measures to maximise opportunities for health and to minimise any detrimental impacts, and identify any 'gaps' that need to be filled. HIA can be used to help address the inequalities in health that continue to persist in Wales, by identifying any groups within the population who may be particularly affected by a policy or plan or proposal.

HIA is based on triangulation of health intelligence and data, stakeholder knowledge / evidence and a review of the literature including peer reviewed journals. As practised in Wales, HIA is grounded on this mixed methodological approach and embraces community and lay knowledge. Wales emphasises the inclusion of all stakeholders including local community citizens as part of the process. Including this type of qualitative evidence is important to assess individual and community concerns, anxiety and fears, for example, and data can be quantified for use in decision-making and / or mitigation and can give a more holistic, contextual view of impacts.

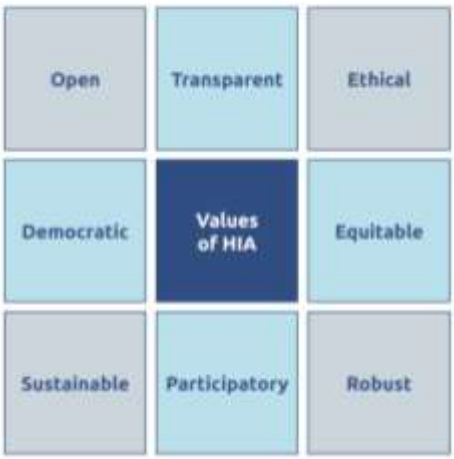
There are three main types of HIA - prospective, concurrent and retrospective.

- *Prospective HIA* – at the start of the development of a project, proposal or plan
- *Concurrent HIA* – runs alongside the implementation of the project (or policy)
- *Retrospective HIA* - assesses the effect of an existing project or policy and can be used as an evaluation tool. Retrospective assessments can also be utilised for unexpected events, as a way of learning lessons for future similar events.

HIA is best used prospectively during the development of a proposal. The process should be activated late enough in a proposal's development to be clear about its nature and purpose, but early enough to be able to influence its design and / or implementation.

Within any of the above, HIA can take one of three different forms depending on the focus and the time and resources available - desktop, rapid or comprehensive. A desktop HIA may take only a few hours or a day to execute; a rapid HIA may take a few days to a few months to complete; and a comprehensive HIA is more in-depth / time and resource intensive and can take many months to complete. The most appropriate type to conduct can be decided through a short scoping meeting and discussion of timeframes, resources and levels of stakeholder involvement.

Often, however, any particular HIA may fit in between two of these categories, as the approach taken will be determined by the nature of the proposal, the timescales involved and the human, organisational and financial resources available to undertake the process.



HIA is also based on a number of key principles and values – these include equity, robustness, openness, transparency, ethical use of evidence, participation, sustainability and democracy.

There are a number of ways in which the potential impacts may be described. Where possible, the following should be assessed:

- **The nature of the impact** - how will the proposal affect health and will the impact be positive or negative? Will it be direct or indirect i.e. via a direct pathway or as an associated impact?
- **The likelihood of the impact** - is the likelihood of the impact of the proposal confirmed, probable or possible?
- **The scale and significance of the impact** - what proportion of the population is likely to be affected? How significant or minimal will the impact be (i.e. will it cause mild distress, improve well-being or lead to deaths)?
- **The timing of the impact** - will the impact be in weeks, months, years? In some instances the short term risks to health may be worth the long term benefits.
- **The distribution of the effects** - will the proposal affect different groups of people in different ways? A proposal that is likely to benefit one section of the population may not benefit others. In some cases, the assessment will identify ways in which members of the least healthy or most disadvantaged or vulnerable populations could be helped. This can be an important contribution to reducing the health inequalities that exist between some communities.

There are five main steps to HIA (Box 1) and, while some may regard it as a linear process, HIAs are most useful and effective when the process is iterative. It is systematic yet flexible to particular timescales and circumstances.

Box 1. HIA Process

1. **Screening:** does the proposal or plan have an impact on population health?
2. **Scoping:** what resources, timeframes, policy windows and evidence needs to be considered? Does a Steering Group need to be established? Roles and responsibilities of any Steering Group outlined.
3. **Appraisal/Assessment of evidence:** triangulation of qualitative and quantitative evidence and health intelligence.
4. **Reporting and recommendations:** construction of HIA report and any non-technical summary.
5. **Review and reflection:** including monitoring and evaluation – did the HIA and any findings have an impact on health and well-being or decision-making process?

Section 3 - Process followed in the Climate Change HIA

A Working Group was established to carry out the HIA, which consisted of internal public health specialists and practitioners from the Policy Team, WHO CC for 'Investment for Health and Wellbeing', Environmental Public Health Team, Bangor University research leads and the Wales HIA Support Unit.

Scoping and screening of the potential public health impacts of climate change in Wales took place using the WHIASU Scoping and Screening checklists and template.

A half-day interactive screening session was undertaken. The participants considered how a wide range of groups could be affected in Wales by climate change and which determinants may be particularly impacted upon, utilising the WHIASU checklists (see Appendix 1). The session was informed by a range of evidence that had been reviewed beforehand, which included academic literature, organisational reports and publications, and any published stakeholder perspectives. The Working Group completed a screening paper that preliminarily identified the potential determinants, populations and areas of policy focus that could be affected by the policy. This is available in Appendix 2.

These were to be explored further and included (examples and the list is not exhaustive):

- Food and nutrition; outdoor lifestyles and physical activity; risk taking behaviour
- Family and community impacts; social capital; and social media
- Mental health and well-being
- A wide range of environmental and living conditions including housing; air quality; flooding; transport; biodiversity
- Access to services and facilities including health care services
- Macro Socio-economic: governmental policies, sustainable development
- Age related groups: Children and young people; older people
- Those in relation to schools; hospitals and health care settings; transport and workplaces
- Those in geographical areas: farmers and rural communities; coastal areas; those in flood risk areas
- Those in outdoor occupations: farmers; outdoor workers including construction; emergency

A Scoping Review document defined the scope of the HIA and how it would be carried out, the timeframes for the work, who would be involved and how, and the evidence needed. It also outlined the governance mechanisms and the types of evidence required to ensure that the HIA and any report based on it was high quality and robust. The following questions were considered as part of the scoping process:

1. What are the time scales? (And when do crucial decisions need to be made?)
2. What financial and human resources are available?
3. Geographical boundaries of the project? (Do you need to consider the impact of people in other areas or communities that may be affected?)
4. What kind of assessment is necessary and/or possible in the time available – rapid or in-depth?
5. Should the assessment be an in-house exercise or should someone be commissioned to do the appraisal?
6. Should you set up a steering group and who should be involved?
7. What elements of the policy/project/plan should the appraisal focus on?

8. Who are the stakeholders?
9. Roles and responsibilities?
10. Methods for collecting evidence?

A Strategic Advisory Group was established to provide advice, guidance, insight and governance to the HIA. Internal Consultants in Public Health and Executive Directors reviewed the HIA and its component parts and provided feedback, amendments or comments.

The Working Group oversaw and carried out the HIA under the SAG's advice and steer.

A depiction of the full HIA process followed is contained in Table 1.

Table 1 : The Methodological Process for the HIA (adapted from Green et al, 2021a)			
HIA Step	**Actions**		**How Step was undertaken in the HIA**
1. Screening	Identified the preliminary health and well-being impacts and those affected in the population.		• A Working Group was established internal to Public Health Wales. • Wide ranging populations and determinants affected were identified. • 2 checklists were used as a guide.
2. Scoping	Used a Scoping checklist to identify the: • geographical boundaries of the HIA • timeframes / deadlines • terminology to be used to define and characterise impact • stakeholders • engagement methods • data and evidence sources		• Proposed scope and approach developed by lead authors and working group • Resources allocated and agreed by PHW • Proposed scope and approach discussed with engagement from the Strategic Advisory Group and finalised • Timeframe for completion was one year initially to inform policy and decision makers. However, this work was suspended during the pandemic.
3a. Appraisal – Evidence Gathering	Literature Review	Carry out literature review and synthesise into summary to identify relevant qualitative and quantitative evidence and statistics	• Research Protocol compiled for a systematic rapid review. • Search carried out • Papers screened • Papers reviewed and samples checked • Quality review • Extraction table completed
	Collate Community Health Profile and environmental data	Used the scoping and screening checklists as a guide to gather data to identify relevant health intelligence and demographic, economic, environmental and social data / statistics. This includes gathering data in relation to population groups affected and determinants of health identified	Data and health intelligence was obtained from robust sources including: • Welsh Government • National Survey for Wales • Public Health Wales Observatory • Welsh Index of Multiple Deprivation • Office of National Statistics • Statistics Wales • Natural Resources Wales • UK Government All data collected was compiled into a Community Health Profile

	Stakeholder evidence	Identified key information, knowledge and evidence of external stakeholders identified as part of the Scoping Process by: • Undertaking interviews and transcribing for analysis • Carrying out 2 participatory stakeholder workshops • Developing a summary of results to input into the final report.	• 19 stakeholder interviews were undertaken • 2 workshops were held with 33 people attending • Stakeholders involved in these included representatives from a wide range of public bodies, academia and the third sector. These included for example: • Natural Resources Wales • Welsh Government • Public Health wales • Health Boards • Local Authorities • Renew wales • Cardiff University • University of West of England Multiple disciplines were also involved including health and social care, housing, land use planning, sustainable development, transport, emergency services, climate change, food and agriculture and community representatives.
3b. Appraisal of Evidence	• Triangulation of evidence to assess and characterise the positive and negative impacts and form a picture of the scale, scope and duration of these. • Form suggestions for action and main findings in dialogue with stakeholders		• Impact on determinants of health identified • Population Groups identified as being affected identified • Characterisation of impact table drafted.
4. Reporting and Recommendations	• Compile report and suggested actions • Carry out quality assurance with key stakeholders • Review and 'Sign off' in PHW • Publication of HIA		• Report published • Dissemination via networks and stakeholders involved
5. Review, reflection and monitoring	• Review and evaluate the process of carrying out the HIA • Develop monitoring indicators / steps		Monitoring and evaluation plan to be developed Review and reflection session Compile review and reflection paper. Ongoing.

Section 4 – Evidence Appraisal

As part of the HIA, the following evidence was gathered and utilised:

- A literature review: to ensure that this was high quality in nature, a research protocol was constructed with support from the Public Health Wales/Bangor University, to rapidly identify relevant published evidence. The protocol can be found in Appendix 3 and evidence summaries derived from the literature can be found in Section 5 of this report.
- Qualitative evidence: the HIA captured knowledge and information held by stakeholder organisations and individuals with expertise in the impacts of climate change or relevant policy areas. In total, 25 stakeholders were interviewed across 19 interview meetings with another 2 providing written feedback and evidence sources. The notes from these were transcribed and analysed using thematic analysis. 2 participatory workshops were held in February in 2020 with a total of 33 stakeholders attending (see Sections 6 and 7 for further details).
- Health intelligence and data: a community and demographic profile of Wales was developed utilising recognised Welsh and UK sources such as the Public Health Wales Observatory (see Appendix 5).
- A case study of the Dyfi Biosphere was also carried out and developed. This was used to illustrate how health and equity impacts can be highlighted at a local and regional level. This is currently unpublished.

All of the above evidence and data was collated, synthesised and analysed. The evidence analysis was carried out by five members of the Working Group. An expert member was also co-opted to the Working Group to contribute to the analysis and identification of impacts.

Appraisal Tables summarising the nature of the impacts were completed based on the collated evidence (see Summary Report). The identified impacts were characterised by duration, scale, intensity and direction. The HIA used specific terminology to describe the impact and Table 2 depicts the characterisation of impacts.

Table 2: Descriptors used to characterise impacts

Type of impact		
Positive / opportunity Impacts that are considered to improve health status or provide an opportunity to		Negative Impacts that are considered to diminish health status
Likelihood of impact		
Confirmed	Strong direct evidence e.g. from a wide range of sources that an impact has already happened or will happen	Confirmed
Probable	More likely to happen than not. Direct evidence but from limited sources	Probable
Possible	May or may not happen. Plausible, but with limited evidence to support	Possible
Intensity / severity of impact		
Major	Significant in intensity, quality or extent. Significant or important enough to be worthy of attention, noteworthy	Major
Moderate	Average in intensity, quality or degree	Moderate
Minimal	Of a minimum amount, quantity or degree,	Minimal
Duration of impact		
Short term (S)	Impact seen in 0 – 3 years	Short term (S)
Medium term (M)	Impact seen in 3 – 10 years	Medium term
Long term (L)	Impact seen in >10 years	Long term (L)

Finally, the last stage of any HIA is to review and reflect on the process carried out and consider any monitoring and evaluation which needs to be in place. It is intended that this work will be reflected on, reviewed and monitored in the short, medium and longer term.

Section 5 – Literature Review

This section provides the evidence summaries developed from the phase 1 literature review.

5.1 Determinants of health

Health Behaviours

Physical and outdoor activity

High temperatures have been associated with increased recreational physical activity (Elliot et al., 2019). Therefore, climate change may bring about opportunities for increased active travel and physical activity, which is beneficial for health and well-being (HM Government, 2017). Evidence demonstrates that physical activity, in the form of cycling, may increase in the winter, spring and autumn months (Heaney et al., 2019). Additionally, more extreme storms and waves and increasing air and sea temperatures may increase opportunities for some water sports such as sailing and surfing (Marine Management Organization, 2016).

However, higher temperatures in the summer may reduce physical activity (Heaney et al., 2019; HM Government, 2017). Environmental heat stress can be a barrier to physical activity participation, especially for the elderly population who have an attenuated ability to dissipate heat (Balmain et al., 2018). People who exercise outdoors and athletes who train or compete outdoors have a higher risk of heat related illnesses as temperatures increase (Centers for Disease Control and Prevention, 2016). Additionally, increased outdoor activity may increase exposure to UV radiation and the risk of tick-borne diseases (HM Government, 2017).

Healthy eating

Climate change may reduce the nutritional quality of agricultural products and the industrialised agricultural and food system that is one of the drivers of climate change is also a driver of unhealthier diets (i.e. "Western" diets rich in fats, sugars, meat and highly processed foods and low in fibre) (An et al., 2018). *See further information under **food***.

Alcohol/substance misuse

Increasing temperatures may lead to increased alcohol and substance misuse (Thompson et al., 2018). A relationship has been observed between changing climatic conditions and increased use of drugs or alcohol as a coping mechanism (Kabir, 2018). Additionally, an increase in drug-related mental disorders has been observed when temperatures increase to over a threshold of 20°C and increases in emergency room visits for substance abuse are evident in warmer temperatures (Cianconi et al., 2020). Material damages following climate disaster can also result in increased substance abuse (Cianconi et al., 2020). However, other research indicates that there is a negative correlation between average global temperature and alcohol consumption (Ventura-Cots et al., 2019). This suggests that the combination of mental health disorders with patterns of excessive alcohol misuse may be less prevalent as temperatures rise (Ventura-Cots et al., 2019).

Risk taking activities

No evidence found.

Physical/general health

Climate change can negatively impact physical health; regions that have experienced 1.5°C warming have seen negative impacts on health (Roy et al., 2018). 3546-4508 million people will be exposed to heat waves with 1.5°C warming and 4517-6710 million people will be exposed to heat waves with 2°C warming. An increase in exposure to heat and heat waves will lead to a higher risk of heat related morbidity and mortality (Centers for Disease Control and Prevention, 2016; Cheng et al., 2019; HM Government, 2017; Hoegh-Guldberg et al., 2018; House of Lords, 2019; Khader et al., 2015; Roy et al., 2018; Sanderson et al., 2017; Tham et al., 2019). Higher temperatures are associated with heat stress (Centers for Disease Control and Prevention & American Public Health Association, no date; Roy et al., 2018; United Nations, 2018), reduced respiratory health (Khader et al., 2015; Tham et al., 2019; United Nations, 2018), heart attack (United Nations, 2018; Sun, Chen, Xu & Li, 2018), stroke (United Nations, 2018), reduced physical functioning (Tham et al., 2019; United Nations, 2018), reduced kidney health (Centers for Disease Control and Prevention, 2016; Lee et al., 2019), heat exhaustion (Centers for Disease Control and Prevention, 2016) and eye and skin damage due to increased ultra-violet B radiation (Intergovernmental Panel on Climate Change, no date). Heat related morbidity varies by region due to acclimatisation, population vulnerability, environment and access to air conditioning (Hoegh-Guldberg et al., 2018). Those most at risk of heat related morbidity and mortality include the elderly, those of low socioeconomic status, people living in hot places (Benmarhina et al., 2015; Mbow et al., 2019) and babies (Kuehn & McCormick, 2017). People living in cooler areas are also at risk due to the lack of acclimatisation to heat (Campbell et al., 2019).

Currently in Wales, there are 2.4 excess heat-related deaths per 100,000 population, which equates to approximately 74 deaths per year. Heat-related mortality in Wales in the 2050s is estimated to increase to between 3.1 and 14.3 per 100,000, based on the UKCP09 medium emissions scenario. Assuming no population growth, this equates to between 96 and 443 deaths (HM Government, 2017). However, milder winters will result in a decrease in the number of cold related deaths per year (Environmental Agency, 2018; HM Government, 2017; Hoegh-Guldberg et al., 2018). In Wales, there may be a reduction in cold related mortality in the 2050s to between 55 and 75 per 100,000, based on the UKCP09 medium emissions scenario, which would equate to 1705 – 2325 deaths per year (HM Government, 2017).

There is an increase in potential flood fatality with 2°C warming (Hoegh-Guldberg et al., 2018). Flooding and storms may lead to exacerbation of cardiovascular, respiratory, gastrointestinal and musculoskeletal diseases and cause wounds and orthopaedic injuries (Saulnier et al., 2017). Saltwater intrusion associated with climate related sea level rise can contribute to hypertension (Talukder et al., 2017). Power cuts due to floods may result in increased use of portable generators, which can cause carbon monoxide poisoning (Centers for Disease Control and Prevention, 2016). *See **flooding** for more information on the physical health impacts of flooding.* Additionally, earthquakes can lead to coronary syndrome and heart attack (Bazoukis et al., 2018). High winds can also cause fatalities, often as a result of accidents involving fallen trees or damaged buildings (HM Government, 2017). Other climate related factors and extreme events also result in adverse physical

health consequences, including injury and loss of life (Adger et al., 2014; Centers for Disease Control and Prevention, 2015; World Health Organization, 2019). *See **air quality**, **wildfires** and **landslides**.*

Climate change will also increase the spread of communicable disease. *See **vector-borne disease**, **zoonotic disease**, **water-borne disease** and **food-borne disease**.* Prisons are at risk of rapid transfer of communicable diseases (Benevolenza & DeRigne, 2019).

Social media

Excessive information, sometimes misinformation and rumours, circulated through social and news media, can contribute to consumer stockpiling (Kuruppu & De Zoysa, 2020). As demonstrated during the COVID-19 crisis, the circulation of excessive information and misinformation often makes situations worse (Kuruppu & De Zoysa, 2020). Multiple channels, for example the internet, social media and television, provide masses of people with timely information about disaster events, which can create uncertainty or fear regarding supply disruption and therefore encourage consumer stockpiling, even if the disaster would not have resulted in supply disruption (Shou et al., 2013; Yuen et al., 2020).

These channels can also facilitate the government and other health organisations to provide updates and advice regarding a given health crisis (Yuen et al., 2020). There is an opportunity to utilise social media as an education tool; by sharing transparent information, perceived risks to consumers can be reduced (Wijaya, 2020).

Social and community factors

Community cohesion and resilience

Collective action against natural disasters can strengthen community resilience and cohesion (HM Government, 2017; Kamara et al., 2018; Torres & Casey, 2017). Adaptation efforts prior to disasters may also strengthen community ties by offering opportunities for volunteering within the community, promoting interaction and trust (Torres & Casey, 2017). Additionally, voluntary migration as an adaptive response to climate change can increase community resilience (Rechkemmer et al., 2016) and improve mental health (Torres & Casey, 2017). As people unite in adversity, communities that are affected by natural disasters may have a lower risk of civil war (Castells-Quintana, Lopez-Uribe & McDermott, 2015).

However, natural disasters can also have negative impacts on social cohesion (HM Government, 2017). Family and community relationships may be adversely impacted as acute climate events could result in the loss of family dwellings, community meeting places and historic places, leading to reduced opportunity for social interaction (Torres & Casey, 2017) and therefore may reduce social cohesion (HM Government, 2017). Additionally, high temperatures can reduce social participation (Kownacki et al., 2019). Familial and community ties may also be affected if some members migrate while others remain (Torres & Casey, 2017). Climate related human mobility has the potential to undermine social cohesion (Warner, 2018), and those who migrate face societal stigma, marginalisation and social isolation (Torres & Casey, 2017). Social isolation and disruption of social connections as a result of migration may lead to adverse mental health implications (Torres & Casey,

2017). Social tensions may rise in areas receiving migrants as a result of overcrowding and overstressing of natural resources and infrastructure (Rechkemmer et al., 2016).

Community divisions and conflict over resources

Climate change in the form of increased heat, drought, heavy rainfall and other extreme weather events can result in increased conflict, violence (including domestic violence), crime and homicide, which may lead to the collapse of societies (Castells-Quintana et al., 2015; Hoegh-Guldberg et al., 2018; Pozarny, 2016; Zuo et al., 2015). In hot temperature, increases in discomfort can lead to feelings of hostility and aggression, potentially contributing to an increase in crime or violent actions (Cianconi et al., 2020). Alcohol is likely to be involved in increasing aggression (Cianconi et al., 2020). Climate change may worsen existing conflicts, aggravate existing inequalities or generate new conflicts by worsening resource scarcity and undermining the state capacity to provide people with services and opportunities (Adger et al., 2014; Castells-Quintana et al., 2015; Pozarny, 2016). For example, agricultural loss, as a result of impacts on crop productivity, leads to a decline in economic growth, resulting in economic disadvantage and promoting political instability and conflict (Cianconi et al., 2020). Alternatively, climate change may lead to social conflict as a result of increased demand for less carbon-intensive forms of energy, such as hydropower (Adger et al., 2014).

The interaction of climate stressors with conflict can lead to large movements of people from developing countries to Europe (Byravan & Rajan, 2017; Warner, 2018). Climate change induced extreme weather events exacerbate the conditions that drive forced migration, for example, intensifying conflict over scarce resources such as water, food and grazing land (Cianconi et al., 2020; White, 2017). Populations who depend on agriculture for their livelihood are particularly vulnerable to conflict over resources, such as water (Ebi et al., 2018; Hoegh-Guldberg et al., 2018). Climatic conditions, by affecting drought severity and the likelihood of conflict, played a significant role as an explanatory factor for asylum seeking in the period 2011–2015 (Abel et al., 2019).

Additionally, increased migration as a result of climate change exacerbates the potential for conflict (Castells-Quintana et al., 2015; Mbow et al., 2019; Rechkemmer et al., 2016). Conflict may worsen or arise in areas receiving migrants due to competition over resources, ethnic tensions and distrust (Pozarny, 2016). Overcrowding, unemployment, environmental pollution and overstressing of natural resources may also contribute to social tension, conflict or crime as a result of migration and urbanisation (Abel et al., 2019; Rechkemmer et al., 2016).

Displacement/loss of communities

Climate related disasters can cause an increase in mass migration and displacement (Castells-Quintana et al., 2015; HM Government, 2017; Torres & Casey, 2017), ultimately changing the geography of economic activity and settlement patterns (HM Government, 2017). Progressive, climate induced changes in the environment can adversely affect lives and living conditions, forcing some people to leave their homes and encouraging some people to voluntarily leave their homes (Zodian, 2017). Movement can be temporary or permanent, and within a national borders or international (Warner, 2018; Zodian, 2017). Climate related changes that may lead to population movements include; increased

frequency and severity of extreme weather events, shoreline erosion, coastal flooding, agricultural disruption, degradation of drylands and impacts on food security (Adger et al., 2014; Rechkemmer et al., 2016; Warner, 2018; White, 2017). These factors threaten the safety and well-being of residents and destroy infrastructure (Warner, 2018). Whether movement is forced or voluntary depends on the severity of these factors and their impacts (Rechkemmer et al., 2016). It is projected that, with 2°C warming, there is potential for significant population displacement (Hoegh-Guldberg et al., 2018). 250 million people could be displaced by climate change by 2050 (White, 2017), and an estimated 150 million 'climate refugees' may exist by 2050 (Castells-Quintana et al., 2015).

Migration is complex, and migration due to environmental reasons often interacts with other reasons, such as economic disruption (Adger et al., 2014; Zodian, 2017). Climate change induced weather events are also likely to intensify conflict, further exacerbating the conditions that drive forced migration and potentially contributing to large movements of people (Byravan & Rajan, 2017; Castells-Quintana et al., 2015; Warner, 2018; White, 2017). In the period 2011-2015, climate conditions contributed to an increased likelihood of armed conflict, which played a significant role as an explanatory factor for asylum seeking (Abel et al., 2019). Conflict and crime in areas receiving migrants is also likely to increase due to competition over resources, overcrowding, unemployment, ethnic tensions, distrust and political destabilisation, which cause social tension to rise (DeFries et al., 2019; Pozarny, 2016; Rechkemmer et al., 2016; Warner, 2018).

Climate change induced population movement can disrupt social ties, especially if some family or community members migrate while others stay in place (Torres & Casey, 2017). Migrants may experience social isolation, marginalisation and a reduction of social and material support, which can cause adverse mental health impacts and psychological distress (Mbow et al., 2019; Pozarny, 2016; Torres & Casey, 2017). People who are displaced by climate change are not formally protected under international refugee law, and therefore may have limited options for political and social integration into destination societies (Torres & Casey, 2017) and could experience limited access to services, such as national healthcare systems (United Nations, 2018). Large scale population movements can also result in suffering, disability and loss of life (Castells-Quintana, Lopez-Uribe & McDermott, 2015). However, in some cases, migration can improve mental health (Torres & Casey, 2017). Environmentally induced voluntary migration can be an adaptive response and could lead to increases in community resilience (Rechkemmer et al., 2016; Zodian, 2017).

Climate change has the potential to alter the quality of migration patterns. Currently, migration following a climate related disaster is typically temporary, short distance and along well-established routes (Castells-Quintana et al., 2015). However, climate change may overwhelm existing coping mechanisms, leading to longer-term and longer-distance migrations that are less well organised and more of a threat to stability and security (Castells-Quintana et al., 2015). In the future, significant unplanned migration flows will be more likely as a result of extreme weather events (HM Government, 2017). Sudden onset disasters are more likely to lead to temporary displacement, and slow onset disasters are more likely to result in permanent displacement or migration (United Nations, 2018). Europe is likely to experience inward, international migration flows (Byravan & Rajan, 2017), although the UK is potentially less susceptible to inward migration than other countries due to its location (HM Government, 2017).

Sea level rise has the potential to exceed one metre by the end of the century, potentially forcing tens of millions of people to leave small islands and coastal areas around the world (Byravan & Rajan, 2017; DeFries et al., 2019; Intergovernmental Panel on Climate Change, no date). Many megacities are located in coastal areas, therefore the impact of climate change on coastal areas will impact large populations (Byravan & Rajan, 2017). Sea level rise may cause some coastal areas and whole low-lying countries to become uninhabitable, leading to permanent displacements (Adger et al., 2014; Byravan & Rajan, 2017; Deere et al., 2017; Intergovernmental Panel on Climate Change, no date; Piguet, 2019) even if preventative measures are put in place (Piguet, 2019). These impacts will be exacerbated through severe storms and drought (Intergovernmental Panel on Climate Change, no date). In the UK, sea level rise and coastal erosion as a result of climate change are likely to cause loss or relocation of communities (HM Government, 2017). Displacement following flooding can be long term, and is likely to represent a significant burden on affected households (HM Government, 2017). A strong cultural identity or connection to a place may result in residents choosing to remain in an area that is at high risk of climate change impacts or of becoming uninhabitable (Adger et al., 2014). Some individuals may also be reluctant to leave their homes due to fear of crime, being a burden to others and concern over leaving pets (Centers for Disease Control and Prevention, 2015).

Climate change can also result in rural to urban migration (Adger et al., 2014) as weather dependent livelihoods, such as agriculture and forestry, deteriorate, forcing these individuals to move to other income generating activities (Vos, 2015; Warner, 2018). This can result in overcrowding in urban destinations, increasing the risk of heat stress, flooding and disease spread (Castells-Quintana et al., 2015). If destination cities are low-lying, additional population shifts are highly likely to occur over time (Warner, 2018). Migratory movements to Europe may increase as climate change continues to impact agriculture dependent countries (Ebi et al., 2018; Hoegh-Guldberg et al., 2018; Werz & Hoffman, 2016).

Displacement caused by extreme weather events is likely to impact deprived people and areas (Rataj et al., 2016). The impacts of climate change in combination with poor development strategies may lead to loss of ecosystem services, increasing poverty and loss of livelihoods and leading to migration (Byravan & Rajan, 2017; Mbow et al., 2019). Whether population movement is forced or voluntary is partly dependent on socioeconomic factors; wealthier people have more opportunity to choose to migrate, and can often relocate to safer areas (DeFries et al., 2019). Additionally, long-distance and international migration require financial capital, and therefore is limited to wealthier populations (Adger et al., 2014). Those who are more disadvantaged are more likely to be forced to leave, and may find it difficult to escape poverty (DeFries et al., 2019). Low income migrants are likely to cluster in high-density areas that are often exposed to flooding and landslides (Adger et al., 2014). Females are often impacted by adverse mental health outcomes during situations of displacement (Adger et al., 2014). Some females may experience an increased work burden or a change in work-family balance if males migrate, leaving families behind. This may also lead to fragmentation of families (United Nations, 2018). The absence of parents, if one parent migrates, may also impact children's psychosocial development, health and education (United Nations, 2018).

Family and intergenerational relationships

Climate change is expected to impact social relationships between family and community members, for the most part, in a negative way. Reduced natural resources may lead to increased competition among community members for food, water, and livelihoods. Acute climate events may result in the loss of family dwellings and community meeting places, leading to reduced opportunity for social interaction and increased social strain. Social ties may also be disrupted when some family members migrate and others stay in place (Torres & Casey, 2017).

However climatic events may have the capacity to strengthen family and community ties. Adaptation efforts prior to disasters may also strengthen community ties by offering opportunities for volunteering within the community, promoting interaction and trust (Torres & Casey, 2017).

Social isolation

Relevant information contained in other sections.

Cultural and spiritual ethos

Climate change may lead to loss and damage of culturally important sites and structures, having cultural and community significance (HM Government, 2017). Coastal areas are particularly vulnerable to this impact (HM Government, 2017). A strong cultural identity or connection to a place may result in residents choosing to remain in an area that is at high risk of climate change impacts or of becoming uninhabitable (Adger et al., 2014). Climate change may also pose a risk to benefits derived from landscapes (House of Lords, 2019) and change the amount, quality and safety of food available for individuals within their cultural context (Mbow et al., 2019). Coastal fishers are at risk of experiencing reduced cultural identity (Ebi et al., 2018; Savo et al., 2017); inability to fish due to changing weather conditions increases emotional burden on those who provide household food supplies (Savo et al., 2017).

Mental health and well-being

Mental health and well-being

The impacts of climate change, particularly climate related disasters, are projected to have and are currently having negative mental health implications (Centers for Disease Control and Prevention, 2015), and hot and arid weather has been associated with a higher frequency of hospital admissions for mental illness and psychiatry admissions (Cianconi et al., 2020; Khader et al., 2015). Large scale social and community effects of climate change that outbreak into forms of violence, struggle over limited resources, displacement and forced migration, post-disaster adjustment and chronic environmental stress can induce long term mental health outcomes (Cianconi et al., 2020). Furthermore, the impacts of climate change have been reported to exacerbate pre-existing mental health conditions (Zuo et al., 2015). A direct correlation has been observed between the intensity of a climate related disaster and the severity of related mental health impacts (Cianconi et al., 2020). High temperatures may affect the risk of onset or continuation of mental disorders by influencing psycho-physiological functions; temperature stress can directly affect biochemical levels, for example altering the production of serotonin and dopamine, and can disrupt the homeostasis of thermoregulation (Cianconi et al., 2020). Flooding brings about

mourning, displacement and psychosocial stress due to loss of lives and belongings, all of which are risk factors for a range of mental disorders. These impacts have the potential to persist after the disaster due to economic difficulties, mourning and behavioural problems in children (Cianconi et al., 2020). However, reduced seasonal thermal discomfort as a result of milder winters may be beneficial in terms of reduced negative effects on well-being (HM Government, 2017).

Climate change, extreme heat, extreme weather events and stress or illness as a result of flooding can contribute to depression and anxiety (Centers for Disease Control and Prevention, 2017a; Cianconi et al., 2020; Public Health England, 2017; Rataj et al., 2016; Thompson et al., 2018). These impacts can persist for a year following the event (Environmental Agency, 2018). People whose homes have been flooded are more likely to experience poor mental health outcomes, and people who have been affected by flooding in other ways may also be impacted by poor mental health (HM Government, 2017; Public Health England, 2017). Additionally, fear of being flooded again is a lasting issue (Environmental Agency, 2018). Climate related weather events are more likely to lead to depression and anxiety in deprived individuals (Rataj et al., 2016). Furthermore, news regarding climate change can induce stress and uncertainty and even feelings of depression with a sense of powerlessness (Cianconi et al., 2020).

Climate factors, such as extreme heat and drought, may also contribute to feelings of loss of self-worth and value and potential for increased feelings of suicide ideation (Cianconi et al., 2020; Kabir, 2018; Smith et al., 2015). Health workers have observed connections between periods of bad weather and increased suicide issues (Kabir, 2018). Suicide rates are reportedly higher for males during conditions of drought (Smith et al., 2015). Drought has also been connected to suicide in older people (Cianconi et al., 2020). Increasing temperatures may also result in self-harm or self-injury as a result of increased mental states of aggression (Cianconi et al., 2020).

Post-traumatic stress disorder (PTSD) may develop as a result of climate change or following extreme weather events, such as flooding (Chen & Liu, 2015; Cianconi et al., 2020; HM Government, 2017; Public Health England, 2017; Rataj et al., 2016). This may be due to loss of lives or property from climate related disasters (Veenema et al., 2017) or due to stress or illness from flooding events (Centers for Disease Control and Prevention, 2017a). Deprived individuals and communities are more at risk of developing climate related PTSD (Rataj et al., 2016) and young children, especially females, are more likely to develop PTSD following cyclones (Smith et al., 2015).

Climate factors have been demonstrated to exacerbate existing mental health and psychological disorders (Tham et al., 2019; Thompson et al., 2018). Extreme heat may exacerbate symptoms of bipolar disorder, schizophrenia, Alzheimer's disease and dementia (Tham et al., 2019; Thompson et al., 2018). Those with schizophrenia, schizotypal disorders and mood disorders are more affected by high temperatures (Cianconi et al., 2020). Increased indoor temperatures can lead to agitation and disruptiveness of dementia patients (Tham et al., 2019).

Other factors can also be influenced by climate change, such as sleep, behaviour and mood (Centers for Disease Control and Prevention, 2017a; Cianconi et al., 2020; Rifkin et al., 2018; United Nations, 2018). Extreme heat can cause sleep disturbance, especially for

individuals who have pre-existing mental health conditions (Rifkin et al, 2018). It can also cause psychological fatigue (Cianconi et al., 2020). Temperature extremes can also impact mood and behaviour (United Nations, 2018) and heat stress caused by heatwaves has been associated with mood disorders (Cianconi et al., 2020). Stress or illness from flooding may result in behavioural change (Centers for Disease Control and Prevention, 2017a). Distress may also be caused due to a lack of access to work as a result of changing climates (Kabir, 2018). Solastalgia, a sense of distress and melancholy related to environmental destruction, may be experienced with climate-related damage of personal assets such as homes (Torres & Casey, 2017). Solastalgia affects those who negatively perceive the state of their living environment during profound environmental change, and is evident in farmers who have experienced persistent drought in rural areas of Australia (Albrecht et al., 2007). Other mental health issues that have been associated with climate related disasters include; physiological hyperarousal, chronic dissociation, detachment, disorganised thinking and behaviour, avoidance and poor concentration (Cianconi et al., 2020).

Children and young people are likely to experience an impact on mental, emotional and psychological health following climate related events (Benevolenza & DeRigne, 2019; Cianconi et al., 2020). Climate related events can lead to increases in post-traumatic stress disorder, depression, anxiety, sleep problems, mood disorders, cognitive deficit, learning issues, panic attacks, acute stress disorder, compulsively repetitive play, flashbacks and psychotic disorders, particularly in children and young people (Cianconi et al., 2020; Smith et al., 2015; Sanson et al., 2019). Most young people are aware of climate change and express fear, sadness, anger and powerlessness about its impact on their lives (Sanson et al., 2019). Most young people worry about how climate change will impact their future and how it will impact people living in developing countries (Sanson et al., 2018). This may lead to distress, increased aggression and violence or increased suicide rates (Sanson et al., 2019). The elderly population are also at a higher risk of mental illness related to climatic events, specifically mania associated with warm temperatures (Cianconi et al., 2020). Additionally, mothers and pregnant women are at risk of experiencing a negative impact on mental health as a result of climate change (Benevolenza & DeRigne, 2019; Kuehn & McCormick, 2017; United Nations, 2018). Extreme heat and poor air quality can lead to an increase in maternal stress (Kuehn & McCormick, 2017). Additionally, stress caused during climate related disasters can affect breast milk production (United Nations, 2018). Hospital patients are also at risk of experiencing distress; climate related disasters may result in temporary relocation of patients which can be highly distressing, especially when the patient is unstable (Man et al., 2018). Cancer patients who experience natural disasters are also at a high risk of intense psychological stress (Man et al., 2018). Coastal fishers are at risk of experiencing the negative mental health implications of climate change; a reduction in the ability to fish increases the emotional burden on fishers who provide household food supplies (Savo et al., 2017). Additionally, farmers and rural communities are at a particularly high risk of experiencing negative mental health impacts due to the direct implications of climate variability and drought on their livelihoods (Cianconi et al., 2020; Daghagh et al., 2019; Smith et al., 2015). People who are displaced as a result of climate factors may also experience psychological stress (Pozarny, 2016). Other groups at a higher risk of experiencing negative impacts on mental, emotional or psychological health as a result of climate change include women in general (Adger et al., 2014; Cianconi et al., 2020; Man et al., 2018), individuals living in a household with a female head (Cianconi et al., 2020), low

income groups, those with a low level of schooling, individuals with a history of negative life experiences, groups of ethnic or linguistic minority, individuals with a disability (Benevolenza & DeRigne, 2019; Cianconi et al., 2020) and emergency workers (Centers for Disease Control and Prevention, 2017a). Women and people with low socioeconomic status have shown to be more vulnerable to anxiety and mood disorders related to disasters (Cianconi et al., 2020).

Local communities strongly perceive the impacts of climate change, impacting mental health at a community level (Cianconi et al., 2020). Families who are not impacted by a climate related disaster, but who live near the affected area, may experience poor mental health outcomes through the disruption of community cohesion (Cianconi et al., 2020). However, community resilience has a preventive effect as it helps communities to cope with current situations and prepares the population for future climate related disasters (Cianconi et al., 2020). Restoring social cohesion of communities following a disaster can reduce suffering and promote effective recovery (Cianconi et al., 2020). Additionally, adaptation efforts prior to disasters can strengthen community ties by offering opportunities for volunteering within the community, promoting interaction and trust (Torres & Casey, 2017).

Social health can also be impacted by climate change (Intergovernmental Panel on Climate Change, no date; Nunfam et al., 2018). Heat stress, as a result of extreme temperatures, can have a negative impact on the social lives of workers as it may lead to family break-down due to physical violence, interpersonal disputes and fatigue, income erosion and loss of employment (Nunfam et al., 2018). Additionally, reduced volume of elements of the terrestrial cryosphere (seasonal snow cover, near surface layers of permafrost, masses of ice) will have an impact on social activities (Intergovernmental Panel on Climate Change, no date).

Participation and inclusion

Relevant information included in other sections.

Psychological adaptation

Relevant information contained in other sections.

Living conditions

Water

Access to water/water quality

Climate change can reduce water availability and threaten water security (Ebi et al., 2018; Hoegh-Guldberg et al., 2018) by decreasing the amount of water in the environment that can be sustainably withdrawn (House of Lords, 2019). Small changes in climate can lead to large water resource problems (Intergovernmental Panel on Climate Change, no date); with 1.5°C warming, 4% more people may be exposed to water stress and regions that have experienced 1.5°C warming have seen negative impacts on water security (Roy et al., 2018). With 2°C warming, 8% more people may be exposed to water stress and risk of water scarcity is higher than with 1.5°C warming (Houses of Parliament, 2019; Roy et al., 2018). By the 2020s, 0.5 billion people are projected to be experiencing water resource stress as a result of climate change (Compagnucci et al., 2018), and by the 2050s, water supply-demand

deficits are expected to be widespread in a high climate change scenario (HM Government, 2017). England is expected to experience significant water shortages by the 2050s, unless action is taken to reduce demand and increase supply (Environmental Agency, 2018).

Climate change factors, such as temperature rise, drought, flooding and sea level rise, threaten water security by impacting water resources, water treatment works and networks and wastewater treatment works and networks (Thames Water, 2016). Extended periods of low rainfall leads to low river flows and groundwater levels which limits the availability of water for consumption (Environmental Agency, 2018; HM Government, 2017). Groundwater supplies approximately 30% of England's drinking water (Environmental Agency, 2018). Additionally, wetter winters and increasing storms may lead to flooding or damage of water treatment assets, which impacts serviceability and threatens the ability to supply customer demand (HM Government, 2017; Severn Trent Water, 2016). Glacial regression may also have implications for water resources, impacting water availability and hydroelectric power potential (Intergovernmental Panel on Climate Change, no date). Changes in volume of snow cover may have a positive or negative impact on regional water sources (Intergovernmental Panel on Climate Change, no date). Also, water supply interruptions can be caused by cold weather, so it is likely that risks to water supply from cold weather will decline over the long term as winters warm in the UK (HM Government, 2017).

These stresses to water availability result in increased populations lacking access to safe drinking water (Adger et al., 2014; Deere et al., 2017). Water quality is compromised due to extreme weather events, such as heatwaves, which affect the nutrients in water (Zuo et al., 2015). Interruption to water services may also be experienced (Thames Water, 2016; Zuo et al., 2015). Additionally, temporary water bans may become more common as a result of droughts (HM Government, 2017), for example, the UK droughts of 2012 lead to loss of water service and water restrictions (Thames Water, 2016). Reduced water availability will worsen the existing stresses of population growth and urbanisation (Compagnucci et al., 2018; Pozarny, 2016). The impact of climate change on freshwater resources is harmful to societies and ecosystems, and therefore could impair economic development (Pozarny, 2016). Increased pressure on water resources and the need to use alternative sources means that there may be a higher cost in order to meet customer needs (Severn Trent Water, 2016).

Flooding, sea level rise and storm surges may lead to contamination of fresh water supply (DeFries et al., 2019; Intergovernmental Panel on Climate Change, no date; Veenema et al., 2017). Sea level rise leads to saltwater intrusion into coastal aquifers, compromising groundwater quality (Environmental Agency, 2018). Increased algal blooms and eutrophication due to high temperatures, where excess nutrients in the water cause ecosystem imbalance, may also decrease groundwater quality (Environmental Agency, 2018). Rainfall and flooding overwhelms sewage and drainage which contaminates drinking and recreational water (Centers for Disease Control and Prevention, 2015). Areas are at high risk of water contamination if their sewerage and drainage infrastructure cannot cope with a high volume of rainfall (DeFries et al., 2019). Water may also be contaminated by runoff from fields when it rains after long, dry periods, which increases the amount of pesticides and pollutants in water sources (Environmental Agency, 2018; Severn Trent Water, 2016).

Exposure to contaminated drinking water can cause illness, infection and gastrointestinal issues (Ahmed et al., 2019; Centers for Disease Control and Prevention, 2017a; Deere et al., 2017; Young et al., 2015) and increases the risk of water-borne diseases such as cholera (Deere et al., 2017). Additionally, saline intrusion into secure water sources, as a result of sea level rise, increases the risk of water-borne disease and some non-communicable diseases as a result of high salt intake (Deere et al., 2017).

Water scarcity may cause conflict between different actors, for example rural and urban consumers, and mining companies and local farmers (Ballesteros Gonzalez, 2015). Additionally, glacial retreat can represent a cultural loss by affecting river flows and therefore livelihoods (Adger et al., 2014).

There is an unknown risk of climate change to households connected to private water supplies; in Wales, there are approximately 14,000 private water supplies that serve approximately 80,000 people (HM Government, 2017). Agricultural communities will be significantly impacted by the projected decrease in water availability (Intergovernmental Panel on Climate Change, no date) and poverty and low income groups will be highly susceptible to the impacts of climate change on water supply and availability due to prevention of long-term planning and provisioning at the household level (Compagnucci et al., 2018).

Water-borne disease

Climate change may also result in increased prevalence of water-borne diseases due to natural disasters such as flooding, increasing temperatures and poor water quality (Compagnucci et al., 2018; Deere et al., 2017; Phung et al., 2015; Pozarny, 2016). Increasing temperatures accelerate the growth and transmission of water-borne pathogens, increasing the risk of water-borne disease (Deere et al., 2017). Additionally, water-borne disease outbreaks may occur if water is contaminated, for example with agricultural waste, sewage or chemicals (Centers for Disease Control and Prevention, 2015; Centers for Disease Control and Prevention, 2017a; Deere et al., 2017). Flood damage to water, sewage and sanitation infrastructure may cause contamination of water due to overflow (Deere et al., 2017). Water contamination, as a result of flooding, drought and heavy rainfall, increases the risk of diarrhoeal disease, especially for disadvantaged populations and children (Lal et al., 2019; Levy et al., 2016; Mbow et al., 2019). An increase in ambient temperature may also cause an increase in diarrhoeal disease (Amegah et al., 2016; Carlton et al., 2016; Philipsborn et al., 2016; Roy et al., 2018). Drought and restricted water use may contribute to disease (Centers for Disease Control and Prevention, 2015). Droughts and water restrictions result in less water being available for cooking and hygiene purposes, which increases exposure to water-borne contamination and disease (Deere et al., 2017).

The transmission of marine pathogens through sea water may also be a risk of climate change, as some marine pathogens are sensitive to higher sea surface temperatures (HM Government, 2017). Additionally, increasing sea temperatures around the UK may result in an increase in marine vibrio infections (HM Government, 2017).

Food

Access to food/food security

Climate change is projected to impact access to food – through changes in price – availability of food, utilization of food – through impact on nutritional quality – and stability of food production as a result of extreme weather events (Mbow et al., 2019). Climate change is currently impacting food security as a result of impacts on agriculture and aquaculture (Mbow et al., 2019; Pozarny, 2016; Roy et al., 2018). This creates a risk for domestic and international food production and trade (House of Lords, 2019). In the UK, climate change could impact food quality and safety through contamination associated with flooding, increased pesticide use and transmission of disease and toxicity through food (HM Government, 2017).

Changing climate, in the form of increasing temperatures, increased precipitation, drought, flooding, other extreme weather and change in atmospheric carbon dioxide may increase or decrease crop production and yield (Adger et al., 2014; Appiah, 2019; Ballesteros Gonzalez, 2015; Daryanto et al., 2017; Gautier et al., 2016; HM Government, 2015; HM Government, 2017; Hoegh-Guldberg et al., 2018; House of Lords, 2019; Houses of Parliament, 2019; Khader et al., 2015; Mbow et al., 2019), although, there have been more decreases than increases to date (Houses of Parliament, 2019) and with 2°C warming, average crop yield is expected to decline (Roy et al., 2018). Increases or decreases in crop yield depend on the type of crop, region of growth and the rate and magnitude of climate change (HM Government, 2017; Intergovernmental Panel on Climate Change, no date). Some crop yields may increase due to rising temperatures, longer growing seasons and increased carbon dioxide (Ballesteros Gonzalez, 2015; Houses of Parliament, 2019; Mbow et al., 2019). There are projected increases in the yield of some maize, wheat, potato, sugar beet and cereal crops (Ebi et al., 2018; HM Government, 2017; Intergovernmental Panel on Climate Change, no date; Mbow et al., 2019). Decreases in crop yields are expected for maize, wheat, rice, soybean, legume, root, potato, barley and cereal crops as a result of increasing temperature and precipitation and reduced water availability (Campbell-Lendrum & Pruss-Ustun, 2019; Daryanto et al., 2017; DeFries et al., 2019; Ebi et al., 2018; HM Government, 2017; Hoegh-Guldberg et al., 2018; House of Lords, 2019; Houses of Parliament, 2019; Intergovernmental Panel on Climate Change, no date ; Mbow et al., 2019; Xiong et al., 2017). Production of some vegetables may also decrease due to rising winter temperatures as some vegetables, such as cauliflower and asparagus, need a period of cold accumulation to produce a harvest (Mbow et al., 2019). Crop pollinators are expected to decrease due to climate factors (Ebi et al., 2018; Mbow et al., 2019) and the prevalence of pests and disease is expected to increase (Ebi et al., 2018; HM Government, 2017; Mbow et al., 2019). Climate change is likely to affect pest species and plant diseases in the UK, which may lead to farmers altering their use of chemicals (HM Government, 2017). However, disease risk may decrease in some regions (Mbow et al., 2019). The quality of some vegetable and grain crops may also be impaired as a result of heat stress and increased carbon dioxide (Mbow et al., 2019).

Climate change also affects agriculture through impact on livestock; increasing temperatures can cause heat stress, affect the ability of livestock to reproduce, decrease milk production and increase livestock mortality (DeFries et al., 2019; HM Government, 2017; Mbow et al., 2019). Flooding events may also lead to mortality of livestock (DeFries et al., 2019). Increased temperature and precipitation variation increases the risk of livestock disease (HM Government, 2017; Mbow et al., 2019) and, along with increased

carbon dioxide, will impact pasture quality and quantity (HM Government, 2017; Mbow et al., 2019).

Due to extreme weather events, such as flooding, and sea level rise, climate change also threatens aquaculture production and infrastructure (Intergovernmental Panel on Climate Change, no date; Mbow et al., 2019). Difficulty harvesting fish and shellfish will lead to shortages of fish protein in many regions (Hoegh-Guldberg et al., 2018; Savo et al., 2017).

Consumer stockpiling

Adverse weather and natural disasters can result in supply disruption, which may lead to consumer stockpiling (Leonard & Chomthongdi, 2014). It is not just the physical disruption of food supply chains that causes problems, but the perception of what may happen; fear drives consumers into excessive purchasing of basic commodities, leading to empty shelves, long queues, personal stress, social tensions and media hysteria (Benton et al., 2012; Edwards, no date; Yuen et al., 2020). Fear and uncertainty cause individuals to imitate the majority who are stockpiling, often overriding individual assessment of a situation due to belief that the majority has a better assessment (Kuruppu & De Zoysa, 2020; Yuen et al., 2020). This behaviour further increases disruption to supply chains (Edwards, no date; Yuen et al., 2020) and can lead to an increase in food prices (Martin, 2011; Yuen et al., 2020). This can result in high stress and anxiety due to worry regarding the availability of food (Cowan, 2020) and can prevent vulnerable individuals, such as the poor and elderly, who are in greater need of the products, from accessing them (Yuen et al., 2020). Consumer stockpiling has been observed following major disasters and health crises including the COVID-19 pandemic, the 2011 Christchurch earthquake, Hurricane Matthew in 2016 (Yuen et al., 2020) and severe droughts in Russia in 2010 (Martin, 2011) and Australia in 2008 (Shou et al., 2013). Supply disruption and resultant stockpiling may even lead to violence among consumers, such as during the 2007 floods in southern England (Martin, 2011).

Food-borne disease

Climate change may increase food-borne disease (Khader et al., 2015) and natural disasters can cause disease related to food contamination and poor sanitation (Centers for Disease Control and Prevention, 2015). Increasing temperatures will accelerate growth and transmission of water-borne pathogens, increasing the risk of food-borne disease (Deere et al., 2017). Additionally, food-borne pathogens may be spread as a result of flooding, or overflow of water and sanitation infrastructure due to flood damage, contaminating water sources (Deere et al., 2017; Mbow et al., 2019). Climate related changes can increase the risk of microorganisms that cause disease entering the human food chain, such as salmonella (HM Government, 2017; Mbow et al., 2019; Welch et al., 2019). Mycotoxin risks are also likely to increase with temperature and water stress during growth of major cereal crops (HM Government, 2017). While these risks are global, the interaction with supply chains represents an increasing level of imported risk to the UK (HM Government, 2017). These risks are often managed by temporary import restrictions, disrupting international trade and cereal availability (HM Government, 2017). Increasing UK sea temperatures may result in an increase in transmission of marine pathogens and marine vibrio infections from eating raw seafood (HM Government, 2017). Additionally, drought can lead to a reduction of hygiene during cooking due to lack of water availability, which increases the risk of food-borne

disease (Deere et al., 2017). Food safety risks during transport and storage may also be exacerbated by climate change (Mbow et al., 2019).

Nutrition

Climate change may bring about a reduction in the nutritional quality of some crops (Ebi et al., 2018; House of Lords, 2019; Mbow et al., 2019). Although elevated carbon dioxide may contribute to faster crop growth, it can reduce the protein and nutrient content of crops (Ebi et al., 2018; Hoegh-Guldberg et al., 2018; Mbow et al., 2019). Reduced nutritional content of crops and reduction of food availability is likely to exacerbate undernutrition and nutrition related health risks (Ebi et al., 2018; Hoegh-Guldberg et al., 2018; Mbow et al., 2019; Pozarny, 2016; Saulnier et al., 2017; Veenema et al., 2017). Low income groups, pregnant women, the elderly and children are most likely to be impacted by undernutrition (DeFries et al., 2019; Ebi et al., 2018; Phalkey et al., 2015; United Nations, 2018). Childhood mortality due to malnutrition is projected to increase by 2030 if the climate warms 1.5°C (Roy et al., 2018).

Cost of food

As a result of the projected net reduction in agricultural food supply, worldwide food prices are expected to increase (Gautier, Denis & Locatelli, 2016; HM Government, 2015; Mbow et al., 2019; Pozarny, 2016). This will threaten food security, particularly for lower income groups (Mbow et al., 2019; Vos, 2015) and may increase the scale and depth of poverty (Adger et al., 2014; Mbow et al., 2019). An increase in food prices, following a production shock, can impact quality and safety of food as a result of disease, toxicity and substitution (HM Government, 2017). The absolute availability of food is not likely to be an issue for the UK, however UK food prices have been, and are likely to be, effected by extreme weather events overseas (HM Government, 2017). The increase in price of agricultural crops may also contribute to the obesity epidemic (An et al., 2018).

Indoor/living environments

Rising temperatures and heatwaves as a result of climate change will impact indoor living environments, having consequences for health and comfort (HM Government, 2017; Mavrogianni et al., 2015; Thompson et al., 2014; Wierzbicka et al., 2018). Higher outdoor temperatures are associated with an increase in indoor temperatures, and therefore may lead to overheating in homes, schools, hospitals, care homes, offices and prisons (HM Government, 2017; Kownacki et al., 2019). The risk of overheating is higher depending on building type and location, for example, urban housing has a higher risk due to lack of shading and green space, and energy efficient buildings have a higher risk due to airtightness (Kownacki et al., 2019; Mavrogianni et al., 2015). The existing building stock in the UK may not be safe or comfortable to account for climate change (Thompson et al., 2014). As the climate warms, it will become increasingly challenging to maintain indoor thermal comfort conditions using passive ventilation-based measures alone (HM Government, 2017). With no adaptation to overheating in buildings, annual heat related mortality may increase in the UK (Environmental Agency, 2018). However, in the winter, there will be reduced cold weather impacts indoors and reduced heating demand (Vardoulakis et al., 2015). Those who are socioeconomically deprived, the elderly population and people with long-term health conditions are most at risk of overheating in the home due to limited access to cooling

mechanisms, less knowledge and ability to control heat in the home or resistance to change their behaviour (Centers for Disease Control and Prevention, 2016; DeFries et al., 2019; Kownacki et al., 2019; Vardoulakis et al., 2015). People with long-term health conditions are at a higher risk of experiencing adverse physical health implications of extreme heat (Centers for Disease Control and Prevention & American Public Health Association, no date); high indoor temperatures can lead to exacerbation of symptoms (Kownacki et al., 2019; Tham et al., 2019). There is a negative relationship between high indoor temperatures and social participation, which is stronger for those living in cities and those with disabilities (Kownacki et al., 2019). The elderly population are also more likely to stay inside during heatwaves (Kownacki et al., 2019).

Homeless people are at high risk of heat stress, heat exhaustion, kidney failure and heart attack due to climate change as a result of direct exposure to heatwaves and increased humidity (Centers for Disease Control and Prevention, 2016; Zuo et al., 2015).

Increasing outdoor air pollutants, which increase in concentration during heatwaves, lead to an increased concentration of indoor air pollutants due to infiltration through open windows and ventilation, especially in buildings with no air-conditioning (Kownacki et al., 2019; Wierzbicka et al., 2018). Indoor air pollutants may cause irritation to the eyes and nose, headaches, dizziness, nausea, allergic reactions, immunosuppression and reproductive disorder (Vardoulakis et al., 2015). People with long-term health conditions are most at risk of the adverse health impacts of poor air quality (World Health Organization et al., no date). Additionally, air pollution concentrations are likely to be highest in deprived areas (Grey et al., 2018).

Increasing humidity as a result of climate change can cause condensation and mould issues indoors (Kownacki et al., 2019) and dryer weather may increase atmospheric dust particles in the home which are able to carry pathogens (Vardoulakis et al., 2015). Additionally, climate change induced flooding may lead to short and long-term health consequences for people living in damp homes (Vardoulakis et al., 2015). Flood damage in the home can result in negative economic impacts (Adger et al., 2014; Centers for Disease Control and Prevention, 2017a; HM Government, 2015). Low income groups and those who are unemployed will be most affected, especially when they are uninsured, as they are more likely to live in flood prone areas (Centers for Disease Control and Prevention, 2017a; Benevolenza & DeRigne, 2019; HM Government, 2017; Yiannakoulias et al., 2018).

Access to play

No evidence found.

Waste

No evidence found.

Disease

Climate change is projected to increase the transmission of infectious diseases as a result of temperature, precipitation and humidity change (Waits et al., 2018). This includes increases in vector-borne, water-borne, zoonotic and food-borne diseases (Khader et al., 2015; Veenema et al., 2017). There is a potential impact of new and emerging pests and

diseases as well as an extended range of some diseases due to warmer, wetter conditions (House of Lords, 2019).

Vector-borne disease

In some areas, there will be an increased prevalence of vector-borne diseases due to increased temperature and rainfall (Centers for Disease Control and Prevention, 2015; Dhimal et al., 2015; Ebi et al., 2018; Houses of Parliament, 2019; Khader et al., 2015; Phung et al., 2015; Saulnier et al., 2017; Veenema et al., 2017). Increased surface water from flooding expands breeding sites for vectors and flooding can force vertebrate hosts closer to humans, increasing the risk of vector-borne disease (Deere et al., 2017). In some areas, the geographic range of vector-borne diseases may expand (Ebi et al., 2018). Some vector-borne diseases may be shifted to higher latitudes as a result of temperature and precipitation change, putting large populations at risk (Intergovernmental Panel on Climate Change, no date). However, depending on the region, some areas may experience a decrease in the prevalence of vector-borne disease (Ebi et al., 2018). Additionally, high levels of rainfall can decrease the risk of vector-borne disease by flushing larvae (vectors) from their habitat in pooled water (Deere et al., 2017). The increase in transmission of vector-borne diseases is projected to be worse with 2°C warming in comparison to 1.5°C warming (Houses of Parliament, 2019).

Diseases such as malaria, which are spread by insect vectors, will start to threaten human populations that are not currently exposed to them (DeFries et al., 2019). Climate change is expected to increase the geographical range, transmission and seasonality of malaria as a result of changing temperatures, rainfall and humidity (Babaie et al., 2018; Hoegh-Guldberg et al., 2018). With 1.5°C warming, malaria is projected to increase by 2030 (Roy et al., 2018). However, the risk of malaria transmission in the UK is low (HM Government, 2017). Pregnant women have a high vulnerability to diseases such as malaria (Hlimi, 2015; Pozarny, 2016).

Climate factors, such as temperature, rainfall and humidity change, may also increase transmission of dengue fever (Hii et al., 2016; Li et al., 2018; Matysiak & Roess, 2017; HM Government, 2017). The mosquito vector for dengue fever, Aedes, is likely to increase in number of mosquitos and geographical range with climate change; these increases will be higher at 2°C than 1.5°C warming (Hoegh-Guldberg et al., 2018). The risk of dengue fever will only increase if there is a risk of invasion by non-native mosquito vectors, and the risk is low in the near term for the UK (HM Government, 2017). Cities are prime environments for the transmission and outbreak of dengue fever due to their dense populations (Li et al., 2018).

Warming also leads to the expansion of geographical regions that are climatically suitable for west Nile virus as well as extension of west Nile virus transmission season (Hoegh-Guldberg et al., 2018). Higher temperatures may facilitate the expansion of a range of west Nile virus vector that has recently invaded South-East England (HM Government, 2017).

Warming may lead to the expansion of the geographical range and seasonality of Lyme and other tick-borne diseases in North America and Europe (Hoegh-Guldberg et al., 2018). The projected changes in Lyme disease are larger with greater warming (Hoegh-Guldberg et al., 2018). There is not yet any evidence that relates to the changes in the incidence of Lyme

disease in Wales (HM Government, 2017). Increasing outdoor activity with warmer weather may increase human contact with ticks (HM Government, 2017).

Projections of mosquito vectors for chikungunya, yellow fever and zika virus also illustrate an increase in geographical range and number of mosquitos with climate change (Hoegh-Guldberg et al., 2018). There may also be an increased risk in growth of host snails for schistosomiasis, increasing the prevalence of human schistosomiasis (Kalinda et al., 2017; Stensgaard et al., 2019). Increasing temperatures in the UK will increase the suitability of the UK's climate for invasive mosquito species (HM Government, 2017). Temperature increase and areas of stagnant water due to drought may also lead to the spread of mosquito-borne diseases – should they be introduced to the UK (Environmental Agency, 2018). Climate change may increase the capacity of UK mosquito species to transmit arboviruses (HM Government, 2017). Densely populated areas, those living in poor quality housing and those who lack access to healthcare are at the highest risk of mosquito-borne diseases (United Nations, 2018).

Zoonotic disease

Climate change may also change the occurrence of some zoonotic diseases. Cases of leptospirosis may increase due to an increase in flooding (Naing et al., 2019). Those at an increased risk of leptospirosis include individuals who are exposed to livestock and males (Naing et al., 2019). Increases in temperature and humidity as a result of climate change may lead to increased incidence of hand, foot and mouth disease (Coates, Davis & Andersen, 2019; Duan et al., 2019), particularly in tropical and subtropical climates (Coates, Davis & Andersen, 2019). Temperature and precipitation may also result in increased occurrence of puumala (Roda Gracia et al., 2015). Additionally, an increase in water temperature increases human exposure to vibro parahaemolyticus (Young et al., 2015). Climate change may lead to increases or decreases in the prevalence of leishmaniosis and Chagas diseases (Hoegh-Guldberg et al., 2018).

Environmental conditions

Wildfires

The risk of wildfires will increase with future warming and more frequent heatwaves (House of Lords, 2019; Houses of Parliament, 2019; Zuo et al., 2015). This risk is larger with 2°C warming than with 1.5°C warming (Houses of Parliament, 2019). Increased tree mortality as a result of drought and pests and disease may also contribute to an increased wildfire risk (HM Government, 2017). In the UK, a trend towards drier summers and increased soil moisture deficits suggests an increase in the risk of wildfires, which may be exacerbated by possible changes in the frequency and intensity of droughts (HM Government, 2017). In Wales, climate modelling suggests that wildfire risk will increase by 30-40% in the Brecon Beacons, Pembrokeshire coast and Snowdonia National Parks by the 2080s due to drier summers and higher soil moisture deficits, not accounting for indirect factors such as human behaviour (HM Government, 2017). Key habitats that have been affected by wildfire in Wales include forest, mountain, heath, bog and semi-natural grassland (HM Government, 2017). In 2012-13, there were 174 forest wildfires, affecting an area of 107 hectares in Wales (HM Government, 2017).

Wildfires cause significant economic damage, property damage, casualties and mental health issues (Cianconi et al., 2020; Zuo et al., 2015). Mental health impacts of wildfires can persist over several years, affecting proximal populations, not just individuals who are directly impacted (Cianconi et al., 2020). Exposure to wildfire smoke can lead to respiratory and cardiovascular morbidity and mortality, causing an increase in hospital admissions (Centers for Disease Control and Prevention & American Public Health Association, 2016; Liu et al., 2015). The elderly population are particularly at risk of these impacts (Liu et al., 2015).

Air quality

Climate change may lead to worsening air quality (HM Government, 2017); the number of events, such as heatwaves, causing high levels of air pollution is increasing (Environmental Agency, 2018) and high temperatures cause build-up of harmful air pollutants (Centers for Disease Control and Prevention & American Public Health Association, no date). Additionally, emissions from wildfires can worsen air quality (World Health Organization et al., no date) and increased energy demands as a result of rising temperatures may increase dangerous air pollutants (Centers for Disease Control and Prevention, 2015). An increase in outdoor and indoor pollution as a result of climate change increases the risk of morbidity and mortality from non-communicable disease (Campbell-Lendrum & Pruss-Ustun, 2019; Centers for Disease Control and Prevention & American Public Health Association, no date; Dyakova et al., 2016; Khader et al., 2015; Pozarny, 2016; World Health Organization et al., no date).

In the short term, high levels of particulate matter may lead to nausea, headache, exacerbation of asthma symptoms and irritation to the nose, eyes and throat (Grey et al., 2018). In the longer term, particulate matter can increase morbidity and mortality from lung cancer, respiratory disease, heart disease and stroke (Grey et al., 2018; Madaniyazi et al., 2015). Particulate matter mortality may increase or decrease depending on climate projections and emission assumptions (Hoegh-Guldberg et al., 2018). In the short term, increasing levels of nitrogen dioxide also increases the risk of respiratory and cardiovascular morbidity (Grey et al., 2018). Climate change will also cause ground level ozone to increase as a result of increased ultra-violet radiation from decreased stratospheric ozone (Intergovernmental Panel on Climate Change, no date). Long term exposure to ozone increases cardiovascular, cardiopulmonary and respiratory mortality and may lead to ischaemic heart disease, diminished lung function and lung cancer (Atkinson et al., 2016; Centers for Disease Control and Prevention & American Public Health Association, 2016; Ebi et al., 2018; Hoegh-Guldberg et al., 2018; Madaniyazi et al., 2015). Increased ozone and allergens aggravate existing allergies and asthma (Centers for Disease Control and Prevention, 2015; Centers for Disease Control and Prevention & American Public Health Association, 2016), and an increase in ground level ozone is also associated with an increase in asthma related hospital admissions and emergency department visits (Centers for Disease Control and Prevention & American Public Health Association, 2016). Climate change also affects allergies through changes in pollen abundance and seasonality (HM Government, 2017; Lake et al., 2017). Higher temperatures, higher concentrations of carbon dioxide and different patterns of rainfall and humidity contribute to the impact of climate change on pollen (HM Government, 2017). These changes can increase the severity of pollen allergy symptoms (Lake et al., 2017). Ozone can also reduce crop growth and yield (Mbow et al.,

2019). Impacts from flooding can cause indoor air quality to decrease due to damp and mould issues, causing both short and long term health consequences, such as hypersensitivity (Centers for Disease Control and Prevention, 2017a; Vardoulakis et al., 2015).

Those living in or commuting to highly populated or urban areas are disproportionately impacted by the physical health implications of poor air quality (Grey et al., 2018; Madaniyazi et al., 2015), as urban areas often face the highest pollution levels (World Health Organization et al., no date). Those living in rural areas are most at risk of air pollution from wildfires (World Health Organization et al., no date). Health outcomes from poor air quality also disproportionately impact vulnerable populations, including children, elderly people, pregnant women and those with chronic disease, due to their lower baseline mortality (Grey et al., 2018; Wang et al., 2016; World Health Organization et al., no date). People living in deprived areas may also be more susceptible to negative health outcomes form poor air quality; Welsh data show that nitrogen dioxide concentrations are highest in deprived areas (Grey et al., 2018).

Landslides

Research shows causal relationships between climate change and landslides; climate change can affect landslides and the stability of natural and engineered slopes due to changes in rainfall frequency and intensity (Gariano & Guzzetti, 2016; Haque et al., 2019; HM Government, 2017). When people and their associated structures are exposed to landslides, fatalities, deaths and physical asset damage may occur, incurring large economic costs (Haque et al., 2019; Froude & Petley, 2018). The annual number of deadly landslides increased between the years 2005-2014 (Haque et al., 2019) and the size of the population exposed to landslide risk is expected to grow (Gariano & Guzzetti, 2016). Cities are particularly at risk of landslide hazards and this risk will increase with 1.5°C warming (Roy et al., 2018).

The UK is subject to extreme seasonal and storm events as a result of climate change, presenting landslide hazards (Winter et al., 2016). Two percent of the UKs rail network is at high risk of landslide disruption, and six percent is at medium risk (HM Government, 2017). An average of 50 landslides disrupt UK rail services per year (HM Government, 2017). Landslide hazards have caused repeated disruption to major road networks in Scotland (Winter et al., 2016). This leads to loss of utility of parts of the road network, the need to make detours to reach a destination, economic losses due to travel delay and the severance of access to and from remote communities (Kownacki et al., 2019; Winter et al., 2016). Therefore, people living in remote communities will have limited or no access to markets for goods, employment, healthcare, education and social activities (Kownacki et al., 2019). These impacts of landslide hazards may lead to a decline in tourism in the summer months, which is harmful to Scotland's economy (Winter et al., 2016).

Flooding

More frequent, intense rainfall and sea level rise as a result of climate change will result in increased flooding events (HM Government, 2017; House of Lords, 2019). Flooding leads to many adverse consequences, including damage to homes, property, infrastructure, transport systems, power stations and clean and waste water treatment sites (Adger et al.,

2014; DeFries et al., 2019; Environmental Agency, 2018; HM Government, 2017; Hoegh-Guldberg et al., 2018; Transport for London, 2011; Veenema et al., 2017). In England, there are many properties and key infrastructure sites located in flood risk areas, and new developments are still being made on flood prone land (Environmental Agency, 2018; HM Government, 2017). This creates a need for investment in flood defences, including the cost of maintenance and repair (Environmental Agency, 2018). Even with shoreline management plans, an estimated 700 properties in the UK will be lost in 20 years, and 2000 properties over 50 years (Environmental Agency, 2018). In some of these areas, it will not be cost-beneficial to protect properties, leading to economic decline (Environmental Agency, 2018). Damage and disruption to transport infrastructure as a result of flooding, such as bridge and road collapse, leads to difficulty accessing employment, health services and education (HM Government, 2017; Veenema et al., 2017). In the UK and Wales, flooding currently impacts road and rail services, and there is a projected increase in the portion of UK rail network vulnerable to flooding as the climate warms (HM Government, 2017). Wales, particularly in the North and West, has long stretches of railway and roads located next to the shoreline that are exposed to flooding from the sea (HM Government, 2017). Additionally, hydroelectric generation is a major component of power capacity in Wales and is vulnerable to extreme flooding (HM Government, 2017). Other services may also be disrupted as a result of flooding, such as healthcare, communications networks and food and water supply (DeFries et al., 2019; HM Government, 2017; Tech UK, 2016; Veenema et al., 2017).

Damage to critical infrastructure from flooding can have long lasting impacts on affected communities (HM Government, 2017). The social impacts of flooding include displacement from homes (HM Government, 2017; Rechkemmer et al., 2016), loss of work and school days and impact on household income (Environmental Agency, 2018; HM Government, 2017). Additionally, flooding may positively or negatively impact social cohesion within communities (HM Government, 2017). Flooding may also contribute to poor mental health outcomes such as depression, anxiety and post-traumatic stress disorder, which may persist for over a year following the flooding event (Centers for Disease Control and Prevention, 2017a; Chen & Liu, 2015; Cianconi et al., 2020; Environmental Agency, 2018; HM Government, 2017; Public Health England, 2017). For these individuals, fear of being flooded again is a persistent issue (Environmental Agency, 2018). With greater frequency and intensity of flooding events, mortality and injury rates are likely to increase (DeFries et al., 2019; HM Government, 2017; Pozarny, 2016) due to falling debris or collapsing buildings, walking on slippery surfaces, motor vehicle injuries when driving through floods, electrocution from flooded electrical equipment, hyperthermia when trapped in flood water, drowning in flood water, respiratory illness from damp homes and exacerbation of chronic illnesses (Centers for Disease Control and Prevention, 2017a; Cianconi et al., 2020; Vardoulakis et al., 2015; Veenema et al., 2017). Flooding can also lead to contamination of drinking water due to overwhelmed sewage and drainage (Centers for Disease Control and Prevention, 2015; Cianconi et al., 2020; Veenema et al., 2017), which may contribute to increases in diarrhoeal disease (Levy, Woster, Goldstein & Carlton, 2016; Mbow et al., 2019), infections, fevers and water-borne and vector-borne diseases (Cianconi et al., 2020; Phung et al., 2015; Saulnier et al., 2017).

Rapid expansion of cities has increased exposure of people and economic assets to flooding (Pozarny, 2016). Urban areas are at risk of surface water flooding, especially if sewerage

and drainage infrastructure cannot cope with a high volume of rainfall (DeFries et al., 2019; HM Government, 2017). Coastal areas also have a high flood risk due to sea level rise (HM Government, 2017; House of Lords, 2019; Roy et al., 2018). Rural communities are highly vulnerable to flood impacts on transport links (HM Government, 2017) and those living in flood risk areas are vulnerable to flooding (Intergovernmental Panel on Climate Change, no date). Occupation may increase individual flood risk, for example, outdoor workers and emergency service workers can be exposed to damaging coastal floods (Centers for Disease Control and Prevention, 2017a). Both people with long term health conditions and pregnant women have a higher sensitivity and vulnerability to the impacts of flooding (Centers for Disease Control and Prevention, 2017a). Additionally, flood exposure can be associated with preterm births and low birth weight (Centers for Disease Control and Prevention, 2017a). Those of low socioeconomic status, low-income migrants and groups of ethnic minority are often at a higher risk of flooding as they are more likely to live in flood prone areas (Adger et al., 2014; Centers for Disease Control and Prevention, 2017a; HM Government, 2017; Yiannakoulias et al., 2018) and those with low income are less likely to be insured (487). However, in some settings, high income areas are associated with the highest flood risk (Yiannakoulias et al., 2018).

Biodiversity

Climate change factors will change plant biodiversity; with no adaptation, plants will have to find new strategies to survive by 2100 (Cianconi et al., 2020). Some species are threatened by invasive, non-native species, for example insect crop pests and diseases targeting forestry trees and garden plants (Environmental Agency, 2018). Warmer, wetter conditions as a result of climate change will lead to the emergence of new pests and diseases and allow pests to extend their range (House of Lords, 2019). However, in some areas and for some diseases, risks may decrease, for example, dry conditions reduce the ability of fungi to survive (Mbow et al., 2019). Temperature and precipitation changes affect forest eco-systems, impacting local populations that are dependent on forest-based resources (Chakraborty et al., 2018). Drought is also a cause of increased tree and crop mortality (HM Government, 2017; Kamara et al., 2018). The increased risk of wildfires as a result of drought further increases the risk of tree mortality (HM Government, 2017). Crops are also negatively impacted by an increase in ultra-violet radiation (Intergovernmental Panel on Climate Change, no date). Some plants, for example, bromeliad plants, that provide benefits to humans, such as food provision and water and disease regulation, are negatively impacted by climate change (Ladino et al., 2019).

Animal biodiversity is also impacted by climate change; high temperatures, drought and water stress increases animal morbidity and mortality (Kamara et al., 2018; Mbow et al., 2019). Climate change is likely to have a negative impact on livestock by influencing pasture quality, water availability and increasing the risk of livestock pests and disease through variation in temperature and precipitation (Hoegh-Guldberg et al., 2018; Mbow et al., 2019). Livestock may also be impacted by increases in ultra-violet radiation, and extreme heat can lead to reduced ability of livestock to reproduce (DeFries et al., 2019; Hoegh-Guldberg et al., 2018; Intergovernmental Panel on Climate Change, no date; Mbow et al., 2019). Additionally, increased flooding events may result in drowned livestock (DeFries et al., 2019). Climate change may also lead to disruption of the mutualistic interaction between animal and plant during pollination (Mbow et al., 2019). There may be an increase

in pathogens that affect pollinators, including insects, birds and bats, and mortality of pollinators is expected to increase due to extreme weathers and habitat loss (Ebi et al., 2018; Mbow et al., 2019).

Climate change may cause a decrease in the abundance, survival and growth of some exploitable fish species due to increasing storm frequency and severity, rising temperatures, ocean acidification and changes in fluvial flows and ocean currents (Marine Management Organization, 2016). In UK waters, there will be a likely decline some species of fish and an increase in others (HM Government, 2017). In the short term, rising temperatures may lead to increased growth rates for some farmed fish species, such as Atlantic salmon, and the opportunity to cultivate new farmed species, such as sea bass and bream (HM Government, 2017). Continued temperature rise may cause a decrease in salmon and trout and an increase in bream and roach in UK freshwater habitats (Environmental Agency, 2018). Some farmed cold-water species, such as cod and Atlantic halibut may decline due to thermal stress (HM Government, 2017). Increased flooding may lead to damage of freshwater ecosystems, endangering some species, such as mussel species in north England (Environmental Agency, 2018). Climate change may also cause an increase in the abundance, survival and growth of non-native pest species, including marine pathogens, harmful algal blooms and jellyfish blooms (HM Government, 2017; Marine Management Organization, 2016). This may lead to an additional decline in fish and can have harmful human health implications (HM Government, 2017; Marine Management Organization, 2016). A decline in coral reef ecosystems also decreases marine biodiversity and may lead to the collapse of coastal fisheries (HM Government, 2015; Roy et al., 2018).

This climate change induced decline in biodiversity is projected to negatively impact tourism (Hoegh-Guldberg et al., 2018). Coastal tourism will be impacted by the loss of beaches and coral reef assets (Hoegh-Guldberg et al., 2018).

Economic conditions affecting health

Economic conditions/financial well-being

Climate related disasters represent setbacks for economic growth. However, if the disaster is moderate, there can be a positive impact on economic growth (Castells-Quintana, Lopez-Uribe & McDermott, 2015). Wildfires, flooding, landslides and other climate related disasters can lead to huge economic losses (Adger et al., 2014; Froude & Petley, 2018; Government Actuary's Department, 2018; Hoegh-Guldberg et al., 2018; Zuo et al., 2015), putting pressure on the economy as public assets need protecting (Government Actuary's Department, 2018). In England and Wales, projected changes in flood risk mean economic damage may increase up to 20 times by the 2080s (Adger et al., 2014). Some coastal communities in the UK could become at risk of economic blight in the absence of plans to manage long-term coastal change, including the effects of coastal flooding and coastal erosion (HM Government, 2017). Decreasing food production, an increase in health issues associated with climate change, and more extreme weather will slow economic growth, making it increasingly difficult to reduce poverty (HM Government, no date). Reduced outdoor work activities and lost work days due to climate factors may also result in economic losses (Environmental Agency, 2018; Zuo et al., 2015).

Climate related events lead to economic impact as a result of destruction of properties and infrastructure (Adger et al., 2014; Environmental Agency, 2018; HM Government, 2015), damage of public assets such as schools and hospitals (Government Actuary's Department, 2018; World Health Organization, 2019), interruption to businesses and business losses (DeFries et al., 2019; Environmental Agency, 2018; Government Actuary's Department, 2018), management of water infrastructure such as flood defenses and irrigation systems (Environmental Agency, 2018; Pozarny, 2016), maintenance of water supply (Compagnucci et al., 2018), a reduction in goods and services provided by natural capital such as timber (House of Lords, 2019), disruption to transport and infrastructure (Froude & Petley, 2018; HM Government, 2015) and food price hikes (Werz & Hoffman, 2016). For some areas in the UK, it will not be cost-beneficial to protect properties and infrastructure against the impacts of climate change, leading to economic decline in the affected areas (Environmental Agency, 2018).

The agricultural industry will experience reduced economic activity through the impact of climate change on crops and livestock (Castells-Quintana et al., 2015; Hoegh-Guldberg et al., 2018; Zuo et al., 2015). Poor soil quality, lack of fresh water and increased prevalence of pests due to climate change results in low crop productivity, damaged crops and reduced production per unit of land, which reduces profitability of crops and therefore economic performance (Castells-Quintana et al., 2015; Zelingher et al., 2019; Zuo et al., 2015). Climate change has an impact on livestock through reduction in feed quality, disease, growth rate, reproduction, reduced milk yield and increased mortality due to heat stress, consequently causing economic losses (Hoegh-Guldberg et al., 2018; Kamara et al., 2018). Farmers who are unable to invest in insurance or mitigation strategies will face further production loss (Vos, 2015). Rising temperatures may reduce productivity where agriculture depends on manual labour, leading to economic losses (Mbow et al., 2019). Additionally, agrarian and pastoral communities who are dependent on forests and forest-based resources will be affected by the impact of temperature and precipitation changes in forest eco-systems (Chakraborty et al., 2018).

Climate change may also contribute to economic losses for fisheries and aquaculture; with 1.5°C warming, there is a projected 1.5 million tons of fishery catch loss (House of Lords, 2019). Potential risks of climate change to fisheries include sea temperature rise, changes in fluvial inputs and increasing frequency of occurrence and concentration of harmful algal blooms in shellfish, which could all lead to economic losses (Marine Management Organization, 2016).

Reduced volume of elements of the terrestrial cryosphere (seasonal snow cover, near surface layers of permafrost, masses of ice) will have an impact on economic activities (Intergovernmental Panel on Climate Change, no date). Changes in volume of snow cover and length of snow cover season may have a positive or negative impact on recreation sectors (Intergovernmental Panel on Climate Change, no date).

For some impacts of climate change, there are large individual costs, which are most likely to affect low income groups and the unemployed as they are less likely to be insured (Benevolenza & DeRigne, 2019; Centers for Disease Control and Prevention, 2017a; HM Government, 2017). A lack of insurance may increase chronic illness if individuals have no access to medical care during a disaster (Cianconi et al., 2020). Rural areas will also be impacted by climate change through impact on agriculture-related livelihoods and employment (Intergovernmental Panel on Climate Change, no date).

Productivity

Occupational exposure to heat can result in decreased productivity and reduced work hours worldwide (DeFries et al., 2019; Ebi et al., 2018; HM Government, 2017; Hoegh-Guldberg et al., 2018); Jacklitsch et al., 2016), particularly for outdoor workers and workers with no access to air conditioning, where productivity could decline by 1-3% for every 1°C rise in temperature (Roy et al., 2018; Zuo et al., 2015). Occupations that depend on manual labour, such as agriculture, construction and manufacturing, also suffer decreased productivity as a result of heat exposure (Flouris et al., 2018; Houses of Parliament, 2019; Levi et al., 2018; Nunfam et al., 2018; Mbow et al., 2019). Projected impacts of climate change on health, such as morbidity and mortality from heat exposure and infectious disease, may lead to declines in labour productivity (HM Government, 2017). However, mid-to-high latitude fisheries could see an increase in fishery productivity (Hoegh-Guldberg et al., 2018).

Additionally, extreme weather events such as flooding can prevent staff from getting to work (HM Government, 2017). Extreme weather may also result in workers being denied access to sites or prevent them from working remotely (HM Government, 2017).

Working conditions

Increasing heat in the workplace increases work-related injury, especially in industries such as agriculture, forestry, fishing, construction, transport, gas, electric and water (Binazzi et al., 2019; Bonafede et al., 2016; DeFries et al., 2019). Heat exposure in the workplace can cause heat strain, acute kidney injury and chronic kidney disease and can increase the risk of vector-borne diseases (Flouris et al., 2018; Levi et al., 2018). It may also result in injury due to sweaty palms and fogged safety glasses, dizziness, burns and reduced brain functioning (Jacklitsch et al., 2016). Heat exposure may also lead to mortality (Nunfam et al., 2018). Males may be at a higher risk of heat-related injury in the workplace as they are more likely to work in high-risk occupations (Binazzi et al., 2019; Bonafede et al., 2016). Outdoor workers are also at a high risk of heat-related injury (HM Government, 2017). Thermal discomfort may be experienced in office-based work, especially in offices built in the 1960s and 1970s, due to poor ventilation (HM Government, 2017). Temperature extremes also contribute to decreased safety in the workplace (United Nations, 2018).

However, cold temperatures also increase work-related injuries, particularly for those who work on plains and those who use vehicles other than cars; there may be a decline in cold induced work-related injuries as the climate warms (Bonafede et al., 2016).

Tourism

It is projected that tourism in Europe will reduce by 5% with 2°C warming (Hoegh-Guldberg et al., 2018). A decline in tourism may be seen due to sea level rise, more frequent storms, loss and degradation of beaches, loss of coral reef assets, decline in biodiversity and loss of important cultural and environmental heritage sites (Hoegh-Guldberg et al., 2018; Marine Management Organization, 2016). Tourism in some locations, such as Scotland, may also be negatively impacted as a result of increasing landslide hazards (Winter et al., 2016). Additionally, climate change is reducing the amount of Olympic Winter Games locations that are climatically reliable for future Olympic and Paralympic winter games (Hoegh-Guldberg et al., 2018). However, rising air and sea temperatures may create benefits, including

increased ecotourism, increased recreational fishing, increased coastal tourism and improved conditions for scuba diving (Marine Management Organization, 2016). There may also be development of 'last chance to see' tourism markets, allowing travellers to visit destinations before they are degraded by climate change impacts (Hoegh-Guldberg et al., 2018).

Access to services

Transport

Flooding, increased precipitation, extreme heat and other extreme weather events are risks to transport services, including road, rail, underground, air, marine and pipeline transportation (Hoegh-Guldberg et al., 2018; Transport for London, 2011). Climate factors may lead to a lesser ability to navigate important transport routes, for example, there are fewer days where large boat-trains are able to travel the river Rhine in Europe (Compagnucci et al., 2018).

Assets vulnerable to future flood damage include motorways, A-roads, railway tracks, railway stations, airports and ports (Adger et al., 2014; DeFries et al., 2019; HM Government, 2017). Flooding causes disruption to these services (HM Government, 2017). Flooding and extreme weather may also cause bridges and roads to collapse, reducing access to employment, healthcare, education and other services (HM Government, 2017). A 4°C warming scenario would lead to 2,400 km of the UK rail network being vulnerable to flooding, rising by 120% by the 2080s (HM Government, 2017).

Heatwaves also pose a risk to transport infrastructure, and may cause bucking of railway track, damage to roads and failure of traffic lights (Zuo et al., 2015). Railways are particularly vulnerable to extreme heat. The frequency of rail buckling is expected to be four times higher under a low climate change scenario and five times higher in a high climate change scenario (HM Government, 2017). High temperatures also affect what maintenance can be performed, for example, tensioning rail track is difficult in due to thermal expansion, and road tarmac dries too fast in high temperatures (HM Government, 2017). Overheating on UK public transport is likely to increase, having adverse impacts on passenger health and well-being (HM Government, 2017). Overheating may also lead to increased disruption to public transport, for example, trains may be stopped if passengers become ill (HM Government, 2017). Cold weather is a major cause of disruption to transport services, and with projected decreases in cold winters and snow and ice days, there will be a likely reduction in winter disruption and maintenance costs (HM Government, 2017; Intergovernmental Panel on Climate Change, no date). However, in a low probability, very high climate change scenario, slowdown of the Gulf Stream and low solar activity could reduce average winter temperatures (HM Government, 2017).

High winds also cause disruption to rail networks; in the UK, 5% of all passenger disruptions to rail transport were due to high winds in 2006-2013 (HM Government, 2017). Disruption to rail networks and tree-related faults may also occur as a result of increases in vegetation growth due to longer growing seasons (HM Government, 2017).

Older, less well-compacted earthworks, such as those supporting the rail network, are deteriorating faster than newer earthworks built to modern construction standards (HM

Government, 2017). In the winter of 2013-14, heavy rain in Wales led to rail routes experiencing three landslides, resulting in extended periods of speed restrictions (HM Government, 2017). Extended periods of rainfall increase the risk of slope and embankment instability for road and rail infrastructure. In a high emissions scenario, soil moisture fluctuations, brought on by cycles of drought and heavy rain, will lead to increased shrink-swell related failures. Wales is particularly at risk due to long lengths of road and railway, often located in steep valleys (HM Government, 2017). Landslide hazards in Scotland have cause repeated disruptions to transport, including loss of utility of parts of the road network, the need to make detours to reach a destination and the severance of access to and from remote communities (Kownacki et al., 2019; Winter et al., 2016).

Coastal areas are particularly at risk of damage and disruption to transport infrastructure due to flooding and storms (HM Government, 2017; Veenema et al., 2017). Wales has long stretches of road and railway located next to the shoreline, especially in the north and west, which is at risk of flooding from sea level rise (HM Government, 2017). Additionally, sea level rise is a threat to ports, which receive 95% of the UKs imports and exports (Environmental Agency, 2018). Urban areas are most at risk of experiencing adverse impacts on commuter comfort and health, due to elevated temperatures on public transport (HM Government, 2017).

Health and care services (including access to healthcare)

Climate related events, such as heatwaves and flooding, can impact the functionality of healthcare services, including mental health care, through disruption or damage of infrastructure and equipment (Cianconi et al., 2020; HM Government, 2017; Man et al., 2018; Saulnier et al., 2017; Veenema et al., 2017; World Health Organization, 2019) and cause overburdening of clinical services due to increased hospital and psychiatry admissions and ambulance call outs (Khader et al., 2015; Zuo et al., 2015; World Health Organization, 2019). In the UK, the number of GP surgeries, emergency service stations and care homes located in flood risk areas is expected to increase as the climate warms, especially in England and Wales (HM Government, 2017). Additionally, UK health services will be vulnerable to an increase in the frequency and intensity of heatwaves (HM Government, 2017). Hospitals may also experience lack of access to clean water due to tropical storms and cyclones (Veenema et al., 2017) and their power supply may be at risk from cascading failures (HM Government, 2017). Flood events may also cause power and communication loss, impacting care homes and vulnerable people who rely on home care providers (HM Government, 2017). These factors contribute to interruption of preventative and follow up care (Ryan et al., 2015; Saulnier et al., 2017; Veenema et al., 2017; World Health Organization, 2019) and difficulty proceeding with work due to loss of medical records and research specimens and destruction of clinical trial centres (Man, Lack, Wyatt & Murray, 2018). Patients may have to be transferred, which puts additional pressure on the healthcare facilities receiving transferred patients (Man et al., 2018). These impacts will also have negative financial implications for healthcare services (World Health Organization, 2019).

Access to medicine may also be reduced due to pharmacy closures, loss of medicines and degradation of medicines as a result of heatwaves (HM Government, 2017; Man et al., 2018). People living in rural communities are more vulnerable to flood impacts on transport links

and therefore may have difficulty accessing health and social care services during extreme weather events (HM Government, 2017). Cold spells, snow storms and flooding interrupt travel for patients and healthcare staff, however, fewer cold events in the future may benefit health system management (HM Government, 2017). Refugees and asylum seekers may also have difficulty accessing healthcare, or have limited access to healthcare services (United Nations, 2018). Additionally, people with mobility issues, such as disabilities or obesity, have difficulty accessing healthcare (Centers for Disease Control and Prevention, 2016).

Macro issues

Infrastructure

Sea level rise and extreme weather events cause damage and destruction of homes, public assets such as schools and hospitals, airports and other infrastructure (Adger et al., 2014; DeFries et al., 2019; Government Actuary's Department, 2018; Hoegh-Guldberg et al., 2018; House of Lords, 2019; Veenema et al., 2017). Climate change may also impact building materials, for example, UV radiation can impact the durability of materials and high temperatures can cause expansion stress in concrete and steel structures (Zuo et al., 2015). If current building design features cannot cope with the changing climate, many buildings could become 'stranded assets' (Thompson et al., 2014).

Climate change can lead to the damage and destruction of infrastructure through extreme weather events and sea level rise (Adger et al., 2014). Infrastructure across Wales is exposed to a range of climate hazards; flooding poses the greatest long-term risk to Welsh infrastructure, and currently accounts for significant losses in infrastructure services, but there are growing risks from heat, water scarcity and slope instability cause by extreme weather (HM Government, 2017). Key infrastructure sites in England are located in flood risk areas, so are also vulnerable to the impacts of climate change related flooding (Environmental Agency, 2018). Extreme heat impacts building materials, for example by causing expansion stress in concrete and steel structures, and UV radiation can affect the durability of materials (Zuo et al., 2015). Rising temperatures may also reduce the capacity and efficiency of infrastructure, such as treatment plants and pumping stations (Environmental Agency, 2018). If current building design features cannot cope with the impacts of climate change, many buildings could become 'stranded assets' (Thompson et al., 2014).

Climate change-induced sea level rise, storms and increased surface water and river flooding due to heavy rainfall leads to damage and flooding of homes and property (Adger et al., 2014; DeFries et al., 2019; Hoegh-Guldberg et al., 2018). In Wales, many residential properties are at risk of flooding, and the expected annual damage to residential properties is projected to rise by between 35-110% in the 2050s. Damage of public assets, such as schools and hospitals, is also an impact of climate related weather events (Government Actuary's Department, 2018). Rehabilitation or rebuilding of educational infrastructure following climate change impacts may result in disruptions to educational programming and a financial burden on education budgets (Pozarny, 2016). Disruption and damage of healthcare infrastructure impacts the functionality healthcare services (HM Government, 2017; Man et al., 2018; Saulnier et al., 2017; Veenema et al., 2017; World Health

Organization, 2019) leading to interruption of care (Ryan et al., 2015; Saulnier et al., 2017; Veenema et al., 2017; World Health Organization, 2019).

High and fast river flows can lead to localised riverbank erosion, which undermines structures, such as bridges, and exposes buried cabling and pipework (HM Government, 2017). Bridges carry services, including gas, telecoms and power, in addition to people and road and rail traffic, so loss of bridges can have multiple negative impacts (HM Government, 2017). Currently in the UK, bridge scour causes, on average, one bridge failure per year and peak river flows in west Wales are expected to increase (HM Government, 2017).

Storms, heavy rainfall, flooding, drought and extreme heat all have the potential to disrupt infrastructure delivering water (HM Government, 2017). However, there may be opportunities arising from fewer snow and ice days, reducing winter disruption and maintenance costs (HM Government, 2017). Clean and waste water treatment sites in the UK are vulnerable to flooding, which causes disruption to water services (HM Government, 2017). The majority of 24 Water Resource Zones in Wales are projected to remain in surplus until the 2080s, even under a high population and high climate change scenario. Overall, Welsh Water has a projected deficit of 69 Ml/d by the 2050s and 136 Ml/d by the 2080s (HM Government, 2017).

Storms, heavy rainfall, flooding, drought and extreme heat as a result of climate change also have the potential to disrupt infrastructure delivering power and information and communication technology (ICT) (HM Government, 2017). Additionally, there may be opportunities arising from fewer snow and ice days, reducing winter disruption and maintenance costs (HM Government, 2017). Flooding causes disruption to power and ICT services where power stations and cables are exposed to flooding (HM Government, 2017; Tech UK, 2016). Substation sites are vulnerable to flooding from heavy rainfall and sea level rise, posing a risk to energy providers and reducing energy supply security (Electricity North West, 2015; SP Energy Networks, 2015). Increased winter rainfall is likely to have an impact on communications networks. Currently, winter flooding has posed the vast majority of the weather-related problems that the sector has had to address, and this has primarily affected local communications infrastructure (Tech UK, 2016). Hydropower output, a major component of power capacity in Wales, is also vulnerable to extreme flooding (HM Government, 2017). However, hydropower output may increase in the winter (HM Government, 2017). Electricity and ICT generation, transmission and distribution infrastructures are particularly vulnerable to extreme heat (Electricity North West, 2015; HM Government, 2017). Higher temperatures also affect the ability for maintenance of control infrastructure (SP Energy Networks, 2015). Additionally, these services may become overloaded in the summer due to transformers affected by urban heat islands and coincident air conditioning demand (Energy Networks Association, 2015). In a high emissions scenario, increases in mean temperature could reduce the rating of overhead power lines in the distribution network on average by 6-10% by the period 2070-2099. On the hottest days in the 2080s, this may be reduced by 27% for some components, reducing the effective capacity of the network (HM Government, 2017). Additionally, hydropower output is vulnerable to drought (HM Government, 2017). High winds are also a significant cause of disruption to electricity networks (HM Government, 2017). Storms, involving wind and lightning, are a risk for disruption to overhead cables for energy distribution and ICT networks, such as those delivering broadband to rural areas (HM Government, 2017). Electricity transmission and

distribution networks are likely to experience an increase of between 4-36%, depending on climate scenario, in lightning-related faults by the 2080s (Environmental Agency, 2018; HM Government, 2017). However, the impact of these events is low, as damage can be quickly repaired (HM Government, 2017). Increased vegetation growth, as a result of longer growing seasons, may also impact overhead cables and increase the number of tree-related faults (Electricity North West, 2015; HM Government, 2017).

Coastal areas are at risk of experiencing the damaging impacts of climate change on infrastructure due to sea level rise (Hoegh-Guldberg et al., 2018; House of Lords, 2019; Veenema et al., 2017). In Wales, there are significant infrastructure assets, including oil refineries and power stations, located in coastal areas that are exposed to flooding from the sea (HM Government, 2017). Additionally, many landfill sites in England and Wales are located within coastal flood and erosion zones (Environmental Agency, 2018).

Education

Extreme weather, as a result of climate change, has the potential to undermine investment in improvement of the quality of education provision (Blum, 2015). Educational infrastructure may be damaged by the impacts of climate change and rehabilitation of this infrastructure results in disruptions to educational programming and significant financial burden for already constrained education budgets (Blum, 2015).

Climate change is projected to cause changing patterns of disease, water, food insecurity, extreme climatic events and population migration, which may have impacts on access to education and learning (Blum, 2015). For example, in some regions, malaria has a significant impact on student and teacher attendance in schools (Blum, 2015).

Inequalities

Relevant information included in other sections.

Legislation

Unequal policies and patterns of sometimes very rapid development are benefiting certain segments of society while making others more vulnerable to climate change (Tucker et al., 2015). Populations that are displaced by climate change are not formally protected under international refugee law and therefore may face limited options for political and social integration into destination societies (Torres & Casey, 2017). Additionally, climate-related risks to health, livelihoods, food security, water supply and human security make it more challenging to meet the sustainable development goals. This is more challenging with 2°C warming in comparison to 1.5°C warming (Houses of Parliament, 2019).

5.2 Population groups

Age groups

Children and young people

Due to the increasing frequency and severity of disasters, climate change will disproportionately impact children, both immediately and long-term (Pozarny, 2016). However, children are potentially the greatest agents of positive change (Pozarny, 2016).

Children have a higher risk of heat related morbidity and mortality (Centers for Disease Control and Prevention, 2015; Centers for Disease Control and Prevention, 2016; Centers for Disease Control and Prevention & American Public Health Association, no date; Ebi et al., 2018; Hoegh-Guldberg et al., 2018; Zuo et al., 2015) and are more sensitive and less tolerant of high temperatures (Centers for Disease Control and Prevention, 2016). With increasing heatwaves and humidity, children are at a higher risk of experiencing sun burn, heat stress and exhaustion, kidney failure and heart attack (Zuo et al., 2015).

A greater frequency and intensity of extreme weather events, such as flooding and heatwaves, will increase infection, mortality and injury rates, particularly for children (Pozarny, 2016; Veenema et al., 2017). Increasing temperature and precipitation can impact child height, weight and haemoglobin levels (Amegah et al., 2016) and has a positive association with all-cause childhood diarrhoea (Lal, et al., 2019; Veenema et al., 2017). Flooding and drought in urban areas may result in water contamination, increasing the risk of diarrhoeal disease in poor children (Mbow et al., 2019).

Children have a higher susceptibility to the adverse physical health impacts from poor air quality, such as increasing particulate matter and nitrogen oxide, due to their lower baseline mortality (Grey et al., 2018; Wang et al., 2016; World Health Organization et al., no date). Additionally, increasing temperatures and variations in temperature increase asthma risk in children (Xu et al., 2018). However, low temperatures also increase asthma risk in children (Xu et al., 2018), therefore asthma cases attributed to low temperatures may decrease as the climate warms. Respiratory related hospitalisations for children may also increase due to wildfire smoke (Liu et al., 2015).

Climate related events, such as drought and flooding, may lead to child undernutrition (Belesova et al., 2019; Ebi et al., 2018; Phalkey et al., 2015; Roy et al., 2018) due to disruption of food security and poor agricultural yields (DeFries et al., 2019; United Nations, 2018). This risk is higher for younger children and displaced children (Phalkey et al., 2015; United Nations, 2018).

Children and young people are more likely to experience an impact on mental, emotional and psychological health following climate related events (Benevolenza & DeRigne, 2019). Climate related events can lead to increases in post-traumatic stress disorder, depression, anxiety, sleep problems, cognitive deficit and learning issues, particularly in children and young people (Sanson et al., 2019; Smith et al., 2015). Most young people are aware of climate change and express fear, sadness, anger and powerlessness about its impact on their lives (Sanson et al., 2019). Most young people worry about how climate change will impact their future and how it will impact people living in developing countries (Sanson et al.,

2018). This may lead to distress, increased aggression and violence or increased suicide rates (Sanson et al., 2019).

Both sudden and gradual climate events may increase children's exposure to domestic violence, family stress and reduced parental capacity to protect children (Sanson et al., 2019). The impact of climate change on parents' well-being can lead to psychosocial issues in children (Sanson et al., 2019). Additionally, the absence of parents, if one is forced to migrate, can impact children's psychosocial development, health and education (United Nations, 2018). If children are forced to migrate, they may experience trauma and adjustment issues (Sanson et al., 2019).

Early years

Children under 5 years may have a further increased mortality risk associated with temperature extremes (Amegah et al., 2016) and are more sensitive and less tolerant of heat (Centers for Disease Control and Prevention, 2016). Children under 12 months are particularly vulnerable to heat due to their underdeveloped heat regulation system (Kownacki et al., 2019). Extreme heat affects foetal outcomes such as stillbirth, premature birth and birth weight (Kuehn & McCormick, 2017). Additionally, flood exposure has been associated with premature births and low birth weight (Centers for Disease Control and Prevention, 2017a).

Older people

Older people in the population, specifically adults aged 60 and over (Amegah et al., 2016), are at an increased risk of morbidity and mortality as a result of increased heatwaves and other extreme weather events due to climate change (Amegah et al., 2016; Benmarhina et al., 2015; Centers for Disease Control and Prevention, 2015; Smith et al., 2015; Centers for Disease Control and Prevention & American Public Health Association, no date; DeFries et al., 2019; Ebi et al., 2018; Hoegh-Guldberg et al., 2018; Kownacki et al., 2019; Pozarny, 2016;) and this risk is anticipated to grow with continued warming (Bunker et al., 2016). A growing number of older people in the UK means that more people are vulnerable to these impacts (Environmental Agency, 2018). Extreme heat can make the elderly population more vulnerable to negative cardiovascular, cerebrovascular, respiratory and genitourinary outcomes (Bunker et al., 2016; Cheng et al., 2019). It also may contribute to infectious disease, sun burn, kidney failure and heat stress/exhaustion (Bunker et al., 2016). Global heat stress is predicted to increase by 2030 with 1.5°C warming, which is likely be accompanied by an increase in elderly heat related mortality (Roy et al., 2018). The elderly population are also more susceptible to negative health outcomes from poor air quality (Grey et al., 2018; Wang et al., 2016; World Health Organization et al., no date) and more at risk of asthma hospitalisations due to wildfire smoke (Liu et al., 2015).

The elderly population is more susceptible to experiencing adverse health impacts of climate change for several reasons. This population group have a lower baseline mortality (Wang et al., 2016), they may be reliant on others to provide care for them or be separated from medical supplies and resources during a climate related disaster (Benevolenza & DeRigne, 2019), they are more sensitive and less tolerant of heat and are less likely to perceive being overheated (Centers for Disease Control and Prevention, 2016), they have an attenuated ability to dissipate heat (Balmain et al., 2018) and they may have more

difficulty accessing healthcare in comparison to other population groups (United Nations, 2018).

Geographical areas

Rural communities

People living in rural areas often experience negative mental health impacts as a result of drought (Smith et al., 2015). Rural areas will also be affected by climate change through impact on agriculture-related livelihoods and impacts on employment (Mbow et al., 2019; Pozarny, 2016). Additionally, rural communities are more vulnerable to flood impacts on transport links and may have more difficulty accessing health and social care services during extreme weather events (HM Government, 2017). People living in rural areas may also be at a greater risk of household air pollution and emissions from agriculture and wildfires (World Health Organization et al., no date).

Urban areas/cities

Cities are exposed to natural disasters due to their infrastructure and high population densities (Pozarny, 2016). Rapid expansion of cities increases the exposure of people and economic assets to the impacts of climate change, including floods, heatwaves, drought and landslides (Pozarny, 2016).

An increasing frequency and intensity of rainfall events is likely to result in more surface water flooding in urban areas (HM Government, 2017).

Cities are prime environments for the transmission and outbreak of vector-borne diseases, such as dengue fever, due to dense populations (Li et al., 2018). Rising temperatures and humidity levels further increases the transmission of vector-borne diseases in areas that are densely populated (Castells-Quintana et al., 2015; United Nations, 2018).

Heatwaves increase mortality in communities with higher relative population densities (Campbell et al., 2019). Additionally, areas with more infrastructure, such as cities, have warmer ground temperatures (Campbell et al., 2019). Heat stress may increase in urban areas due to elevated rural-to-urban migration as a result of climate factors, which increases population density in urban areas (Castells-Quintana et al., 2015). With 1.5°C warming, it is projected that twice as many megacities could become heat stressed (Hoegh-Guldberg et al., 2018).

Cities often face the highest pollution levels (World Health Organization et al., no date), so health outcomes from poor air quality disproportionately impact those living or commuting to urban areas (Grey et al., 2018; HM Government, 2017). Cities are at risk of flooding and contamination of water if the drainage infrastructure cannot cope with a high volume of rainfall (DeFries et al., 2019). Areas where population density is high are more likely to experience the impacts of climate change on water supply and availability (Compagnucci et al., 2018). Additionally, food security in urban areas can be impacted by climate change through reduced supplies, reduced access and impacts on city infrastructure (Mbow et al., 2019). Poor urban dwellers are more vulnerable to rapid changes of food prices as a result of climate change (Mbow et al., 2019).

Urban heat islands

The health impacts of climate change, such as mortality, are exacerbated by the urban heat island effect (Centers for Disease Control and Prevention, 2016; Zuo et al., 2015), which cities are particularly vulnerable to (DeFries et al., 2019; HM Government, 2017). Climate change will add to the urban heat island effect; rising outdoor temperatures, fewer winds and reduced cloud cover increase heat stress, which is further enhanced by urban growth (Chapman et al., 2017; HM Government, 2017). High outdoor temperatures in urban areas exacerbates overheating in buildings, since the urban heat island effect prevents buildings from cooling down, particularly at night (HM Government, 2017). Urban heat island areas are more at risk of deadly heatwaves (Ebi et al., 2018; Hoegh-Guldberg et al., 2018) and more deadly heatwaves are projected with 1.5°C and 2°C warming (Hoegh-Guldberg et al., 2018).

Coastal areas

Coastal areas are highly exposed to natural hazards, such as flooding and storms surges, that may occur as a result of climate change (HM Government, 2017; Intergovernmental Panel on Climate Change, no date; House of Lords, 2019) and are at risk of flooding due to climate change induced sea level rise and coastal erosion (HM Government, 2017; House of Lords, 2019). An estimated 31-69 million people living in coastal areas are exposed to coastal flooding if the climate warms by 1.5°C, and if the climate warms by 2°C, the estimated number of people exposed to coastal flooding rises to 32-79 million (Roy et al., 2018). Social deprivation may be associated with a higher risk of exposure to coastal flooding (HM Government, 2017).

Climate change will also impact coastal areas through damage to infrastructure (Hoegh-Guldberg et al., 2018; House of Lords, 2019; Veenema et al., 2017). Flooding and other natural hazards may lead to damage of properties, transport infrastructure and other infrastructure such as ports and airports (DeFries et al., 2019; Veenema et al., 2017). This will also lead to economic losses (HM Government, 2017; Hoegh-Guldberg et al., 2018). Damage to critical infrastructure can have long lasting effects on communities (HM Government, 2017). Loss and damage of culturally important sites as a result of climate change may have well-being and community impacts (HM Government, 2017).

Sea level rise, flooding and damage to coastal cities may cause populations to be displaced from high risk areas (Deere et al., 2017; DeFries et al., 2019; Intergovernmental Panel on Climate Change, no date), leading to a reduction in cultural identity (Ebi et al., 2018). Displacement may be permanent as coastal areas become uninhabitable (Adger et al., 2014; HM Government, 2017; Pozarny, 2016); a projected sea level rise of one metre by 2100 may result in some coastal areas and island countries becoming uninhabitable, displacing tens of millions of people (Intergovernmental Panel on Climate Change, no date). Some low-lying coastal areas face the threat of existence as their lands become inundated (DeFries et al., 2019; HM Government, 2017). Some locations in Wales are known to be at risk from long term changes to the coastline, such as the village of Fairbourne; in the longer term, protecting the village using flood defences is unsustainable (HM Government, 2017). Sea level rise, increased storminess and coastal erosion as a result of climate change are also expected to have a great impact on the coasts of South Wales (HM Government, 2017).

Sea level rise in coastal areas can also result in saline intrusion of secure water sources (House of Lords, 2019), increasing the risk of water-borne disease and some non-communicable diseases due to increased salt intake (Deere et al., 2017). Contamination of water due to sea level rise may also affect communities living further inland (DeFries et al., 2019). An increase in storm surges and cyclones in coastal areas also threatens lives (DeFries et al., 2019).

Flood risk areas

See "Flooding" under "Determinants of health".

People with existing health conditions/disabilities

Existing physical health conditions

Climate change factors can worsen existing long-term health conditions (Benevolenza & DeRigne, 2019; Centers for Disease Control and Prevention, 2017a) and disproportionately impact people with existing long-term health conditions and disabilities (Grey et al., 2018).

People with existing long-term health conditions are at a higher risk of developing heat related illnesses (Centers for Disease Control and Prevention, 2017a; Centers for Disease Control and Prevention & American Public Health Association, no date; Ebi et al., 2018; Hoegh-Guldberg et al., 2018) and increasing temperatures may worsen some chronic illnesses such as cardiovascular disease, respiratory disease and diabetes (Centers for Disease Control and Prevention, 2015; Centers for Disease Control and Prevention, 2017a; Cheng et al., 2019; Tham et al., 2019). Therefore, increasing temperatures due to climate change may lead to increased hospitalisation for people with a range of chronic illnesses (Smith, Keys, Lieske & Smith, 2015). Additionally, certain medications can heighten an individual's vulnerability to heat (Hoegh-Guldberg et al., 2018) by reducing the ability to regulate heat (Centers for Disease Control and Prevention, 2016), increasing the risk of heat related mortality (Ebi et al., 2018). High indoor temperatures may also result in reduced social participation, particularly for those with a disability (Kownacki et al., 2019).

Those with existing physical health conditions may be more susceptible to the adverse health impacts of increasing air pollution due to a lower baseline mortality (Grey et al., 2018; Wang et al., 2016; World Health Organization et al., no date). Increased allergens and atmospheric ozone as a result of climate change will aggravate existing allergies and asthma (Centers for Disease Control and Prevention, 2015; Centers for Disease Control and Prevention & American Public Health Association, 2016). Additionally, the adverse respiratory effects of wildfire smoke may be elevated due to weaker immune systems (Liu et al., 2015) and an increase in pollen, in addition to a longer pollen season, may cause an increase in pollen related allergies (Lake et al., 2017).

Decline in water quality as a result of climate change can be a significant health threat for the immunocompromised (Young et al., 2015).

Additionally, climate change can impact those with existing long-term health conditions through interruption of health care (Veenema et al., 2017); flood related disasters, storms and cyclones can interrupt treatment and care of patients with non-communicable and chronic illnesses (Ryan et al., 2015). Continuity of routine care following a disaster is challenging as patients may need to be evacuated or relocated, and medication may not be

available in disaster locations (Ochi et al., 2014). Temporary relocation is distressing, especially when patients are clinically unstable (Man et al., 2018), and can impact the quality of care given (Man et al., 2018). Individuals with long-term health conditions may also experience an impact on health due to reliance on others to provide care (Benevolenza & DeRigne, 2019). People with disabilities may have difficulty accessing resources that contribute to their ability to adapt to climate change (United Nations, 2018). Furthermore, those with mobility issues, such as obesity and those who are bedridden, will have difficulty accessing healthcare, medical treatments and prescriptions (Centers for Disease Control and Prevention, 2017a; Centers for Disease Control and Prevention & American Public Health Association, no date; United Nations, 2018).

Existing mental health conditions

People with underlying mental health conditions are more likely to experience an impact on mental, emotional and psychological health following climate related events (Benevolenza & DeRigne, 2019). People with mental disorders have an increased vulnerability to heat waves, and heat waves can exacerbate pre-existing mental ailments (Zuo et al., 2015). Those with a mental illness may be three times more likely to run the risk of death from a heatwave than those without a mental illness (Cianconi et al., 2020). High temperatures may also result in sleep disturbance and daytime dysfunction for people with underlying mental health conditions (Rifkin et al., 2018). Additionally, schizophrenia symptoms can increase during periods of increased heat and dementia patients may become agitated due to increased indoor temperatures (Tham et al., 2019). Exacerbation of mental health issues due to climate related events may lead to increases in substance abuse and domestic violence (Cianconi et al., 2020). This group may also be impacted by climate change through disruption of mental health care following climate related disasters (Veenema et al., 2017).

Sex / Gender groups

Men

Compared to women, some research shows that men may have a higher risk of experiencing the physical health impacts of climate change; men have higher mortality rates for extreme heat (Smith et al., 2015), including cardiovascular mortality (Cheng et al., 2019). Men are more susceptible to drowning due to cyclones (Veenema et al., 2017) and are at risk of bacterial infection (leptospirosis) from flooding (Naing et al., 2019). Additionally, men present a higher risk of suicide during drought conditions (Smith, Keys, Lieske & Smith, 2015). Men may also be impacted by climate change as a result of their occupation; men are more likely to work in high-risk occupations, such as construction and forestry (Binazzi et al., 2019), where they are at risk of work-related injuries due to increasing heat (Binazzi et al., 2019; Bonafede et al., 2016).

Women

Other evidence suggests that women have a higher risk of heat related morbidity and mortality (Ebi et al., 2018; Hoegh-Guldberg et al., 2018)). Women are also at risk of experiencing poor health outcomes as a result of other climate related factors, such as flooding and poor air quality (Pozarny, 2016; World Health Organization et al., no date) and

are often affected by adverse mental health outcomes in situations of displacement (Adger et al., 2014). In some regions, men and women have different access to information, technologies, services and support due to sociocultural normative inequalities, which typically leave women at a disadvantage (Mbow et al., 2019; Pozarny, 2016). Additionally, some women may be exposed to sexual violence in a post disaster context (Pozarny, 2016).

Mothers and pregnant women are more likely to experience an impact on mental, emotional and psychological health following climate related events (Benevolenza & DeRigne, 2019; Cianconi et al., 2020). Stress caused during a disaster can affect a mother's milk production, which poses a significant health risk where clean water is not available when using milk substitutes (United Nations, 2018). Additionally, air pollution and extreme heat cause increased stress for mothers and pregnant women (Kuehn & McCormick, 2017). Pregnant women have a higher susceptibility to the negative physical health implications of air pollution (particulate matter and nitrogen dioxide) due to their lower baseline mortality (Wang et al., 2016) and have a higher prevalence of anaemia, malaria, pre-eclampsia and eclampsia which may occur as a result of rainfall and temperature changes (Hlimi, 2015; Pozarny, 2016). Pregnant women are more sensitive and less tolerant of heat due to their elevated core body temperature (Centers for Disease Control and Prevention, 2016; Kownacki et al., 2019) and may be more vulnerable to the impacts of coastal flooding (Centers for Disease Control and Prevention, 2016).

Working people

Farmers and agricultural workers

Farmers are at a disproportionately higher risk of experiencing the negative implications of climate change (House of Lords, 2019) due to its impact on food systems (Food and Agricultural Organization of the United Nations et al., 2019). The benefits of longer growing seasons are likely to be outweighed by reductions in water availability and an increase in extreme weather events (Environmental Agency, 2018). This could lead to a decline in the number of farmers (Food and Agricultural Organization of the United Nations et al., 2019).

Where agriculture depends on manual labour, farmers are highly susceptible to heat stress and occupational injury due to high outdoor temperatures and heatwaves (Binazzi et al., 2019; DeFries et al., 2019; Jacklitsch et al., 2016; Mbow et al., 2019). Farmers may also be at risk of leptospirosis as a result of exposure to flooding (Naing et al., 2019). Additionally, farmers' mental health is reportedly worse than other professions due to climate variability (Daghagh et al., 2019).

Farmers will experience economic losses as a result of climate change due to reduced productivity of livestock and crops (Mbow et al., 2019; Pozarny, 2016). Livestock productivity may be impacted due to reductions in water availability, pasture quality and quantity, disease prevalence, flooding, drought and heat stress, which affects livestock reproduction (DeFries et al., 2019; Hoegh-Guldberg et al., 2018; Kamara et al., 2018; Mbow et al., 2019). Additionally, as food prices in the UK become more liable to spikes, farmers' ability to purchase livestock feed is reduced (HM Government, 2017). Crop productivity may be reduced as a result of exposure to high temperatures and drought, water availability, flooding, soil quality and prevalence of pests and disease (Adger et al., 2014; Castells-Quintana et al., 2015; DeFries et al., 2019; Intergovernmental Panel on Climate Change, no

date; Kamara et al., 2018; Levi et al., 2018; Mbow et al., 2019; Nunfam et al., 2018; Zelingher et al., 2019). The risk of wildfires is also increased due to rising temperatures (Environmental Agency, 2018). Productivity of agriculture and farming in the UK may be impacted by reduced water availability, increased soil aridity and continued loss of soil carbon (HM Government, 2017). However, in some areas, cereal crop production may increase and the risk of pests and disease may decrease (Intergovernmental Panel on Climate Change, no date; Mbow et al., 2019). As a result, farmers may experience a reduction in resilience (Pozarny, 2016). However, an increase in collective action against disasters can strengthen community resilience in farmers (Kamara et al., 2018).

The impact of climate change on food systems means farmers will need to adopt new production techniques or generate income elsewhere (Vos, 2015). Therefore, farmers migrate to urban areas in order to escape adversity in rural areas (Kamara et al., 2018). Poorer farmers are more likely to migrate as they lack resources to be able to adapt to climate change (Kamara et al., 2018; Savo et al., 2016). This increases the divide between poorer and richer farmers (Cianconi et al., 2020; Savo et al., 2016).

Outdoor workers

Rising heat increases outdoor work-related injuries in industries such as forestry, agriculture and fishing (Bonafede et al., 2016). Outdoor workers are likely to be at the greatest risk of heat stress and other heat related illness, particularly those who engage in heavy outdoor manual labour, due to greater exposure to temperature extremes (Centers for Disease Control and Prevention, 2016; Centers for Disease Control and Prevention & American Public Health Association, no date; HM Government, 2017; Jacklitsch et al., 2016). Additionally, chronic kidney disease is associated with heat exposure in outdoor workers (Levi et al., 2018). The risk of vector-borne diseases is also higher as a result of increasing temperatures (Levi et al., 2018) and workplace safety may be compromised due to temperature extremes (United Nations, 2018). Outdoor worker productivity is likely to decrease; each 1°C rise in temperature could reduce work related productivity by 1-3% for outdoor workers (Roy et al., 2018). Outdoor workers are also more likely to be exposed to damaging coastal floods (Centers for Disease Control and Prevention, 2017a).

Fishers

Climate change will continue to impact fisheries and aquaculture, with a projected 1.5 million tons of fishery catch lost with 1.5°C warming (House of Lords, 2019). Sea level rise, flooding and storm intensification will threaten fisheries and aquaculture infrastructure (Hoegh-Guldberg et al., 2018; Intergovernmental Panel on Climate Change, no date; Mbow et al., 2019). Additionally, increased frequency of storms reduces the opportunity to go fishing (Savo et al., 2016; Savo et al., 2017), and depletion of stocks means fishers must go further out to sea, increasing their vulnerability to coastal storms (Marine Management Organization, 2016; Savo et al., 2017). Those who fish for a living to provide household food supplies may experience a negative impact on cultural identity (Savo et al., 2017). The difficulty harvesting fish and shellfish may lead to a reduction of protein and nutrient availability in diets (Savo et al., 2017).

Climate change may cause an increase or decrease in the abundance, survival and growth of some exploitable fish species due to increasing storm frequency and severity, rising

temperatures, ocean acidification and changes in fluvial flows and ocean currents (HM Government, 2017; Marine Management Organization, 2016). Negative impacts may be exacerbated by low oxygen conditions, and presence of pollutants and marine contaminants (Marine Management Organization, 2016). On a global scale, projected impacts on fisheries and aquaculture are negative, with displacement of stocks already being observed (HM Government, 2015), although some mid-to-high latitude fisheries may experience an increase in fishery productivity (Hoegh-Guldberg et al., 2018). In UK waters, there will be a likely decline some species of fish and an increase in others (HM Government, 2017). The UK is expected to have a 1-2% increase in fishery yield by 2050 (HM Government, 2017). In the short term, rising temperatures may lead to increased growth rates for some farmed fish species, such as Atlantic salmon, and the opportunity to cultivate new farmed species, such as sea bass and bream (HM Government, 2017). Continued temperature rise may cause a decrease in salmon and trout and an increase in bream and roach in UK freshwater habitats (Environmental Agency, 2018). Some farmed cold-water species, such as cod and Atlantic halibut, may decline due to thermal stress (HM Government, 2017). Increased flooding may lead to damage of freshwater ecosystems, endangering some species, such as mussel species in north England (Environmental Agency, 2018). Climate change may also cause an increase in the abundance, survival and growth of non-native pest species, including marine pathogens, harmful algal blooms and jellyfish blooms (HM Government, 2017; Marine Management Organization, 2016). This may lead to an additional decline in fish and can have harmful human health implications (HM Government, 2017; Marine Management Organization, 2016). A decline in coral reef ecosystems also decreases marine biodiversity and may lead to the collapse of some coastal fisheries (HM Government, 2015; Roy et al., 2018). Increased water temperatures and ocean acidification could result in significant long-term changes to marine ecosystems and food chains, threatening the viability of commercial fisheries and aquaculture (HM Government, 2017).

Construction workers

Construction workers are at high risk of productivity loss due to high temperatures and heat exposure (Levi et al., 2018; Nunfam et al., 2018). They may also be at risk of heat stress (Jacklitsch et al., 2016) and heatwaves can make construction work more dangerous (DeFries et al., 2019). Hot weather can result in drier soils and more dust which can increase the risk of lung diseases (HM Government, 2017).

Healthcare and emergency service workers

Sleep disturbance as a result of natural disasters may lead to impaired work performance of health employees (Rifkin et al., 2018). Heatwaves may lead to thermal comfort issues for both employees and patients (HM Government, 2017). The relative risk of heat-related mortality is higher in care and nursing homes than in the general population, even after accounting for the health status of residents (HM Government, 2017). Cold spells, snow storms and flooding interrupt travel for healthcare workers. Fewer cold events in the future may help benefit health system management (HM Government, 2017). Additionally, healthcare staff may be displaced or unemployed due to damage of care facilities (Man et al., 2018; World Health Organization, 2019). Emergency service workers are likely to be exposed to damaging coastal floods (Centers for Disease Control and Prevention, 2017a) and extreme temperatures, putting them at a high risk of heat stress (Jacklitsch et al., 2016).

Emergency personnel who wear protective clothing, such as firefighters, are at a high risk of the negative health impacts of high temperatures (Kownacki et al., 2019). Emergency service workers are highly likely to experience increased mental health issues after attending to climate related disaster events (Centers for Disease Control and Prevention, 2017a).

Workers (general)

Increasing temperatures and increased exposure to heat in the workplace can reduce worker productivity and lead to reduced work hours worldwide, especially for those with no air conditioning in the workplace (DeFries et al., 2019; Ebi et al., 2018; Flouris et al., 2018; Hoegh-Guldberg et al., 2018; Jacklitsch et al., 2016; Nunfam et al., 2018; Roy et al., 2018); work related productivity could decrease by 1-3% for every 1°C increase in temperature (Roy et al., 2018).

People working in offices may be at risk of thermal discomfort, especially offices built in the 1960s and 1970s due to poor ventilation (HM Government, 2017). Occupational exposure to heat can result in increased injury rates, morbidity and mortality (Bonafede et al., 2016; Flouris et al., 2018; Jacklitsch et al., 2016). Safe working is compromised as exposure to heat can lead to sweaty palms, fogged safety glasses, dizziness, lack of focus and reduced brain functioning (Ebi et al., 2018; Centers for Disease Control and Prevention, 2016; Jacklitsch et al., 2016; United Nations, 2018). Working in hot places, such as factories or bakeries, further increases the risk (HM Government, 2017; Jacklitsch et al., 2016) and younger workers may be more susceptible to heat related injury as they are more likely to partake in arduous tasks with less training (Binazzi et al., 2019).

Heat stress in the workplace may induce a negative impact on workers' social lives in the form of interpersonal disputes, physical violence, inadequate time for family, fatigue, income erosion or loss of employment (Nunfam et al., 2018).

Income groups

Deprived/low socioeconomic status/poverty

The effects of climate change on populations is likely to be strongly influenced by their social, economic and cultural environment (HM Government, 2017); people with low socioeconomic status in both developed and developing countries will be most vulnerable to the impacts of climate change (HM Government, 2017; HM Government, no date; Pozarny, 2016; United Nations, 2018; Welsh Government, 2019). This is due to a lesser capacity to adapt as a result of limited access to resources (Benevolenza & DeRigne, 2019; Houses of Parliament, 2019; Kamara et al., 2018; Pozarny, 2016; United Nations, 2018). Those who are dependent on natural resource-based livelihoods are at a heightened risk (Pozarny, 2016; Tucker et al., 2015). Populations with low socioeconomic status are most likely to be impacted by climate induced flooding events, as they are more likely to live in flood prone areas with older infrastructure and less able to evacuate (Centers for Disease Control and Prevention, 2017a; HM Government, 2017; Yiannakoulias et al., 2018). For example, in Wales, Powys, Carmarthenshire and Rhondda Cynon Taff have the highest proportion of socially disadvantaged communities located in flood risk areas (HM Government, 2017). This group are also less likely to be insured, further reducing the ability to respond to such events

(Benevolenza & DeRigne, 2019; Centers for Disease Control and Prevention, 2017a; HM Government, 2017). Additionally, some deprived areas have a lack of accessible healthcare, leading to poorer health outcomes in flooding events due to reliance on transport (Veenema et al., 2017).

Deprived populations are most likely to experience injury caused by extreme weather events, such as heat stress and kidney failure as a result of heatwaves (Benmarhina et al., 2015; Centers for Disease Control and Prevention & American Public Health Association, no date; Rataj et al., 2016; Zuo et al., 2015; United Nations, 2018). Those of low socioeconomic status are generally less equipped to cool their homes, for example by using air conditioning, increasing the risk of heat related illness (Centers for Disease Control and Prevention, 2016; DeFries et al., 2019; 288). In Wales, the most socially disadvantaged neighbourhoods exposed to heat risk in the future are projected to be in Cardiff, Swansea, Newport and Rhondda Cynon Taf (HM Government, 2017). Adverse health outcomes from poor air quality also disproportionately impact vulnerable populations; Welsh data show that air pollution concentrations are highest in deprived areas (Grey et al., 2018). Flooding and drought in poor urban areas may result in water contamination, which increases the risk of diarrhoeal disease in poor children (Mbow et al., 2019). Additionally, deprived populations are more likely to experience an impact on mental, emotional and psychological health following climate related events (Benevolenza & DeRigne, 2019; Rataj et al., 2016). Those who are less well-educated tend to have poorer coping mechanisms when responding to the impacts of climate change, which may result in poverty (Kamara et al., 2018).

Food prices in the UK have been, and are likely to be, affected by extreme weather events overseas (HM Government, 2017). The rise in food prices will disproportionately impact lower income households (HM Government, 2017; Mbow et al., 2019; Vos, 2015). This leads to reduced quality of life and poor health (HM Government, 2017; Kamara et al., 2018). Additionally, the impact of climate change on water availability is likely to be more severe for disadvantaged people and communities (Campbell et al., 2019; Compagnucci et al., 2018; HM Government, 2015). These impacts are likely to exacerbate existing poverty and, by slowing economic growth, make it increasingly difficult to reduce poverty (Adger et al., 2014; Campbell et al., 2019; HM Government, no date; Hoegh-Guldberg et al., 2018; Mbow et al., 2019). Additionally, food insecurity and reduction in food availability as a result of climate change are projected to exacerbate undernutrition and increase mortality, especially in low income groups (Mbow et al., 2019; United Nations, 2018).

Climate change can disrupt domestic and international food production and supply chains. These disruptions influence markets, trade and domestic prices. These, in turn, have direct impacts on UK businesses, especially farmers (Mbow et al., 2019). Low income food producers will be most negatively impacted by the effect of climate change on food due to a lack of resources to adapt (Kamara et al., 2018; Mbow et al., 2019; Savo et al., 2016). Therefore, poorer famers will more likely have to abandon their livelihoods and seek other employment (Kamara et al., 2018).

Some populations may be forced to migrate from their homes as a result of climate change induced extreme weather events and reduced employment opportunities (DeFries et al., 2019; HM Government, 2017; Mbow et al., 2019). Wealthier people are able to relocate to safer areas, whereas poorer people may find it difficult to escape poverty (DeFries et al.,

2019). Long-distance and international migration require financial capital and therefore is restricted to wealthier populations (Adger et al., 2014). Additionally, poorer migrants are more likely to cluster in high-density areas that are exposed to flooding and landslides, risks that will increase with further climate change (Adger et al., 2014). Deprived people and those who are dependent on natural resource-based livelihoods are more likely to experience displacement, but have less option for migration and diversification (Rataj et al., 2016; Tucker et al., 2015).

Actions taken in response to climate can aggravate existing inequalities (Adger et al., 2014). Unequal policies and patterns of sometimes very rapid development are benefiting certain segments of society while making others, such as those in poverty, more vulnerable (Tucker et al., 2015), despite these communities contributing the least to climate change (Welsh Government, 2019).

Homeless people

Homeless people are at high risk of heat stress, heat exhaustion, kidney failure and heart attack due to climate change as a result of direct exposure to heatwaves and increased humidity (Centers for Disease Control and Prevention, 2016; Zuo et al., 2015).

High income groups

Higher income areas will still experience the impacts of climate change, however, this group will have access to resources and strategies to better reduce the impact, such as medical care and warning systems (Campbell et al., 2019). Although, in some settings, high income areas are associated with the highest flood risk (Yiannakoulias et al., 2018).

Refugees and asylum seekers

See information under the "Displacement/loss of communities" determinant of health.

Ethnic minority groups

Prejudice, discrimination and hardships for ethnic minority groups can be made worse by trauma in the form of natural disasters and their consequences (Benevolenza & DeRigne, 2019). Those of ethnic minority are more likely to live in flood prone areas with older infrastructure and limited access to transport (Centers for Disease Control and Prevention, 2017a) and therefore may be more exposed to heat risks and illness or injury during flooding events (Centers for Disease Control and Prevention, 2017a; United Nations, 2018).

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Section 6 – Interview methods and questions

The experts interviewed were identified linked to the key health impacts arising from the screening exercise. Participants were interviewed from the following organisations and subject areas:

Organisation	Subject area
Public Health Wales (two experts interviewed together)	Air quality and extreme weather plans, general environmental health protection
	Water scarcity, general environmental health protection
Public Health Wales	Active travel, climate change
Public Health England	Urban heat islands and other environmental determinants
Centre for Climate Change and Social Transformation (Cardiff University)	Psychological adaption / mental well-being, social and community factors
Sustainable Places Research Institute (Cardiff University)	Food security
Cardiff Metropolitan University	Built environment, housing adaptation research
Denbighshire County Council	Land use / planning
Wrexham County Borough Council	Sustainability
Welsh Government	Road travel and infrastructure
Welsh Government	Adaptation planning
Welsh Government	Food policy and strategy
Welsh Government	Health and well-being curriculum
Royal College of General Practitioners	Primary care
Natural Resources Wales	Climate change
Natural Resources Wales	Flooding
Renew Wales	Community action on climate change
Rural Health and Care Wales	Rural health and well-being
Wales Adventure Tourism Organisation	Tourism

The interviewees were invited to participate via email and, once they had accepted the invitation, were sent a participant information sheet (see Appendix 4) and the interview questions (see below), and were asked to sign an informed consent form. Interviews were conducted face to face or via telephone, depending on the interviewee's availability. Interviews were semi-structured, i.e. the interview questionnaire was used as a basic framework, but other questions could be asked as deemed appropriate. All interviews were recorded. They were not transcribed, but the interviewers took notes and used the recording to fill in any missing information. The notes were then emailed to the interviewees to allow them to change / adapt anything and to confirm that all the information recorded was correct.

Interview summaries were constructed to inform the HIA, and these (redacted) are available on request.

Stakeholder Interview Questions

- What is the role of your organisation / department/team?
- What **population groups or geographical areas** do you think are particularly vulnerable to climate change in Wales?
- Do you have particular groups/areas that you are prioritising? Do you have any data / evidence to support this? (use checklist to guide this discussion).
- Which **social determinants of health** do you think could be impacted positively or negatively? Do you have any data / evidence to support this? (use checklist to guide this discussion).
- What **population health outcomes** do you expect to be impacted? E.g. physical/mental/social health Do you have any data / evidence to support this?
- Does your organisation have a policy, strategy or specific programme of work on Climate Change?
- What are the **key issues** that have been identified?
- How is your organisation working to **prevent / mitigate** Climate Change – i.e. low carbon plan?
- How is your organisation working to **prepare/adapt to** Climate Change?
- Have you identified any **barriers to change** for implementation of adaptation and mitigation?
- What **knowledge / evidence / experience** can your team offer to understand health impact and climate change in Wales?
- Are there **gaps in knowledge/evidence or policies** in Wales to support and enable mitigation and adaptation planning – especially in relation to health and well-being?

Section 7 – Stakeholder workshops

Participatory HIA Workshops

Stakeholder workshops were held on 6th and 25th February 2020. A wide range of key cross sector stakeholders were invited to participate and contribute. This included representatives from a range of organisations and disciplines including public health and allied health care professionals; sustainable development, decarbonisation and climate change; housing, emergency services, environmental health and planning sectors; Third sector; academia and community representatives. Information about the HIA and an overview of the HIA process were sent out in advance with the invitation.

In total, 33 people attended the workshops. The aim was primarily to document any contextual knowledge and qualitative evidence from a range of affected bodies, disciplines, communities and sectors who attended, about the potential impacts of climate change on them and the population of Wales. The workshops were run as an open, transparent and interactive process. Participants agreed to the findings being reported anonymously.

The sessions were independently facilitated by the Wales Health Impact Assessment Support Unit (WHIASU) and the participants held discussions as one large group, or 2 break out groups thus allowing for transparency of discussions. To guide the discussions, two checklists were used – one as an aide memoire to the potential population groups affected and one which listed the wider determinants of health (See Appendix 1).

All comments and views were scribed by the facilitators and additional note takers and were circulated and agreed by the participants. Additional evidence and data links were also provided by the participants and captured.

A summarised narrative record of the workshop is available on request.

The workshop participants were asked to complete a feedback and evaluation form. The results were very positive, and attendees found it useful on a number of levels – with opportunities to discuss the wider health implications of climate change and who will be affected, contribute to the evidence, connect with other stakeholders, gain different perspectives and learn about HIA all cited.

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Appendix 1 – WHIASU Population groups and determinants of health and wellbeing checklists

These are available to download from here.

Population Groups Checklist

This checklist is for use during a HIA Screening and Appraisal in order to identify the population groups who could be more impacted than others by a policy/project/proposal.

The groups listed below have been identified as more susceptible to poorer health and wellbeing outcomes (health inequalities) and therefore it is important to consider them in a HIA Screening and Appraisal. In a HIA, the groups identified as more sensitive to potential impacts will depend on the characteristics of the local population, the context, and the nature of the proposal itself.

This list is therefore just a guide and is not exhaustive. It may be appropriate to focus on groups that have multiple disadvantages. Please also note that terminology can change over time/publication.

Sex/Gender related groups

- Female
- Male
- Transgender
- Other *(please specify)*

Age related groups *(Could specify age range for special consideration)*

- Children and young people
- Early years (including pregnancy and first year of life)
- General adult population
- Older people

Income related groups

- Economically inactive
- People on low income
- People who are unable to work due to ill health
- Unemployed/workless

Groups at higher risk of discrimination or other social disadvantage

- Black and minority ethnic groups *(please specify)*
- Carers
- Ex-offenders
- Gypsies and Travellers
- Homeless
- Language/culture *(please specify)*
- Lesbian, gay and bisexual people
- Looked after children

- People seeking asylum
- People with long term health conditions
- People with mental health conditions
- People with physical, sensory or learning disabilities/difficulties
- Refugee groups
- Religious groups *(please specify)*
- Lone parent families
- Veterans

Geographical groups and/or settings (*note- can be a combination of factors*)

- People in key settings: workplaces/schools/hospitals/care homes/ prisons
- People living in areas which exhibit poor economic and/or health indicators
- People living in rural, isolated or over-populated areas
- People unable to access services and facilities

Health and Wellbeing Determinants Checklist

1. Behaviours affecting health	• Diet / Nutrition / Breastfeeding • Physical activity • Risk-taking activity i.e. addictive behaviour, gambling • Sexual activity • Social media use	• Use of alcohol, cigarettes, Electronic Nicotine Delivery Systems (i.e. e-cigarettes), • Use of substances, non-prescribed medication, and abuse of prescription medication
2. Social and community influences on health	• Adverse childhood experiences i.e. physical, emotional or sexual abuse. • Community cohesion, identity, local pride • Community resilience • Divisions in community • Domestic violence • Family relationships, organisation and roles • Language • Cultural and spiritual ethos	• Neighbourliness • Other social exclusion i.e. homelessness, incarceration • Parenting and infant attachment (strong early bond between infant and primary caregiver) • Peer pressure • Racism • Sense of belonging • Social isolation/loneliness • Social capital, support & networks • Third Sector and Volunteering • Citizen power and influence
3. Mental Health & Wellbeing	Could there be potential impacts on: • Emotional wellbeing, life satisfaction or resilience? • Feeling worthwhile, valued or having a sense of purpose? • A sense of control? • Uncertainty or anxiety? • Participation in community and economic life? • Feeling safe and secure?	
4. Living & environmental conditions affecting health	• Air Quality • Attractiveness of area • Community safety • Access, availability and quality of green and blue natural spaces • Housing quality and tenure • Indoor environment • Health and safety • Light pollution	• Noise • Quality and safety of play areas (formal and informal) • Road safety • Odours • Urban/Rural built and natural environment & neighbourhood design • Waste disposal, recycling • Water quality i.e. sea water
5. Economic conditions affecting health	• Unemployment • Poverty including food and fuel poverty • Income • Personal and household debt	• Economic inactivity • Type of employment i.e. permanent/temporary, full /part time • Working conditions i.e., bullying, health and safety, environment
6. Access and quality of services	• Careers advice • Education and training • Information technology, internet access, digital services • Leisure services • Medical and health services	• Other caring services i.e. social care; Third Sector, youth services, child care • Public amenities i.e. village halls, libraries, community hub • Shops and commercial services

Physical, mental, social, environmental health & wellbeing

	• Welfare and legal advice	• Transport including parking, public transport, active travel	
7. Macro-economic, environmental and sustainability factors	• Biodiversity • Climate change i.e. flooding, heatwave • Cost of living i.e. food, rent, transport and house prices • Economic development including trade and trade agreements	• Government policies i.e. Sustainable Development principle (integration; collaboration; involvement; long term thinking; and prevention) • Gross Domestic Product • Regeneration	

Appendix 2 - Health Impact Assessment Screening Workshop

Population groups identified:

Age related groups
- Children and young people, for example with respect to mental well-being, air quality, education
- Early years, for example with respect to family stress, heat, water scarcity
- Older adults, for example with respect to heat, water scarcity

People in settings
- Schools
- Workplaces
- Hospital and care homes
- Transport

Geographical areas
- Farmers and rural communities
- Urban heat islands
- Coastal areas
- Flood risk areas

Other disadvantaged groups
- Refugees and asylum seekers
- Homeless
- People with disabilities or long term health conditions

Gender related groups
- Men – in relation to higher risk of suicide
- Women – caring responsibilities may increase

Occupations
- Farmers
- People working outdoors
- Fishers
- Construction
- Emergency services

Screening Workshop – Matrix: Positive and negative health impacts of climate change

Determinants	Pathway to impact	Positive impacts	Negative impacts
Social Determinants of Health			
Lifestyles			
Access to food /food security	• Extreme weather in UK and globally • Increasing heat/drought/heavy rains • Gradual climate change	• May increase range of crops that can be grown in UK/Wales	• Topography of Wales limits ability to adapt to new forms of agriculture • Changing climatic conditions damages growing conditions and harvests • Extreme weather impacts growing conditions and harvest in UK and globally • Global supply chains of certain foods may be affected
Nutritional value of food	• Change in soil / growing conditions		• Reduced nutritional value of food due to soil erosion
Cost of food	• Climate change • Extreme weather		• Increased cost of certain foods if supplies become limited
Food borne disease	• Increased heat • Increase in outdoor lifestyle/cooking		• Increased heat may lead to increase in food borne illness - requires change in food safety practice • Increase in outdoor cooking – may increase health risk
Healthy eating	• Increase in outdoor lifestyle/cooking • Drive for plant-based diet as part of mitigation measures	• May increase consumption of "Five a day"	• May increase meat intake if increase on outdoor eating/BBQ
Alcohol intake	• Increase in outdoor lifestyle/cooking		• May increase if increase in outdoor lifestyle • Stress may increase use

Determinants	Pathway to impact	Positive impacts	Negative impacts
Access to water	• Increased risk of drought		• Periods of water scarcity increases • Large number of people (80,000) on private water supplies in Wales with no recourse to public supply if their private source dries up.
Water quality	• Extreme weather		• Reduced quality of water – danger of water-borne illness
Risk taking activities: water based activity	• Extreme weather: heat and drought	• Increase in water sports	• Potential for increase in injury from swimming in dangerous locations and / or jumping into low rivers/lakes etc. during drought
Risk taking activities	• Extreme weather linked to stress, mental distress		• Potential for increase in self-harm/alcohol/drug use
Physical activity	• Weather is warmer. • Extreme weather – heatwaves etc. • People increase outdoor physical activity and time spent outdoors • Weather related changes impact pollens and allergens /air quality	• Increase in physical activity due to warmer weather • Increase in time spent in green and natural spaces	• Possible increase in UV exposure (skin cancer) • Possible increase in heat related illness/dehydration • Possible increase in asthma/respiratory problems
Outdoor activity	• Weather is warmer • People increase outdoor physical activity and time spent outdoors • Weather related changes impact pollens and allergens / air quality	• Increase in time spent in green and natural spaces • Increase in social activities	• Possible increase in UV exposure (skin cancer) • Possible increase in heat related illness/dehydration • Possible increase in asthma/respiratory problems

Determinants	Pathway to impact	Positive impacts	Negative impacts
Social Media	• Extreme weather/risk of isolation	• Could be important communication tool to reduce isolation or take action in emergencies • But potential impact is limited by poor signal and digital exclusion in some areas in Wales	• Possible rapid spread of misinformation / panic
Social and community factors			
Social isolation	• Extreme weather • Displacement of people		• People may stay indoors at home more due to extreme weather and this could increase a sense of isolation • Displaced people/communities feel isolated in new location/community
Community cohesion	• Migration increases in response to climate change	• New migrants bring skills to offer to community	• Potential for challenges to community cohesion • Rise in discrimination/racism
Community resilience	• Local impacts of climate change	• Communities work together to adapt to climate change and this builds additional social capital and resilience	• Pressures on resources • Extreme weather events may fragment communities

Determinants	Pathway to impact	Positive impacts	Negative impacts
Divisions in and between communities and conflict	• Climate change	• Initiatives are implemented to solve conflicting priorities and build "bridging capital"	• Different opinion groups on climate change may be in conflict, major protests create community tension • Different economic sectors may be in conflict, for example fossil fuel based industries workers versus environmental groups • Tensions between people who have the resources to invest in adaptation and mitigation measures for their own home/families and those who cannot – driver of widening inequalities • People may protect their resources/assets through more extreme ways, for example firearms
Conflict over resources	• Coastal erosion, impact of extreme weather		• Conflict between which communities get investment for mitigation and "protection" and which do not e.g. flood and coastal defence
	• Water scarcity		• Conflicts could arise over water scarcity and the control of water supplies within Wales and between UK nations
Displacement /loss of communities	• Coastal erosion or other climate change / extreme weather effects		• Whole communities displaced. Lack of insurance contributes to communities becoming unviable.

Determinants	Pathway to impact	Positive impacts	Negative impacts
Homelessness	• Coastal erosion or other climate change / extreme weather effects		• People have to leave homes due to climate change • Housing may be damaged and not be insured • Housing may become unfit for habitation
Community safety	• Extreme weather – in particular heat waves		• Evidence from Australia indicates increased violence and criminality during heatwaves
Family relationships/ Intergenerational relationships	• Major societal change • Extreme weather events become more frequent • Strain on community resources		• Impact of extreme weather events which are no longer "one off" may create stress and pressure on family relationships
	• Ageing population		• "Generational differences" may develop in attitudes to climate change • Displacement/migration may change/put strain on family relationships and caring roles

Determinants	Pathway to impact	Positive impacts	Negative impacts
Parenting	• Major societal change • Extreme weather events become more frequent • Strain on resources	• The way in which parents respond to and communicate about climate change could have positive or negative impacts on children and young people	• The way in which parents respond to and communicate about climate change could have positive or negative impacts on children and young people • Limited advice for parents • Knowledge and attitude differences between parents and children could cause strain, for example children tend to be very aware of environmental issues this could cause conflict in families if parents have a different attitude • Parents could be stressed by changing environment in which they are caring for children • Potential impact on Adverse Childhood Experiences (ACE)
Cultural and spiritual ethos	• Extreme weather • Changing climate	• New culture emerges that creates positive responses to change and environmental crisis – the key question is how do people of the future identify themselves ?	• Loss of land and meaningful places, animals and culturally important activities causes distress - “solastalgia”
	• Extreme weather • Changing climate		• Chapter 5 of the UK Climate Change Risk Assessment 2017 discussed risks to historical and cultural assets, for example buildings/places
Mental health and well-being			

Determinants	Pathway to impact	Positive impacts	Negative impacts
Emotional well-being	• Extreme weather • Changing climate		• Uncertainty • Stress • Many possible losses: land, home, natural environment • Sense of control – this is very important – many factors relating to climate change are outside of the control of individuals and communities • Flooding – strong evidence base on increased rates of anxiety and depression
Suicide	• Extreme weather: drought and heatwaves		• Australian evidence on increased suicide in heatwaves and droughts • Farmers are already a high-risk groups and climate change will have particular impacts on their livelihoods and homes
Participation and inclusion		• Political participation – increased engagement could be positive and provide a focus for increasing a sense of control and finding solutions	• Political participation – could become more polarised and extreme

Determinants	Pathway to impact	Positive impacts	Negative impacts
Resilience and community assets		• Acknowledgement of shared "crisis" could leverage community action, bringing shared purpose and strengthening of communities ties. Some community based action already in evidence, for example, Transition Towns, Renew Wales	
Transition to change / psychological adaptation		• Impact depends on individual approach to change, but also how policy develops at local and national level and what resources are invested in supporting transition	
Living and environmental conditions			
Air Quality	• Increased heat		• Strong evidence on negative impacts • Ozone • Increased heat may act on chemicals, for example in diesel fuel to release pollutants • Increased wild fires

Determinants	Pathway to impact	Positive impacts	Negative impacts
Housing	• Extreme weather • Increased heat		• Increase heat, rainfall and extreme weather – query whether building regulations currently take changes to climate into account for new buildings • New building requirements in planning policy (to address environmental concerns) may incur extra costs to developer and make house building less viable in Wales • Wales has an ageing housing stock that may not be adapted to the changing weather • Older people and people with disabilities may spend more time at home due to changing weather • Fuel poverty and energy efficiency measures may not address "new" climate related issues such as overheating and the need for ventilation
Flooding	• Extreme weather		• Expected to increase in frequency and severity – may impact on land use decisions • Major health impacts include injury, anxiety and depression.

Determinants	Pathway to impact	Positive impacts	Negative impacts
Indoor environment, for example homes, schools, workplaces, hospitals and care homes	• Increased heat		• Increase in heat not addresses in many buildings or building regulations • No maximum temperature for workplaces • Major concerns for care and hospital settings due to vulnerable population and current buildings
Transport	• Extreme weather • Increased heat	• Opportunity to develop and expand the use of active travel	• Major concerns re heat on public transport • Disruption due to extreme weather
Wild Fires	• Extreme weather • Increased heat • Water scarcity		• Become more likely and could damage green spaces etc.
Biodiversity	• Climate change • Extreme weather		• Climate change and extreme weather impacting on species and habitats • Increase in tourism and staycations may further impact protected areas and damage natural spaces
Access to play areas	• Increased heat		• Extreme heat – lack of shade and water provision in public spaces and parks may limit opportunity for play in hot weather • Play equipment can also become too hot to use
Waste	• Increased heat		• Increase temperature may increase hazards associated with waste, for example vermin, odour
Water availability and quality	• Increased heat • Water scarcity		• Water scarcity already identified as an issue • Water quality – algae in lakes may increase due to heat
Vector borne disease	• Climate change		• Likely to increase

Determinants	Pathway to impact	Positive impacts	Negative impacts
Economic conditions affecting health			
Productivity	• Extreme weather • Increased heat		• Potential for decrease in heat waves • Disruption to economy and infrastructure in extreme weather
Working conditions	• Extreme weather • Increased heat		• Certain occupations may face increased hazards at work, for example heat, skin cancer • Indoor and outdoor work environments • New evaluations of risk and working practices may be required – the UK is not adapted to very hot weather
Debt / financial well-being	• Extreme weather • Flooding		• Damage to homes and other property and lack of insurance or high premiums may place additional economic burdens on people • Crop failure may increase cost of food
Access to services			
Health and care services	• Extreme weather • Increased heat		• Possible disruption due to travel/ transport issues due to extreme weather, i.e. staff cannot get into work • Heat in buildings major concern • Less predictable spikes in demand, i.e. not just "winter" pressures
Third Sector	• Climate change		• Possible increase in demands
Macro issues			

Determinants	Pathway to impact	Positive impacts	Negative impacts
Education	• Climate change • Extreme weather	• Potential for education to have a positive impact on increasing knowledge of environmental sustainability • Eco schools • Behaviour change	• Education may become disrupted due to extreme weather
Inequalities	• Climate change		• Impacts of climate change are expected to have disproportionate impact on disadvantaged groups • Tensions between people who have the resources to invest in adaptation and mitigation measures for their own home/families and those who cannot – driver of widening inequalities
Infrastructure including transport	• Extreme weather • Increased heat		• Effects of extreme weather, floods etc. will disproportionately impact on areas with poorer infrastructure
Legislations: Well-being of Future Generations (Wales) Act (2015)		• Potential to influence engagement with sustainable development and action on climate change across the public sector • Note: how does the "Global Wales" goal influence economic development and trade in relation to climate change?	

Appendix 3 - Literature review protocol

Introduction
This protocol sets out the process that was followed for the literature review element of a Health Impact Assessment (HIA) into the impact of climate change on public health and well-being in Wales.

Background
The Wales Health Impact Assessment Support Unit (WHIASU) and the Policy and International Development Directorate, Public Health Wales (PHW) are carrying out a HIA exploring the potential impacts of climate change on public health and well-being in Wales.

The purpose of the HIA is to inform Welsh Government, PHW, key strategic organisational partners and the general population about the potential differential health impacts that may arise in Wales from climate change and how the population will potentially be affected. This will help both PHW and external partners develop future plans to mitigate the effects of climate change on population health.

Purpose
This literature review will inform a Health Impact Assessment on the public health and well-being implications of climate change in Wales. The findings from this literature review will be combined with qualitative stakeholder views, generated from interviews and workshops, and a population health profile. All three sources will be used to identify the potential impacts of climate change.

Review question
What does the literature say about the impact that climate change might have/has had on the social determinants of health and on different population groups?

This will include impacts on: Lifestyle, social and community factors, mental health and well-being, living and environmental conditions, access to services and macro issues.

The literature review will consider the following key population groups/geographical areas: children and young people, early years, older adults, refugees/asylum seekers, people with disabilities and long-term health conditions, men, women, workers (outdoor workers, farmers, fishers, construction workers and health and emergency service workers), rural areas, urban areas and coastal areas.

Stages of literature review protocol

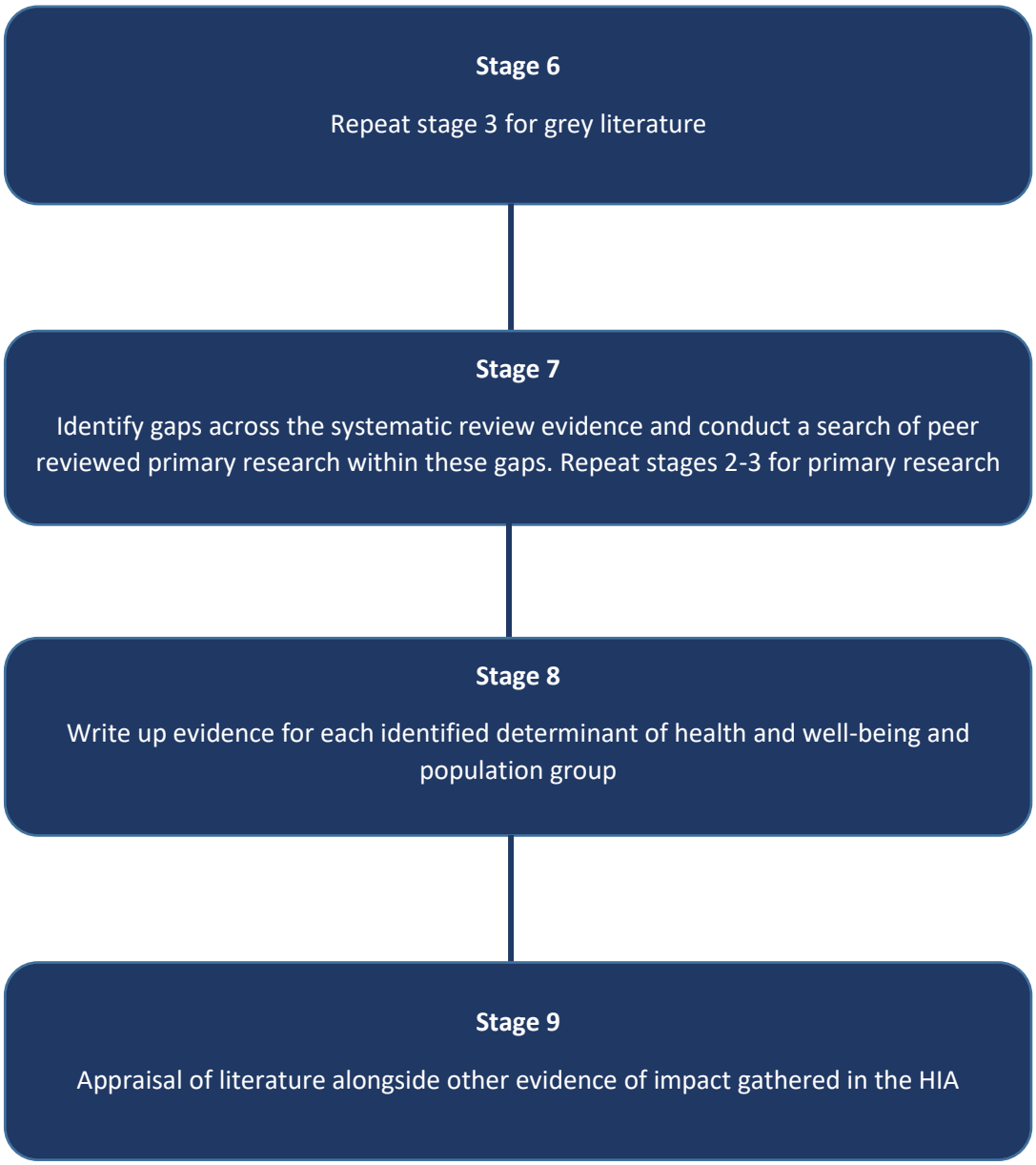


Figure 1. Summary of literature review protocol

Systematic search of systematic reviews and meta-analyses

Search strategy

Searches were made through *ProQuest* across the following databases: SciTech Premium, Agricultural and Environmental Science Collection, Social Science Premium Collection, Georef, PsychINFO, Science Database, Computer Science Database and PTSDpubs. Searches were restricted to the last 5 years. Searches that yielded 0 results were restricted to the last 10 years. No restrictions were made on country/region.

Table 1. *Search strategy for systematic search of systematic reviews and meta-analyses*

Search no.	Search terms
S1	"Climate change" OR "global warming" OR "extreme weather" OR flood* OR heatwave* OR "heat wave*" OR "coastal storm*" OR hurricane*
S2	"systematic review" OR "meta-analysis" OR "meta analysis"
S3	S1 AND S2
The remaining searches were combined with S3…	
Lifestyle	
S4	Alcohol OR drug OR "risk-taking" OR "risk taking"
S5	"Physical activity" OR sport OR "outdoor activity" OR exercise OR fitness
S6	"Social media"
S7	"Public health"
Social and community factors	
S8	Loneliness OR (social AND (exclusion OR isolation))
S9	Community AND (cohes* OR resilien* OR conflict OR action)
S10	Displacement OR migration
S11	Homeless* OR housing
S12	Parent*
S13	Family
S14	Conflict
S15	Cultur* OR spirit*
S16	"Adverse childhood experience" OR (child* AND (adverse OR adversity OR trauma))
S17	Violence OR abuse OR assault OR "intentional injury" OR "community safety" OR crime
Mental health and wellbeing	
S18	Wellbeing OR well-being OR "mental health" OR "mental illness" OR "mental disorder*" OR suicid* OR "self harm" OR "self-harm" OR stress OR distress
S19	Solastalgia
S20	(Social OR psychosocial) AND (adaptation OR transition)
S21	Political AND (participation OR engagement)
Living and environmental conditions	
S22	Food OR nutrition OR diet
S23	Water

S24	Home OR school OR workplace OR hospital OR “care home”
S25	(Indoor OR built) AND environment
S26	“Thermal comfort”
S27	Disease OR arbovirus
S28	(Scarcity OR lack) AND resources
S29	“Wild-fire” OR “wild fire”
S30	Biodiversity
S31	Touris*
S32	“Play area” OR playground OR park
S33	Waste
S34	“Air quality”
S35	Pollution AND (air OR light OR noise)

Economic conditions affecting health	
S36	Work* AND (condition* OR environment)
S37	Debt
S38	Employment OR productivity
S39	Income
S40	Trade
S41	Poverty

Access to services	
S42	Transport
S43	Access AND (health OR care OR “third sector” OR service*)

Macro issues	
S44	Education OR school*
S45	Inequalit*
S46	Infrastructure
S47	Policy OR legislation
S48	Racism OR bully* OR discriminat*

Population groups	
S49	Child* OR youth OR (young AND (people OR generation))
S50	“Early year*” OR infant* OR newborn OR new-born OR “new born” OR baby OR babies
S51	Elderly OR (Old* AND (adult* OR generation OR people))
S52	Farmers OR (rural AND (communit* OR area))
S53	“Urban heat island*”
S54	Coast* AND (living OR area OR hous* OR home*)
S55	Refugee* OR “asylum seek*” OR “seek* asylum” OR immigrant* OR migrant*
S56	Deprivation OR deprived OR disadvantaged
S57	Disabilit* OR ((chronic OR long-term OR “long term”) AND (health OR condition OR illness))
S58	Men OR man OR male
S59	Women OR woman OR female
S60	Work* AND (outdoor* OR outside)
S61	Fisher*
S62	Construction AND work*

S63	"Emergency service*" OR "fire service*" OR ambulance OR police* OR policing
S64	Wales Or Welsh Or Cymru Or Cymraeg NOT "New South Wales"
S65	UK OR U.K. OR "United Kingdom" OR Britain OR England OR "Northern Ireland" OR Scotland

To address the gaps in academic literature and emerging topic areas, a second search of systematic reviews and meta-analyses was carried out. The second search was made across the same databases and was restricted to the last 5 years. Searches that yielded 0 results were restricted to the last 10 years. No restrictions were made on country/region.

Table 2. *Revised search strategy for second systematic search of systematic reviews and meta-analyses*

Search no.	Search terms
S1	"systematic review" OR "meta-analysis" OR "meta analysis"
The remaining searches were combined with S1…	

Lifestyle	
S2	"Physical activity" OR sport OR exercise OR fitness OR "outdoor activity" OR "recreational activity" OR "leisure" **AND** Heat OR ((hot* OR warm*) AND weather) OR heatwave* OR "heat wave*" OR "humidity" OR "temperature"
S3	"Social media" OR facebook OR snapchat OR Instagram OR "communication technique*" OR misinformation OR "mis-information" OR "market communication*" OR "media communication*" OR media **AND** "Climate change" OR "global warming" OR "extreme weather" OR flood* OR heatwave* OR "heat wave*" OR "coastal storm" OR hurricane*

Social and community factors	
S4	Refugee* OR "asylum seeker" OR (seek* AND asylum) OR "displaced person" OR "climate change refugee" OR escapee OR evacuee OR emigrant **AND** "Climate change" OR "global warming" OR "extreme weather" OR flood* OR heatwave* OR "heat wave*" OR "coastal storm" OR hurricane*

Living and environmental conditions	
S5	"Healthy eating" OR diet OR vegetarian* OR vegan* OR flexitarian* OR "5-a-day" OR "5 a day" OR "five a day" OR "five-a-day" **AND**

	"Climate change" OR "global warming" OR "extreme weather" OR flood* OR heatwave* OR "heat wave*" OR "coastal storm" OR hurricane*
S6	Waste OR (reduce AND reuse AND recycle) OR recycl* OR garbage OR trash OR rubbish OR landfill **AND** "Climate change" OR "global warming" OR "extreme weather" OR flood* OR heat* OR "heat wave*" OR "coastal storm" OR hurricane*
S7	("coal tips" AND (instability OR landslide* OR "land slide*")) OR landslide* OR "land slide*" **AND** "Climate change" OR "global warming" OR flood* OR "coastal storm" OR rain* OR "sea level" OR "sea level rise" OR "rising sea water"

Screening

Systematic reviews and meta-analyses were screened by title and abstract using the inclusion/exclusion criteria in table 3. The included sources were then screened by full text using the inclusion/exclusion criteria in table 3. Each source was screened independently by two reviewers and 10% of sources were cross-checked by a third reviewer. Discrepancies between reviewers 1 and 2 were resolved through discussion with a third reviewer. Figures 2 and 3 demonstrate the number of sources included and excluded at each stage of the screening process. Decisions made at each screening stage were recorded in an excel spreadsheet.

Table 3. *Inclusion/exclusion criteria for systematic reviews and meta-analyses*

Include	Exclude
• Related to the identified public health outcomes • Related to the identified population groups • Systematic review • Meta-analysis	• Not related to climate change or extreme weather • Not related to the identified public health outcomes or population groups • Ecological/environmental impacts of climate change (if not linked to public health) • Assessment/measurement tools • Not a systematic review or meta-analysis

Figure 2.

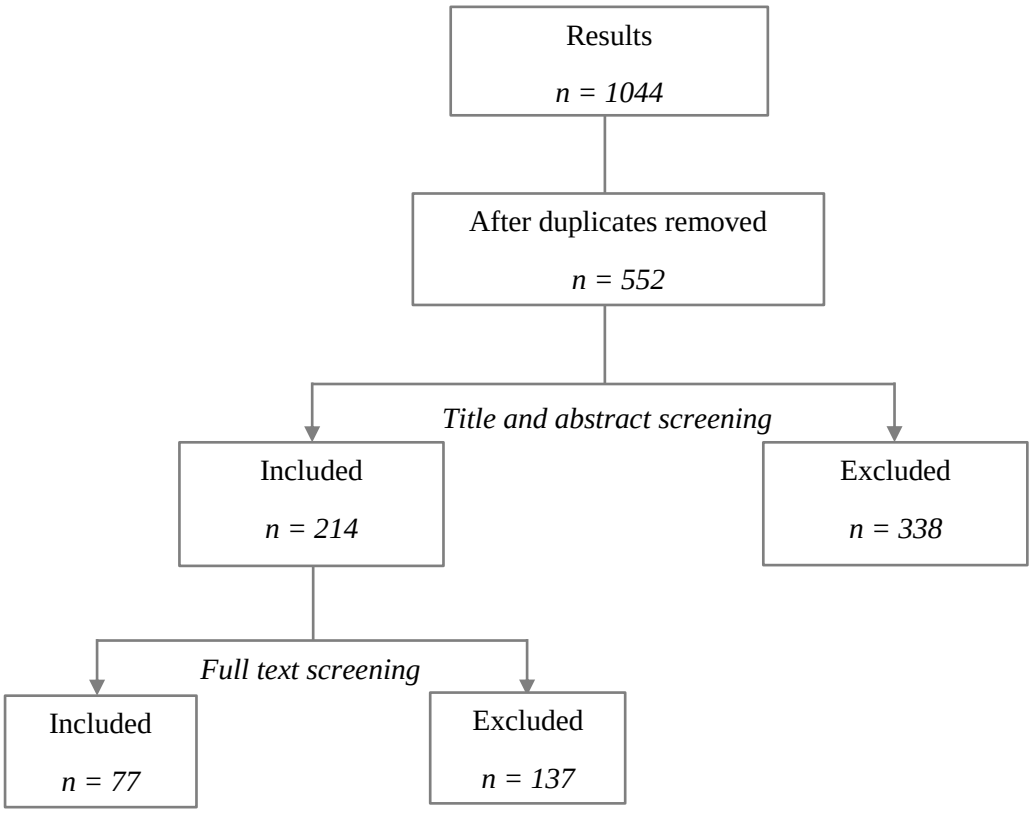


Figure 2. Flow diagram of systematic search and screening process

Figure 3.

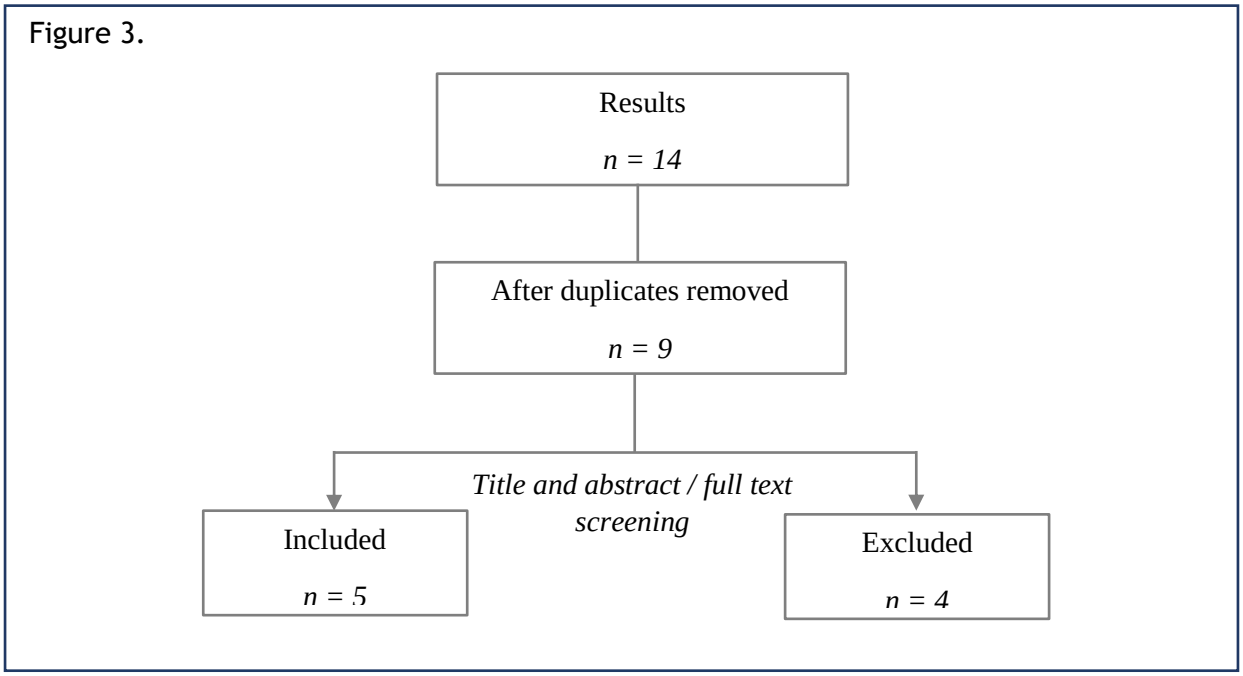


Figure 3. Flow diagram of systematic search 2 and screening process

Table 4. *Search results for systematic search of systematic reviews and meta-analyses. Shows the number of sources included and excluded at each screening stage.*

	Stage 1: Title and abstract screening	Stage 2: Full text screening	Stage 3: Screening of second search
Include	214	77	5
Exclude	338	137	4

Quality assessment

Systematic reviews and meta-analyses were critically appraised using the University of Oxford and the Centre for Evidence-Based Medicine systematic reviews critical appraisal sheet to assess quality and relevance. Each source was quality assessed by one reviewer and 20% of sources were cross-checked by a second reviewer. Each source yielded a quality assessment score, which was recorded in an excel spreadsheet.

Systematic search of grey literature

Search strategy

Searches were made through *Google Advanced Search* across the following sources; UK parliament, UK Government, Welsh Government, Welsh Assembly, Centers for Disease Control and Prevention, Intergovernmental Panel on Climate Change, World Health Organization, United Nations, Public Health Wales and academic research units (Grantham Research Institute on Climate Change and Tyndall Centre for Climate Change). Searches were restricted to PDF format and to the past 5 years (28/01/2015 - 28/01/2020).

Table 5. *Search strategy for grey literature*

Search no.	Search term
S1	"Climate change" OR "global warming" OR "extreme weather" OR flood* OR heatwave* OR "heat wave*" OR "coastal storm*" OR hurricane*
The remaining searches were combined with S1…	
S2	Child* OR youth OR (young AND (people OR generation))
S3	"Early year*" OR infant* OR newborn OR new-born OR "new born" OR baby OR babies
S4	Elderly OR (Old* AND (adult* OR generation OR people))
S5	Farmers OR (rural AND (communit* OR area))
S6	"Urban heat island*"
S7	Coast* AND (living OR area OR hous* OR home*)
S8	Refugee* OR "asylum seek*" OR "seek* asylum" OR immigrant* OR migrant*
S9	Deprivation OR deprived OR disadvantaged
S10	Disabilit* OR ((chronic OR long-term OR "long term") AND (health OR condition OR illness))
S11	Men OR man OR male

S12	Women OR woman OR female
S13	Work* AND (outdoor* OR outside)
S14	Fishing OR fisherman OR fishermen
S15	Fishing OR fisherman OR fishermen
S16	Construction AND work*
S17	“Emergency service*” OR “fire service*” OR ambulance OR police* OR policing
S18	Wales OR Welsh OR Cymru OR Cymraeg
S19	UK OR U.K. OR "United Kingdom" OR Britain OR England OR "Northern Ireland" OR Scotland

Screening

Grey literature sources were screened by title using the inclusion/exclusion criteria in table 6. The included sources were then screened by full text using the inclusion/exclusion criteria in table 6. Each source was screened independently by two reviewers and 10% of sources were cross-checked by a third reviewer. Discrepancies between reviewers 1 and 2 were resolved through discussion with the third reviewer. Figure 4 demonstrates the number of sources included and excluded at each stage of the screening process. Decisions made at each screening stage were recorded in an excel spreadsheet.

Table 6. *Inclusion/exclusion criteria for grey literature*

Include	Exclude
• Related to the identified public health outcomes • Related to the identified population groups	• Not related to climate change or extreme weather • Not related to the identified public health outcomes or population groups • Ecological/environmental impacts of climate change (if not linked to public health)

Figure 4.

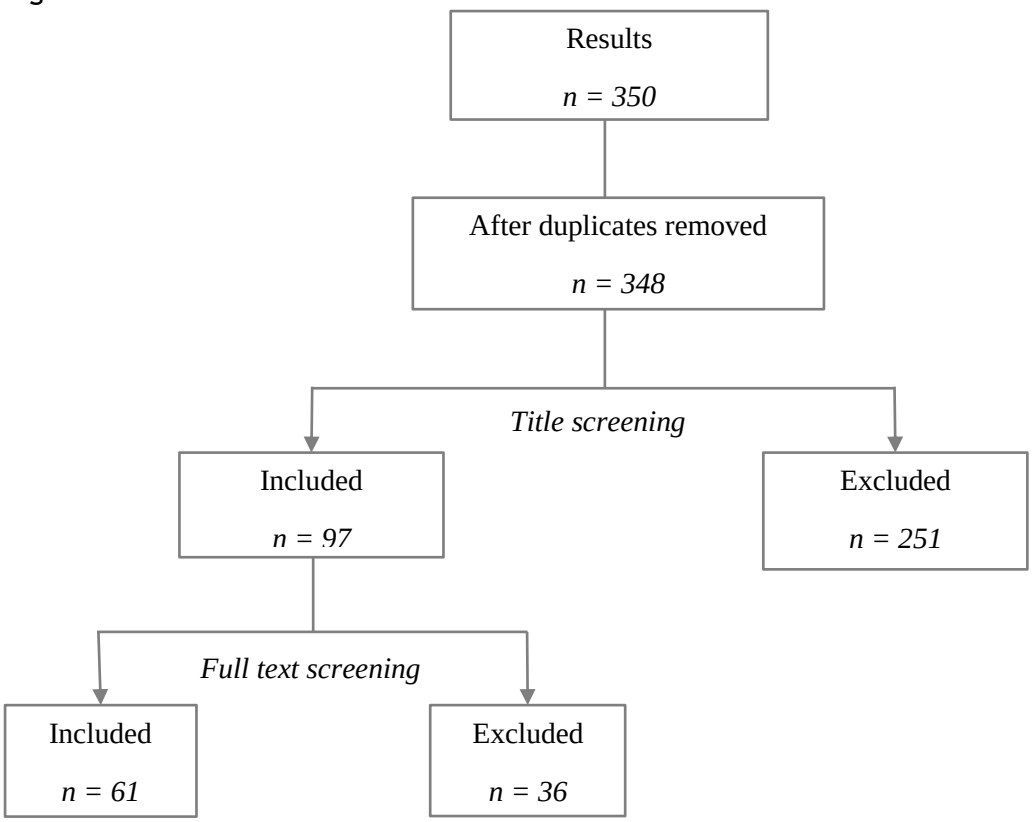


Figure 4. Flow diagram of systematic search and screening process

Table 7. *Search results for grey literature. Shows the number of sources included and excluded at each screening stage.*

	Stage 1: Title screening	Stage 2: Full text screening
Include	97	61
Exclude	251	36

Quality assessment

Grey literature was critically appraised using the Joanna Briggs checklist for text and opinion to assess quality and relevance. Each source was quality assessed by one reviewer and 20% of sources were cross-checked by a second reviewer. Each source yielded a quality assessment score, which was recorded in an excel spreadsheet.

Systematic search of primary research

Search strategy

A systematic search of primary research was carried out in order to address the gaps in systematic reviews, meta-analyses and grey literature. Searches were made through *ProQuest* across the following databases: SciTech Premium, Agricultural and

Environmental Science Collection, Social Science Premium Collection, Georef, PsychINFO, Science Database, Computer Science Database and PTSDpubs. Searches were restricted to the last 5 years. Searches that yielded 0 results were restricted to the last 10 years. No restrictions were made on country/region.

Table 8. *Search strategy for primary research*

Search No.	Search terms
Lifestyle	
S1	"Alcohol use" OR "alcohol consumption" **AND** "Climate change" OR "global warming" OR weather OR heat*
S2	"Physical activity" **AND** "Climate change" OR "global warming"
Social and community factors	
S3	(Family AND relationship) OR "intergenerational relationship" OR parent* **AND** "Climate change" OR "global warming"
S4	"Social isolation" OR loneliness **AND** Flood*
S5	Refugee **AND** "Climate change" OR "global warming"
Mental health and well-being	
S6	"Young people" AND "mental health" **AND** "Climate change" OR "global warming"
Living and environmental conditions	
S7	"Indoor environment" OR "indoor temperature" **AND** "Climate change" OR "global warming" OR heat*
S8	Child* AND playground **AND** "Climate change" OR "global warming"
S9	Waste OR landfill OR vermin **AND** "Climate change" OR "global warming"
S10	("Coal tips" AND (instability OR landslide* OR "land slide*")) OR landslide* OR "land slide*" OR landfill **AND** "Climate change" OR "global warming" OR rain* OR "sea level" OR "sea level rise" OR "rising sea water"

Screening

Primary research sources were screened by title and abstract using the inclusion/exclusion criteria in table 9. The included sources were then screened by full text using the inclusion/exclusion criteria in table 9. Each source was screened independently by two reviewers and 10% of sources were cross-checked by a third reviewer. Discrepancies between reviewers 1 and 2 were resolved through discussion with the third reviewer. Figure 5 demonstrates the number of sources included and excluded at each stage of the screening process. Decisions made at each screening stage were recorded in an excel spreadsheet.

Table 9. *Inclusion criteria for primary research*

Include	Exclude
• Identified public health outcomes • Identified population groups • Single studies • Reviews • Opinion pieces	• Not related to climate change or extreme weather • Not related to the identified public health outcomes or population groups • Ecological/environmental impacts of climate change (if not linked to public health) • Assessment/measurement tools

Figure 5.

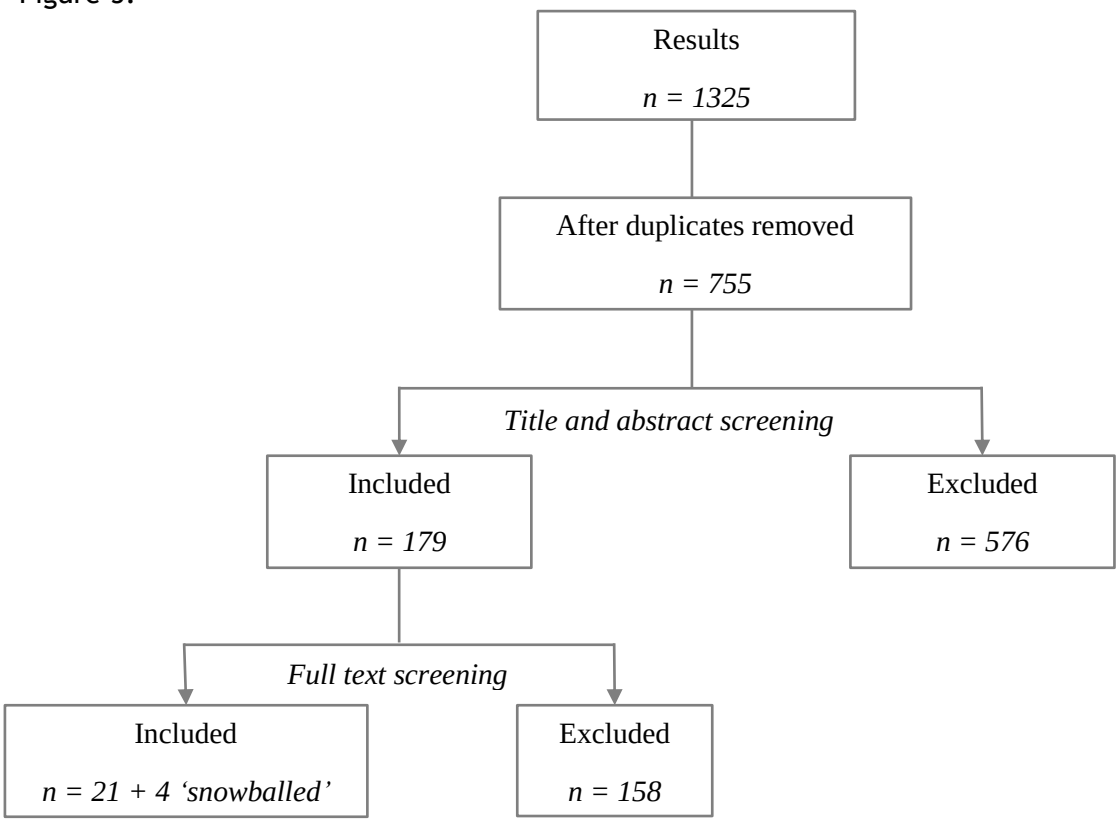


Figure 5. Flow diagram of systematic searches and screening process

Table 10. *Search results table for primary research*

	Stage 1 Title and abstract screening	Stage 2 Full text screening
Include	179	25
Exclude	576	158

Note. 4 primary research papers were 'snowballed' from the literature.

Quality assessment

Single studies were critically appraised using the following 6 quality assessment criteria (i) Is the research question clearly stated? (ii) Are the methods clearly described and appropriate to answer the question? (iii) Do the data come from credible sources? (iv) Are the analyses clearly described? (v) Are the conclusions appropriate given the results? (vi) Are sources of bias described or weaknesses considered?

Literature reviews were critically appraised using the following 5 quality assessment criteria (i) Is the main question clearly stated? (ii) Are the methods clearly described? (iii) Is there an inclusion or exclusion criteria? (iv) Is the quality of the sources discussed? (v) Does the article summarise the results/ answer the question?
Opinion pieces were critically appraised using the following 2 quality assessment criteria (i) Has the source been peer reviewed? (ii) Do the authors come from a reputable organisation? Does the author have nothing to gain from writing the piece?

Each source was quality assessed by one reviewer and 20% of sources were cross-checked by a second reviewer. Each source yielded a quality assessment score, which was recorded in an excel spreadsheet.

Google search

A focused google search of the following topic areas, in relation to climate change, was conducted to address the emerging gaps in evidence.

- Healthy eating behaviour
- Social media
- Intergenerational relationships and conflict
- Waste
- Panic buying

10 relevant papers were identified and included in the literature review.

Reference management

Systematic reviews, meta-analyses and primary research

References were extracted from databases and imported into Mendeley; a reference management software that allows references to be shared and synchronised across research team members. An excel spreadsheet of the titles, authors, abstracts and related information (including a unique ID number) was also created to aid with screening and recording of inclusion/exclusion. PDFs of included articles were downloaded.

Grey literature

An excel spreadsheet of the titles, organisations, authors, and related information (including a unique ID number) was created as a record of the grey literature references and to aid with screening and recording of inclusion/exclusion. PDFs of included reports were downloaded.

Data extraction

Information from the included sources was extracted into the Excel spreadsheet (described above) based on the following items: unique ID number, title of publication, year of publication, authors, country/region studied, study population, outcome evaluated and main findings. Data extraction was completed by one researcher and cross checked by a second researcher for consistency. Any discrepancies were resolved through discussion with a third researcher.

Synthesis

The extracted data were sorted in excel by coding the information by population group and determinant of health and well-being. The information was transferred into an evidence table according to the corresponding category. Each category was structured and then summarised in order to form a literature review.

Limitations

Restricting the initial search by systematic reviews and meta-analyses may mean that more recent primary research has not been included for topic areas where systematic reviews and meta-analyses exist. Additionally, restricting the searches by date may mean that other relevant information was excluded from the present literature review. The English language restriction may have resulted in exclusion of relevant information that is available in other languages. The systematic search of grey literature was restricted to PDF format and by geography – only searches for UK literature were carried out – due to time restrictions and for ease of searching. Additionally, only a limited number of sources were searched and there may be other sites that contain relevant grey literature.

Appendix 4 - Participant Information Sheet

The Public Health Implications of Climate Change in Wales: Health Impact Assessment

Participant Information Sheet

Researchers:

Liz Green – Programme Director – Wales Health Impact Assessment Support Unit
Nerys Edmonds – Senior Public Health Practitioner – Wales Health Impact Assessment Support Unit
Karen Hughes – Research and Capacity Development Manager (Specialist Projects) – Public Health Wales
Sara Wood – Public Health Researcher – Public Health Wales
Katie Cresswell – Researcher – Public Health Collaborating Unit
Natasha Judd – Researcher – Public Health Collaborating Unit

Invitation

You are invited to take part in a health impact assessment (HIA). Before you agree to take part, it is important that you understand why the HIA is being done and what it will involve. Please take time to carefully read the following information and do not hesitate to ask if anything is unclear or if you have any questions. You may wish to speak to others about the study before taking part. Please note that you are free to withdraw at any time, without giving a reason. Additionally, you do not have to take part in this study; your participation is entirely voluntary.

Project Summary

On Monday 29th April, the Minister for Environment, Energy and Rural Affairs, Lesley Griffiths, declared a climate emergency in Wales. This HIA is being conducted by the Wales Health Impact Assessment Support Unit (WHIASU) and Public Health Wales (PHW) in response to the declared climate emergency, and will explore the potential public health implications of climate change in Wales.

The European Academies Scientific Advisory Council (EASAC) Policy report on climate change and health reports that climate change poses major risks for health, but concrete objectives for health are often poorly integrated in climate change adaptation plans. EASAC also highlight that some mitigations for climate change could provide significant opportunities for health improvement. The Climate Change Risk Assessment for Wales highlights a number of areas, relating to health impacts in Wales, that lack sufficient evidence and that there is a need to understand more about the interaction and distribution of impacts across the population.

The purpose of this work is to inform PHW and key strategic decision makers in a range of organisational settings to understand the potential differential health and wellbeing impacts that may occur in Wales in response to climate change and related events.

This project will use a HIA approach to assess the potential physical, mental and social well-being impacts on the population of Wales. It will consider any inequalities that may

arise and provide strategic recommendations and actions to address any potential detrimental impacts and maximise any benefits or opportunities.

What would taking part involve?

If you decide to take part, you will be required to sign a consent form. You will be asked to attend a face-to-face interview with one of the HIA researchers, taking approximately 30-60 minutes of your time. You will be asked open-ended questions and be encouraged to share your expertise related to the questions asked. Questions will cover the impact of climate change on the wider determinants of health in relation to the Welsh population, and the preparedness of your organisation for the adverse effects of climate change.

Confidentiality and the use of my data

During the interview, a researcher will take note of your answers and the interview will be recorded. Only the HIA researchers will have access to the notes and recording of your interview. Before the information you provide is used in the HIA, you will be sent a record of your interview to ensure the information is correct. This is also an opportunity for you to provide supplementary information. Your name and personal information will not be used in the HIA; the information from your interview will be represented by the name of your organisation.

What are the possible benefits of taking part?

Your knowledge will contribute to the HIA and consequently help inform key decision makers of the potential health and well-being impacts of climate change on the Welsh population.

What are the possible disadvantages or risks of taking part?

The interview may be time consuming, however you will only need to give a maximum of 60 minutes of your time.

If you have questions or comments about the HIA please contact:

Nerys.S.Edmonds@wales.nhs.uk

Liz.Green@wales.nhs.uk

Appendix 5 – Community Health Profile

Contents

1 Introduction

This community health profile was constructed during the second phase of the HIA in 2022.

It is important to note that whilst many of the indicators and data sources contained in this profile were used in the analysis, the main chapters and summary report of the HIA sometimes contains more up to date data than reported here due to the time lag between constructing the profile and final publication.

The WHIASU population groups and determinants checklist (Appendix 1) and the climate disadvantage framework (Lindley et al. 2011[1]) informed the development of this population profile, along with the screening findings (Appendix 2).

[1] Lindley, S; O'Neill, J; Kandeh, J; Lawson, N; Christian, R and O'Neill, M (2011) Climate change, justice and vulnerability. Joseph Rowntree Foundation. Available at https://www. jrf.org.uk/report/climate-change-justice-and-vulnerability

2 Population structure and projected change

Demographics and projected change

Demographic descriptions of Wales's population vary in a number of dimensions; Age distribution, population densities, births and deaths, and migration resulting in differences in the projected/ future population (Welsh Government, 2020a).

2.1.1 Age structure (overview)

In 2020, Wales's population was reported as 3,170,000 (Welsh Government, 2021a).

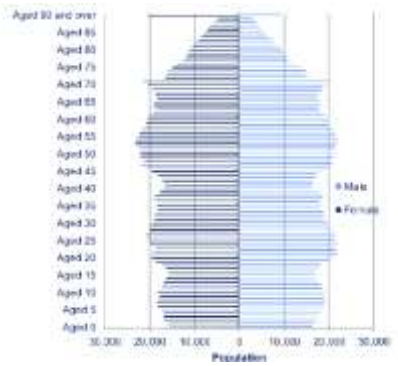
- Those aged 65+ account for 21% of Wales's total population, this is the highest proportion across all UK countries.
- Swansea was the only local authority to have experienced a decline in their population over this period of 0.2%.
- The COVID-19 pandemic is expected to have had an impact and this may continue in future, however the evidence to understand this is still emerging (Welsh Government, 2021a).

National population projections for Wales indicate that (Office for National Statistics, 2022):

- From 2020 to 2030, the population is projected to increase by 2.6% from 3.17 million to 3.25 million, a lower rate of growth than the UK average of 3.2%.
- From 2020 to 2045, the population is projected to increase by 4.2% to 3.30 million.

Figure 1: Comparison of current population structure vs projected change

a.



b.

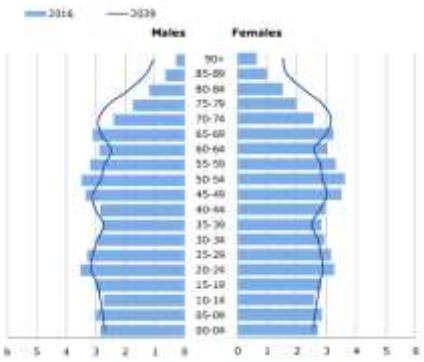


Figure 1: Comparison of current population structure by age and sex versus projected population change in Wales; **a)** The percentage of Wales population by age and sex for the year 2018 (Welsh Government, 2021a); **b)** The percentage of Wales population by age and sex for the years 2016 and 2039 using 2014-based population projections taken from (Public Health Wales Observatory, 2017)

- Number of children aged under 16 is projected to decrease by 10.5% by 2030.
- Number of people aged 16-34 is projected to increase by 1.7%.
- Number aged 65+ is projected to increase by 16.1%.
- Those aged 75+ are projected to increase by 23.9%.

Population component of change (see also **Section 2.1.4**):

- In Wales it is projected that there will continue to be more deaths than births, with a net reduction of 77,000 from 2020 to 2030 due to this.
- Migration is expected to make a net contribution to population growth of 159,000 from 2020-2030.

The projected trend of age structure for the period 2018 to 2028 (Welsh Government, 2020b) is:

- 0-15 years old: projected that all local authorities will decrease, other than Newport, the Vale of Glamorgan, Bridgend, Neath Port Talbot and Merthyr Tydfil.
- 16-64 years old: Projected that there will be a decrease in all local authorities except for certain local authorities in South East Wales; Newport, Cardiff, Swansea, Rhondda Cynon Taf, and Bridgend.
- 65+ Years: Projected that there will be an increase in people in this age group in Wales. The number of local authorities where over a quarter of the population will be aged 65+ is projected to double from 4 in 2018 to 8 in 2028.
- 75+ Years: projected that there will be an increase in numbers across Wales.
- Newport is the only local authority to projected to have a growth in the number of those aged 0-15. Ceredigion will experience the largest decrease in this age group and of those aged 16-64.
- Pembrokeshire will experience a large increase in those aged 65+ and 75+.
- Over a quarter of Powys population will be aged 65+.

Age structure is a material consideration for climate disadvantage because of Wales's ageing population, being more vulnerable to heat related issues, in extreme weather situations, and having a greater need for public health and social care services.

2.1.2 **Ethnic identity**

Race inequality exists in Wales (First Minister's BAME COVID-19 Advisory Group, 2020). People who experience racism (Inc Arts, 2019) in Wales have unequal health outcomes (First Minister's BAME COVID-19 Advisory Group, 2020). As identified by the First Minister's Black Asian and Minority Ethnic (BAME) COVID-19 Advisory Group data that might be drawn on to evidence and address these inequalities is itself "poor and not transparent" (First Minister's BAME COVID-19 Advisory Group, 2020, p. 8), and additionally identifies that:

- Welsh specific data on ethnic identity is lacking.
- Existing poor quality of ethnicity data has resulted in poor health decisions.

- Public bodies hold insufficient data on the ethnicity of their staff.
- Census data are known to be out of date with population changes since 2011.
- Ethnicity is not recorded on death certificates.

Bearing in mind the inadequacy of existing data it is important to highlight those racial inequalities are also closely related to wider determinants of health (**Section 3.2**) including but not limited to (First Minister's BAME COVID-19 Advisory Group, 2020):

- Effectiveness and communication of health information
- Health and social care services
- Income and employment insecurity
- Housing overcrowding and environment
- Migration status
- Violence against women

At the time of writing data from the 2021 census which will give a more accurate picture was not available.

Table 1: Ethnicity by age group in Wales in 2021 redrawn from Stats Wales (Stats Wales, 2022a) data:

Percentage Ethnicity	**Age group**			**Wales**
	0-15	**16-64**	**65+**	**total**
White	90.5%	95%	98.9%	95%
Mixed/Multiple ethnic groups	2.8%	0.7%		0.9%
Asian	3.6%	2.5%		2.3%
Black/African/Caribbean/ Black British	1.5%	0.9%		0.9%
Other ethnic groups	1.3%	0.9%		0.8%

(Stats Wales, 2022a)

- The second largest ethnic group in Wales between 2017-19 was Asian, 2.4% of the population.
- In Wales the percentage of the Welsh population who described themselves as white was around 95% of the total population in 2021 (Stats Wales, 2022b).
- Mid and South West and South East Wales contain the most ethnically diverse populations in Wales. With the South East having the greatest level of diversity.
- The above data is noted by Stats Wales as being of poor quality but 'acceptable' for use.

Ethnic identity is a material consideration for climate disadvantage due to certain groups facing unequal health outcomes and how these can intersect and overlap with other factors such as housing, income, access to outdoor and green spaces, and living environment which mediate health impacts experienced from climate change.

2.1.3 **Where people currently live and projected change**

In Wales greater numbers of people live within cities and urban areas, including the South Wales Valleys. Rural areas of Wales have a lower population density. Figure 2 illustrates Wales population density by local authority area in 2020 (Infobase Cymru, 2022).

Figure 2:

Figure 2: Wales population density (Population count/area in sq Km) in mid-2020

(Infobase Cymru, 2022)

- Population density varies significantly across Wales from the city of Cardiff with 2,585.2 people /Km^2 to the county of Powys with 25.6 people/ Km^2.
- Using ONS class settlements (Office for National Statistics, 2016; Woods et al., 2021), about a third of people (Woods et al., 2021) in Wales live in rural[2] local authority areas, including Isle of Anglesey, Gwynedd, Conwy, Denbighshire, Powys, Ceredigion, Pembrokeshire, Carmarthenshire, and Monmouthshire (Welsh Government, 2008; Woods et al., 2021).
- In 2019, 25.4% of those in rural counties of Wales were aged 65+, an increase of 19.6% since 2000 and this is projected to about 32% by the year 2043 according to 2018-based population projections (Stats Wales, 2021a). In comparison those aged 65+ accounted for 18.9% of those in Wales's urban areas as of 2019 (Woods et al., 2021).

Table 2: 2018-based population projections by 2043 for rural Wales (Stats Wales, 2021a):

	Population projected by 2043 for 65+	**Total population projected by 2043 (all ages)**	**Percentage of the population aged 65+ by 2043**
Wales	851,156	3,309,154	25.72%
Local authority			
Isle of Anglesey	22,385	65,575	34.14
Gwynedd	34,033	132,200	25.74
Conwy	43,684	123,200	35.46
Denbighshire	30,445	98,848	30.80
Powys	46,439	133,927	34.67
Ceredigion	22,368	68,745	32.54

[2] According to Woods *et al* (2021) "there is no single official definition of rural Wales. At a local authority scale, 'rural Wales' is commonly understood to be constituted by the areas of the nine predominantly rural counties represented in the WLGA Rural Forum" (Woods et al, 2021., p.5).

Pembrokshire	43,970	130,196	33.77
Carmarthenshire	58,248	197,218	29.53
Monmouthshire	33,038	101,230	32.64
Total in classified rural areas:	334,610	1,051,139	31.83

(Stats Wales, 2021a)

- The 9 local authorities identified as rural in Wales, will account for 39.2% of Wales total population aged 65+ by 2043.

In terms of the possible future population size (Welsh Government, 2020b):

- Majority of local authorities will experience an increase in population sizes
- Populations are projected to decrease in 9/22 local authorities.
- The local authorities whose populations are expected to increase the most are Newport (5.1%), the Vale of Glamorgan (3.6%) and Bridgend (2.9%).
- The local authorities whose populations are expected to decrease the most are Ceredigion (6.4%), Wrexham (3.2%) and Powys (2.8%).

(Welsh Government, 2020b)

Until recently, the largest population increase projected at local authority level was in Cardiff, which is projected still to increase by around a third from 345,000 in 2011 to over 455,000 in 2036 (Public Health Wales Observatory, 2016).

When broken down by age groups in line with **Section 2.1.1** the following key points arise (Office for National Statistics, 2021a):

- **Under 16's**: Highest concentrations of under 16's appears to be within cities and urban areas of Wales.
- **16-64 years:** Higher concentrations of those adults aged 16-64 years appear to be concentrated in urban areas.
- **65-84 years:** Higher concentrations of those adults aged 64-84 years appear to be concentrated within towns and more rural areas of Wales.
- **85+ years:** Highest concentrations of those aged 85+ years are more concentrated within rural and coastal areas of Wales.

The reason this is important for climate disadvantage is that it shows climate disadvantage will vary by place within Wales and whilst there are large populations within urban areas there are vulnerable population groups across Wales, therefore approaches need adjustment to the local context. This information is important for future planning, knowing which populations are projected to experience growth in this case the largest growth will be that amongst those aged 65+. This helps to inform groups who are particularly vulnerable to certain climate impacts such as heat risk and allows for their locations to be known.

2.1.4 **Migration**

Migration in Wales, is expected to be a key driver of positive net change for some local authorities:

Figure 3:

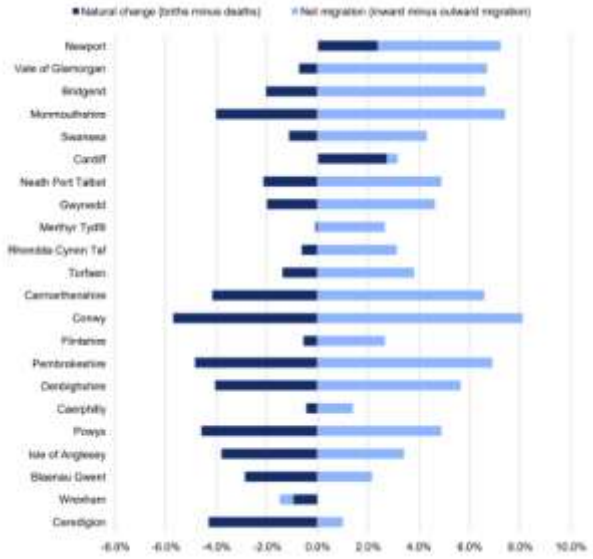


Figure 3: Changes in population projections by local authority and component change 2018-2028. (Welsh Government, 2020b)

- In areas of growth, this is projected to be due to net migration except for Cardiff and Newport were natural change (more births than deaths) is a material factor.
- For areas with a reducing population this is driven by negative natural change (more deaths than births) except for Wrexham which is also projected to have net negative migration (people moving away) from 2018 to 2028.

Climate change globally will create risks for more people and lead to an increase in "persons displaced in the context of disasters and climate change (United Nations High Commissioner for Refugees, 2022). Displacement due to climate change may add more pressure to some regions in terms of food, water, and energy security.

The reason this is important for climate disadvantage is that displacement of communities in Wales from climate hazards may result in movements of people internally, this could lead to a higher demand on resources and housing in other parts of the country. Relocation may have a negative health and well-being impact on those migrating through social isolation, marginalisation and a reduction of social and material support (Mbow et al., 2019; Pozarny, 2016; Torres and Casey, 2017).

2.1.5 Number of asylum seekers and refugees

- Wales is a Nation of Sanctuary (Welsh Government, 2019a, 2021b).
- Refugees are protected under international law and the ability to claim asylum is a human right (United Nations High Commissioner for Refugees, 2022). The majority of refugees stay in their region of displacement (United Nations High Commissioner for Refugees, 2022).
- Asylum seekers and refugees are not included in migration figures above.
- Climate change globally will create risks for more people and lead to an increase in "persons displaced in the context of disasters and climate change" (United Nations High Commissioner for Refugees, 2022) some of whom will be refugees, although the implications for this for Wales are uncertain.

Level of international displacement to Wales arising from challenging environmental conditions elsewhere, is uncertain and not expected to be significant in the short term (House of Lords Select Committee on the European Union, 2020).

- In Wales at the end of March 2022 there were 2603 supported asylum seekers (UK Government, 2022).
- These groups have specific health needs and factors that may negatively affect health and well-being, for example those seeking asylum do not have the right to work.

Asylum seekers in receipt of support by local authority (UK Government, 2022):

- The local authorities of Wales with the greatest support to Asylum seekers as of March 2022 were as follows; Cardiff (1347). Swansea (707), Newport (406) and Wrexham (122).

The reason this is important for climate disadvantage is that climate change may generate displacement within other more vulnerable regions.

3 Health outcomes

Overarching outcomes
The health of the population of Wales varies between and within communities. All UK nations and many others across Europe have seen a plateau in life expectancy since the turn of the decade. Wales is consistently lower than the top international comparators and England (Welsh Government, 2021c).

3.1.1 Life expectancy and healthy life expectancy

There has been a slight reduction in these figures for both males and females, due to higher death rates experienced in 2020 associated with the impact of the COVID-19 pandemic (Welsh Government, 2021c).

Table 3: Life expectancy and Healthy Life expectancy in Wales as of 2020:

	Life Expectancy	**Healthy Life Expectancy**
Male	78.3	61.4
Female	82.1	62.0

Life expectancy source; (Office for National Statistics, 2021b; Welsh Government, 2021c)

Healthy Life Expectancy; (Office for National Statistics, 2021c)

- Male and female life expectancy in Wales has only increased by 0.2 years and 0.1 years respectively since 2010-12. Prior, increases had been 2.6 years and 2 years respectively between 2001-03 and 2010-12 (Public Health Wales Observatory, 2020).
- All-cause mortality rate for Wales decreased by almost 20% between 2002 and 2011, there has been little change since (Public Health Wales Observatory, 2020).

ONS (2021c) data for Wales shows females born during 2016-18 were expected to live on average around 4 years longer than males:

- The gender gap in life expectancy narrows when Health Life Expectancy is considered.
- In Wales females spend an equivalent of 75.4% of their life in good health, for males this percentage is 78.4%. (Office for National Statistics, 2021c; Welsh Government, 2021c).
- Life Expectancy figures for Wales are lower than the UK averages over this period; with the UK national average being 82.9 years for females and 79.3 for males.

Healthy Life Expectancy continues to be worse for those in the more deprived areas (Welsh Government, 2021c).

Based on the period of 2017-19, analysis suggests the difference in Health Life Expectancy (measured by the Slope Index of Inequality) between the most and least deprived areas of Wales has not changed. The difference is 17.0 years less for males and 18.3 years less for females, representing an inequality of people living in more deprived areas spending a greater proportion of their lives lived in ill health.

The gap in life expectancy is 9.0 years for males and 7.4 years for females.

The reason this is important for climate disadvantage is that females in Wales spend a greater proportion of their lives in ill health, meaning that they are at a material climate disadvantage when it comes to climate change hazards such as heat related risks.

3.1.2 **Well-being ONS**

Annual personal well-being statistics are gathered by ONS (2021d) across the UK:

- Anxiety: UK average scores were around 3.31, in comparison Wales's average was 3.42 for 2020-2021. Recorded yearly mean average scores for Anxiety in Wales were decreasing up until 2020 when the COVID-19 pandemic hit.
- Happiness: UK average scores were around 7.31, with Wales's average for 2020-2021 sitting just below this at 7.30. This figure has fluctuated over the past 4 years.
- Life Satisfaction: During 2020-2021 according to ONS surveys the UK recorded a mean average score of 7.39 for Life satisfaction. For Wales this was lower at 7.38. However, compared to present tends over the period 2017-2020 this has declined.
- Worthwhile: During 2020-2021 the UK recorded a mean average score of 7.71. Wales average was lower at 7.69 for 2020-2021. The value being lower than recorded in previous years (2017-2020).

Results of NSW surveys (Welsh Government, 2022a), indicate that overall satisfaction with life tends to be higher with age:

- 35% of those aged 75+ stated very high satisfaction with life
- 23% of those aged 25-44
- 27% of those aged 16-24

The COVID-19 pandemic is likely to have had an impact on well-being in Wales, as the result of lockdowns and the lack of social interaction/ opportunities. Anxiety levels in Wales have increased since the start of the pandemic, with average mean scores for life

satisfaction, worthwhile and happiness having declined in line with occurrence of COVID-19.

Office for National Statistics (2020) findings include:

- During the COVID-19 lockdown, the factors most strongly associated with high levels of anxiety were that of loneliness, marital status, sex, disability, whether someone feels safe at home or not and work being affected by the pandemic.
- The percentage of those reporting high levels of anxiety significantly increased for those who were married or in a civil partnership during the lockdown to 39%.
- Those aged 75+ were almost twice as likely as those aged 16 to 24 to report high levels of anxiety during this period.
- 80% of UK adults were concerned about the effect that the coronavirus pandemic was having on their life.

The reason this is important for climate disadvantage is that climate change can negatively impact various domains of well-being of populations exposed to climate change hazards, especially those at a climate or social disadvantage.

3.1.3 **Health status**

Collated data from 2018-2019 to 2019-2020 suggests within Wales the average percentage of the adult (16+) population (Stats Wales, 2020):

Table 4: Health status 2018-2019 to 2019-2020 in Wales (Stats Wales, 2020):

Health Category	Wales average (%)
Living in Good or Very Good Health	72%
Living in Fair Health	20%
Living in Bad or Very Bad Health	9%

(Stats Wales, 2020)

The reason this is important for climate disadvantage is, being in poor or very bad health increases the need for access to public health care services, which may be disrupted by extreme weather. People with a number of health problems are more susceptible to the most adverse effects of climate change such as heat related risks, changes to air quality and flooding.

3.1.4 **Long term illnesses**

In terms of experiencing long term illness, the highest percentage rates of adults (16+) in Wales are within those residents in the Health Board areas of Aneurin Bevan, Cwm Taf Morgannwg, Hywel Dda and Swansea Bay University according to collated data from 2018-2019 to 2019-2020 (Stats Wales, 2020). Information for this period was absent for Abertawe Bro Morgannwg and Cwm Taf Health Boards.

Table 5: Long term illness in Wales by percentage of adults affected (Stats Wales, 2020):

Long term Illness	The percentage of adults (16+) in Wales
Musculoskeletal	16%
Heart and Circulatory	13%
Respiratory system complaints	8%
Mental disorders	10%

(Stats Wales, 2020)

In relation to primary care data, hypertension is the G.P. disease register with the highest prevalence rate across all health boards in Wales according to the Quality Assurance and Improvement Framework (QAIF) of 2019-2020. Key disease prevalence rates for Wales based on QAIF primary care data are illustrated in Table 6:

Table 6: Prevalence rates by disease register in Wales, 2019-20 (Welsh Government, 2021d):

	Percentage (%) in Wales
Prevalence rate of all patients (a)	
Asthma	7.4
Chronic obstructive pulmonary disease	2.4
Age-specific prevalence rates for specific disease registers	
Obesity (Patients aged 16+)	10.1

Source: Quality Assurance and Improvement Framework Digital Health and Care Wales (DHCW). More data: Statswales. (Welsh Government, 2021d)

The leading causes of Disability adjusted life years (DALYs)[3] in Wales are Neoplasms (Cancers, 19%) and cardiovascular disease (18%), followed by musculoskeletal and mental substance use disorders as illustrated in Figure 4 below (Public Health Wales Observatory, 2017).

Figure 4:

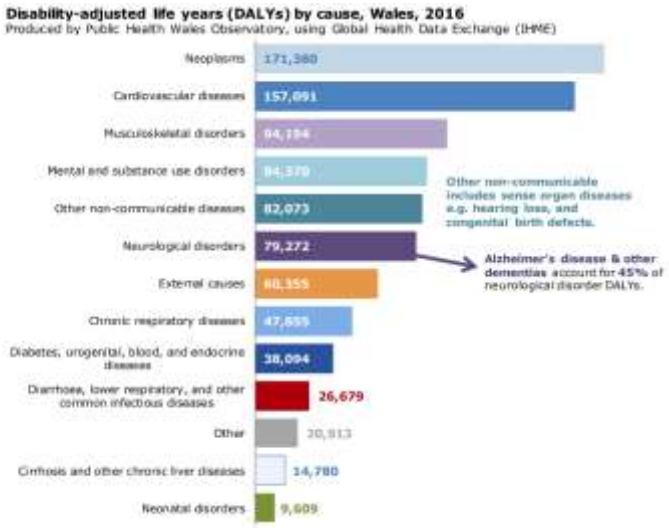


Figure 4: Disability-Adjusted Life Years by cause in Wales as of 2016 (Public Health Wales Observatory, 2017)

[3] *Note: DALYS: Disability adjusted life years, the sum of years of life lost (YLL) and years lived with a disability (YLD) One DALY can be thought of as one lost year of "healthy" life.*

The sum of these DALYs across the population can be thought of as a measurement of the gap between current health status and an ideal health situation where the entire population lives to an advanced age, free of disease and disability (Public Health Wales Observatory, 2017)

- Musculoskeletal disorders and mental and substance use disorders are the main causes of Years Lived with Disability (YLD) in Wales.
- The causes of DALYs changes with age. Mental health and musculoskeletal disorders contribute most to working age (18-64). Neoplasms, neurological disorders, and cardiovascular disease dominant age groups in Wales in later life 65+.
- Mental health and musculoskeletal disorders are the main causes of YLD during adulthood. Other non-communicable diseases (includes sense organ diseases) contribute to YLD throughout life.
- For young adults in Wales, 50% of Years of Life Lost (YLL) are caused by injuries (external causes). Neoplasms (cancers) and cardiovascular disease are the major causes of YLL for people aged 40+.

The reason this is important for climate disadvantage is that those with pre-existing health concerns will be more susceptible to impacts of climate change such as heatwaves and flooding. Those in poor health will have a reduced capacity to cope with risks associated with climate change and are amongst the most vulnerable.

3.1.5 **Percentage of low birthweights**

In Wales overall, 5% of babies were born with a low birth weight between 2009-2018, equivalent to a yearly average of around 1,800 babies (Welsh Government, 2021e). At the local authority level, the Vale of Glamorgan recorded the lowest proportion of babies born with a low birth weight at 4%, whereas Rhondda Cynon Taf and Merthyr Tydfil both recorded rates of 7% (Welsh Government, 2021e).

Percentage of babies born with low birth weights in Wales in 2020 (Welsh Government, 2021e):

Table 7: Percentage of low birthweights (<2.5kg) in Wales during 2020 (Welsh Government, 2021e):

Live births	Percentage with low birth weights (<2.5kg) in Wales.
Single births	6.1%
Multiple births (twins and triplets)	59%

(Welsh Government, 2021e)

- In 2020, 7.2% of all births had a low birthweight in Wales.
- Percentage of all live births with low birth weight has remained fairly steady over long-term with the rate for all live births fluctuating at 7% for Wales.
- For single live births, the rate has fluctuated at 5.5% over the timeseries with a slight upward trend in recent years.
- 67% of single births had a birth weight between 3-4kg with a mean birthweight of 3.38kg.
- 66% of multiple births had a birth weight between 2-3kg, with a mean birthweight of 2.28kg.

This is material consideration for climate disadvantage as birth weight is a proxy measure for area deprivation, it is also one of the few measures available in Wales at the smallest

geographic scale enabling comparison between small areas. Additionally low birth weight can cause problems for children in later life (Welsh Government, 2019b).

3.2 Wider determinants of health

This section addresses the additional economic and social factors that can determine and influence the state of health of a population. These factors are referred to as the '*Wider determinants of health*'. Findings of the most recent Welsh Index of Multiple Deprivation (WIMD) report (2019b), which covers eight domains. Wider determinants of health will be further broken down into the following sub-sections:

- **Economic conditions affecting health:** Child poverty, food poverty, fuel poverty, employment and working conditions, income and those Not in Employment, Education or Training (NEET).
- **Education:** literacy levels, education, and qualifications; and digital skills.
- **Social and community influences on health:** people who volunteer, community cohesion and social loneliness.
- **Living and environmental conditions that affect health:** Housing conditions and Homelessness.
- **Access and quality of services within Wales:** WIMD access to services, number of residential care homes and access to digital infrastructure.

3.2.1 Area Deprivation

The Welsh Index of Multiple Deprivation (WIMD) (2019b) is the official measure of relative deprivation for small areas in Wales. The index uses an overall summary and eight domains of income, employment, health, education, access to services, community safety, physical environment, and housing. It should be recognized that people and communities across Wales have many assets and that some communities have been stigmatized by being labelled as deprived. Nevertheless, in spite of these many assets some communities face greater barriers to good health and the index identifies these in a consistent way across Wales within the limitations of the indicators in the index (Welsh Government, 2019b).

Main findings identified from the WIMD report of 2019 were (Welsh Government, 2019b) are that:

- Children aged 0-4 were most likely to live in deprivation compared to children and adults of all other age groups in Wales.
- 48,000 young children (0-4) in Wales were living in income deprivation in 2016-17; equivalent to 28% of all children in Wales in this age group.
- Proportion of young children in income deprivation has decreased yearly; 30% in 2012-13 to 27% in 205-16. Rate of deprivation increased slightly in 2016-17 to 28%.
- Children of reception age in the most deprived 10% of local areas were 76% more likely to be overweight than those in the least deprived 10%.
- Areas of high levels of deprivation in one indicator were more likely to be deprived in others.
- Obesity, low birth weights, and education at foundation phase were found to be linked to income deprivation.

All areas of Wales have communities who live in places identified as being in the 10% of most deprived areas in Wales. The highest proportion of these areas are in urban areas and the South Wales Valleys. Rural areas of Wales tend to be less deprived than that of urban areas (Welsh Government, 2014). However, despite this in rural areas deprivation

tends to be in geographically dispersed areas compared to the high concentrations of deprived areas in urban parts of Wales. Those in rural communities suffer many of the same issues as those in disadvantaged or deprived areas in urban centres of Wales (Welsh Government, 2014).

Note: It is people living in areas identified through an index which assess deprivation, it is not the people who are necessarily deprived.

The Welsh Governments Well-being report of (2021c) found that in Wales:

- Almost a quarter of the population (23%) were living in relative income poverty (after housing costs) between 2017 and 2020. Children were most likely to be in relative poverty (31% of children) (Welsh Government, 2021c).
- Almost half (49%) of single parents were in material deprivation during 2019-2020 and 1% of households reported having used a food bank during 2020-2021. A further 2% stated they had not received food from a food bank but had wanted to.
- 13% of adults (16+) in 2019-20 were classed as materially deprived (unable to afford certain things i.e., keeping the house warm enough, make regular savings, or have a holiday once a year). Material deprivation was higher for females at 15% compared to 11% for males.
- Approximately 155,000 households (12%) in Wales were living in fuel poverty in 2018.
- General mortality rates are normally higher in more deprived areas of Wales. Over the course of March to the end of July 2020, the mortality rate involving COVID-19 in the most deprived areas was almost twice as high of that in the least deprived areas of Wales.

The reason this is important for climate disadvantage is that those situated in more deprived areas of Wales are likely to be more vulnerable and have a reduced capacity to cope with the effects of climate change. Those in deprived areas are also likely to have reduced access to services such as healthcare making the ability to recover after an event such as flooding more difficult. Deprived areas are often situated in urban centres, crowded urban environments with a lack of open/ green space increase the risk of heat stress during heatwaves.

3.2.2 Economic conditions: Percentage of children living in poverty

- 31% of children were living in relative income poverty in Wales (after housing costs) during 2017-2020.
- 71% who were living in relative income poverty lived in working households (140,000), this has increased for the last 5 periods from 60% in 2012-2015.
- 14% of children in Wales between 2017-18 and 2019-20 were in material deprivation and low-income households. An increase of 3% from the previous reported year (Welsh Government, 2021c).

In Wales during 2017-18 and 2019-20, 23% of individuals living in Wales were in relative income poverty, this figure was 31% for children (Stats Wales, 2021b).

Table 8: Percentage of those living in relative income poverty in Wales (Stats Wales, 2021b):

Indicator for Wales	Percentage (%) living in relative income poverty (2017-18 & 2019-20)
All individuals	23
Children	31
Working-age adults	22
pensioners	18

(Stats Wales, 2021b)

In Wales across 2020-21 (Stats Wales, 2021c):

Table 9: Number of pupils eligible for Free School Meals by region of Wales (Stats Wales, 2021c):

Region of Wales:	Number of pupils eligible for Free School Meals
North Wales	18,716
South West and Mid Wales	25,114
Central South Wales	35,001
South East Wales	20,304
Total for Wales:	
Wales	99,135

(Stats Wales, 2021c)

- 99,135 pupils were eligible for free school meals.
- This figure was greatest in the local authority of Cardiff at 14,267 pupils.
- Central South Wales contained the greatest number of those eligible for free school meals; 35,001 pupils.

This is material consideration for climate disadvantage as those receiving Free School Meals, are likely living within food insecure households (low-income households) which makes them more vulnerable to losses in education and to ill health than those who do not receive Free School Meals. Those living in food insecure households often are situated in the most deprived areas so are therefore more likely to be vulnerable to climate risks of heatwaves, flooding and poor air quality from air pollution and have a reduced capacity to cope/ recover.

3.2.3 Economic conditions: Food poverty

National and household food security are key determinants of health, well-being, and equity at a national level in Wales and at individual and community level (Green et al., 2021). They should be integral considerations as part of post Brexit recovery planning from the COVID-19 pandemic and climate change adaptation (Green et al., 2021).

The 'Triple challenge' of Brexit, climate change and recovery from COVID-19, already has and will continue to have a major, multifaceted and inequitable impact on varying population groups in Wales (Green et al., 2021).

The triple challenges, in Wales has negatively impact food security for a wide range of population groups such as those on:

- Low incomes

- Age related groups (children and older people)
- Women
- Families with young children
- Single parents
- Those working in the agricultural sector (Farmers and fishers)
- Those living in areas of deprivation

Wales itself does not possess its own food system, food security in Wales is shaped by international, national and local policies such as those on:

- Trade, economy, and environmental sustainability

These policies interact in a multidimensional and complex fashion and present a series of 'unknown unknowns' for policymakers, health, and wellbeing according to the work of Green *et al*, (Green et al., 2021). According to the Department for Food, Environment and Rural Affairs (DEFRA) (2020) cited in Green et al (2021, p. 6) the UK is:

- 64% self-sufficient in all foods
- 77% self-sufficient in 'Indigenous' foods

According to work by Chatham House (2020) in Green et al (2021, p. 6), expressed that in April 2020, Food bank dependence was up 89-175%, and has been increasing for the past 5-years.

83% of Wales's population were classified as food secure in 2021 (FAO et al., 2021). With 14% of families in Wales reported as being food insecure, compared to 17% for the UK as a whole according to the Food Foundation (2020)[4] cited in Green *et al* (2021, p. 25).

In 2019 in Wales according to the Food Standards Agency (2019) cited in Green et al (2021, p. 7):

- 17% of the population stated their household had worried in the last 12 months about running out of food.
- 13% stated in the last 12 months they had experienced food running out, when they did not have the money to obtain more.
- 10% stated that their household had experienced not being able to afford to eat a balanced meal.
- 44% had made at least 1 change in their buying or eating arrangements in the last 12 months for financial reasons.

This is material consideration for climate disadvantage as food insecurity can negatively impact physical and mental health along with social and emotional well-being (Green et al., 2021; Leddy et al., 2020; Lee et al., 2012). Poor diet and nutrition associated with food insecurity can result in a range of adverse health outcomes such as obesity and metabolic conditions (Type 2 diabetes) and cardiovascular diseases (Green et al., 2021; National Institute for Health and Care Research (NIHR), 2020). Food insecurity results in malnutrition especially for vulnerable population groups such as children living in low-income households or areas of deprivation (Green et al., 2021; Gundersen and Kreider,

[4] Food Foundation (2020) New Poll Data: More than five million people in households with children have experienced food insecurity since lockdown began https:// foodfoundation.org.uk/vulnerable_groups/new-poll-data-more-than-five-million-peoplein-households-with-children-have-experienced-food-insecurity-since-lockdown-began/

2009; Lee et al., 2012). There is an established link between food security/ production and climate change (Green et al., 2021).

3.2.4 Economic conditions: Fuel poverty

Local authority results for fuel poverty in Wales as of 2018 are illustrated in Figure 5 (Welsh Government, 2020c):

Figure 5:

Figure 5: Map of proportion of households in Wales in fuel poverty (10% definition) 2018. Lighter colours indicate lower overall fuel poverty proportions and darker colours show higher proportions. Values in brackets give the number of local authorities in each category. (Welsh Government, 2020c, p. 3)

Key variables used to identify local area fuel poverty in Wales were:

- Household type: categorized into; couples with no independent children; couples with dependent children; lone parents; single person households; and other multi-person households.
- Dwelling age: categorized into; homes built pre-1919; homes built between 1919 and 1944; homes built between 1945-1980 and homes built post-1980.

The reason this is important for climate disadvantage is that those living in fuel poverty are more at risk of illness during cold winters due to lack of ability to heat their homes. The elderly, young children and those households on low incomes are especially vulnerable, as was determined within the 2019 report by Public Health Wales '*Improving winter health and well-being and reducing winter pressures in Wales*' (Azam et al., 2019). Fuel poverty contributes to access deaths across the UK during cold winters, costing the NHS billions. Fuel poverty can lead to power shortages/outages, which renders people vulnerable as it can reduce their awareness to climate hazards, which are often broadcast online, via the news stations and by text alert.

3.2.5 Economic conditions: Employment and working conditions

As of 2021 in Wales, approximately over 10% of the population works in each of the sector's manufacturing, wholesale and retail trade, and human health and social work industries as illustrated in Table 10:

Table10: Workforce jobs by industry section in Wales as of September 2021 (N. Office for National Statistics, 2021):

Workforce jobs by industry section (SIC 2007) - seasonally adjusted (September 2021)

	Wales (Level)	Wales (%)	United Kingdom (Level)	United Kingdom (%)
Total	1,453,000	-	35,131,000	-
A : Agriculture, Forestry And Fishing	25,000	1.7	364,000	1.0
B : Mining And Quarrying	3,000	0.2	58,000	0.2
C : Manufacturing	148,000	10.2	2,526,000	7.2
D : Electricity, Gas, Steam And Air Conditioning	6,000	0.4	143,000	0.4
E : Water Supply; Sewerage, Waste Management	14,000	1.0	236,000	0.7
F : Construction	107,000	7.4	2,225,000	6.3
G : Wholesale And Retail Trade; Repair Of Vehicles	173,000	11.9	4,800,000	13.7
H : Transportation And Storage	57,000	3.9	1,803,000	5.1
I : Accommodation And Food Service Activities	126,000	8.7	2,403,000	6.8
J : Information And Communication	38,000	2.6	1,521,000	4.3
K : Financial And Insurance Activities	29,000	2.0	1,089,000	3.1
L : Real Estate Activities	20,000	1.4	634,000	1.8
M : Professional, Scientific And Technical Activities	75,000	5.2	3,221,000	9.2
N : Administrative And Support Service Activities	108,000	7.4	3,065,000	8.7
O : Public Administration And Defence	95,000	6.5	1,621,000	4.6
P : Education	134,000	9.2	2,955,000	8.4
Q : Human Health And Social Work Activities	217,000	14.9	4,584,000	13.0
R : Arts, Entertainment And Recreation	43,000	3.0	955,000	2.7
S : Other Service Activities	34,000	2.3	864,000	2.5
T : Activities Of Households As Employers;...	1,000	0.1	62,000	0.2

Source: ONS workforce jobs by industry (SIC 2007) - seasonally adjusted
Notes: % is a proportion of is proportion of total workforce jobs

(N. Office for National Statistics, 2021)

In 2019, agriculture, forestry and fishery industries accounted for 1% of all industries in Wales, contributing around £660 million to the Welsh economy (Stats Wales, 2021d). Around 25,000 jobs in 2021 in Wales were in the Agriculture, Forestry and Fishing Sector, constituting 1.7% (Nomis Labour market, 2022) of Wales's workforce up 0.7% compared to 2019.

This is a material consideration for climate disadvantage as some industries will have workforces at higher risk of heat and or flooding, including for example, those working in agriculture, forestry and fishing, construction, emergency services, human health, and social work.

Over the course of 1999 to 2021 (Welsh Government, 2022b):

Table 11: Employment in Wales (Welsh Government, 2022b):

Employment in Wales	**Percentage increase between 1999 to 2021**
Number of Workforce jobs	15.3%
Self-employment	29.7% (equivalent to 12.9% of total workforce jobs)
Job sector	**Percentage increase from 2020 to 2021**
Administrative and support services	7.3%

Arts entertainment and recreation	17.2%
Accommodation and food service (hospitality)	15.7%

(Welsh Government, 2022b)

The number of employees in 2020 by industry sector is illustrated in Figure 6:

Figure 6:

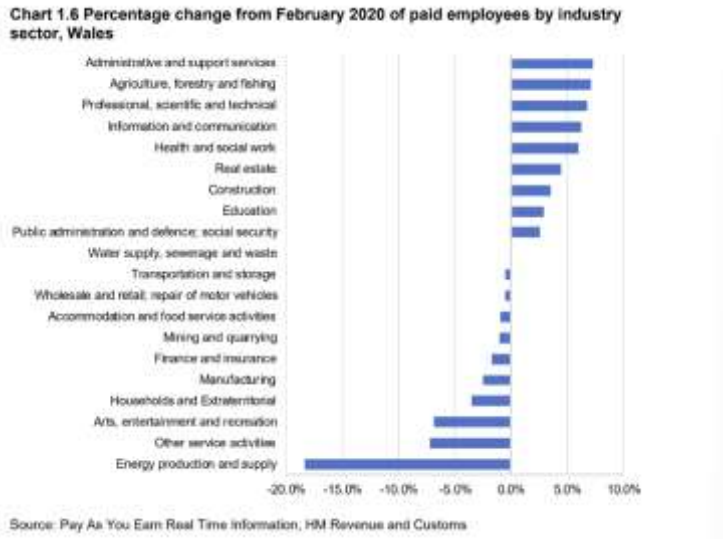


Figure 6: Percentage change of paid employees by industry sector in Wales from 2020 (Welsh Government, 2022b)

- The sector with the largest percentage decrease in employment over 2020-2021 was in the Energy production and supply sector, declining by 18.4%.

Half of workplace employment is situated in South East Wales. The region contains the greatest range of workplace employment levels, including the local authorities with both the highest and lowest number of available jobs (Welsh Government, 2020a):

Across Wales in 2020, over 50% of jobs fell within 2 broad sectors:

- Public administration; defense; education and health
- Wholesale; retail; transport; hotels and food.

9.8% of the total Welsh working age population were employed in the public sector as of 2020 (Welsh Government, 2022b). Real estate activities represent the smallest sector in Wales.

According to the WIMD report of (2019b):

- 20.8% of people who are employment deprived are in the most deprived 10% of small areas for the employment domain.
- Just over half of those who are deprived are in the most deprived 29.6% of areas for the employment domain.

Employment in Wales in early 2022 (Welsh Government, 2022b):

Table 12: Rate of employment and unemployment in Wales as of 2021 (Welsh Government, 2022b):

Rate of:	**Percentage in Wales**	**Percentage change in 2021**
Employment	74.5%	2% increase
Unemployment	3.1%	1.4% decrease

(Welsh Government, 2022b)

- The employment rate in early 2022 was the largest annual increase since December to February 2019.
- Unemployment was at its lowest rate since April to June 2020 and was the largest annual decrease since July to September 2016.

Between October to December 2021 (Welsh Government, 2022b):

- 47,000 people in Wales were unemployed.
- 22,200 unemployed men and 24,700 unemployed females

In 2021 the Annual Population Survey estimated 21,600 people were in long-term unemployment (for a period of 12 months +) in Wales.

- Unemployment within the age group 16-24 was higher in Wales than the rest of the UK from 2017 to 2020.
- 438,000 people in the final quarter of 2021 in Wales were economically inactive, 23.1% of those aged 16-64.

The reason this is important for climate disadvantage is that those in unemployment will be more vulnerable and exposed hazards related to climate change. Due to unemployment, it is likely they will have a reduced capacity (financial capacity) to cope and recover post disaster event rendering them more vulnerable to the impacts of flooding and heatwaves.

3.2.6 **Economic conditions: Income**

Gross Value Added (GVA) per head in Wales was £20,738 in 2018 an increase of 2.9% from 2017 (Welsh Government, 2020a). For the UK in 2017, GVA per head was £27,430 (Office for National Statistics, 2018).

Gross Disposable Household Income (GDHI) the estimate of the amount of money that households have available for spending or saving in Wales was £15,754 in 2018.

- ONS estimate that in 2019, 22.6% of employees in Wales were earning below the national living wage (Welsh Government, 2020a).

In Wales there were high pockets of income deprivation in the South Wales Valleys and large cities and in some areas of North Wales's coastal towns (2019b). All local authorities baring Monmouthshire had at least some areas with over 30% of residents living in income deprivation.

The reason this is important for climate disadvantage is that those living in income deprivation will have a reduced capacity to prepare, respond and recover from adverse impacts from hazards related to climate change. Those with low incomes or less GDHI to spare will be more vulnerable/exposed as they will be less able to afford to cope with climate change and rebuild after a disaster event.

3.2.7 Economic conditions: Not in full-time education, employment or training

Young people (Welsh Government, 2022c):

Table 13: percentage of those aged 16-18 and 19-24 Not in full-time Education, Employment or Training (NEET) in 2022 (Welsh Government, 2022c)[5]:

Age group (years old)	Year	Percentage Not in full time Education, Employment or Training (NEET)
16-18	2019	11.7
	2020	11.1
19-24	2019	16.1
	2020	15.2

(Welsh Government, 2022c)[6]

- After the beginning of the 2008 recession the proportion of those aged 19-24 in Wales who were not in full time education, employment, or training saw a large increase, which then decreased annually up to 2017.

3.2.8 Education: Literacy levels

Literacy levels[7] (National Literacy Trust,2010) across the UK vary and each nation has a different definition of basic literacy skills, therefore it is not possible to compare the countries. The latest available statistics for adult literacy levels are from 2010 for Wales (National Literacy Trust, 2010):

[5] Estimates for those not in full time education, employment, or training (NEET) vary depending on the method used for calculation. For further information refer to source data from Welsh Government (2022c).

[6] Estimates for those not in full time education, employment, or training (NEET) vary depending on the method used for calculation. For further information refer to source data from Welsh Government (2022c).

[7] Those with poor or lack of, literacy skills can usually understand short straightforward texts on familiar topics accurately and independently, and obtain information from everyday sources, but reading information from unfamiliar sources, or on unfamiliar topics, could cause problems. This is also known as being functionally illiterate. (National Literacy Trust, 2010).

Table 14: Measure of literacy levels across the UK (National Literacy Trust, 2010):

Region	Literacy skills
Wales	12% (1 in 8) adults lack basic literacy skills
England	16.4% (1 in 6) adults have very poor literacy skills
Scotland	26.7% (1 in 4) adults experience challenges due to lack of literacy skills
Northern Ireland	17.9% (1 in 5) adults have very poor literacy skills

(National Literacy Trust, 2010)

- Households' income was closely related to assessment levels for both literacy and numeracy in the 2010 survey in Wales (National Literacy Trust, 2010).
- Respondents assessed at level 2 or above for literacy had an average household income of almost twice that assessed at Entry Level or below (£31,791 for those at Level 2 or above, £16,383 for those at Entry Level) (National Literacy Trust, 2010).

In terms of digital inclusion and exclusion, those with Entry Level literacy were much less likely to have access to the internet or use of a computer than the whole sample of respondents (National Literacy Trust, 2010):

Table 15: Literacy levels and its relation to internet and computer access (National Literacy Trust, 2010):

Literacy Level	Percentage who had access to the internet	Percentage who had use of a computer
Entry Level	68	61
Level 2 or above	94	94

(National Literacy Trust, 2010)

- Levels of basic skills need are greatest amongst those with no qualifications (17% of sample)
- From the results, individuals appear to develop their skills after leaving school and entering the world of work (National Literacy Trust, 2010).

The reason this is a material consideration for climate disadvantage is that, those with low literacy levels, computer knowledge and access may be less aware of climate change and its potential impacts. Those with low/no access to computers or internet knowledge are likely to be less able to access relevant information and alerts to hazards related to climate change, rendering them more exposed and vulnerable to climate incidents of flooding and heatwaves.

3.2.9 **Education: Education and qualifications**

In Wales the percentage of adults with qualifications at the different levels of the national qualifications in 2020 were (Welsh Government, 2021f):

Table 16: The percentage of working age adults with no qualifications in Wales (Welsh Government, 2021f):

Year	Percentage of working age adults (18-64) with no qualifications
2019	8.2
2020	7.3

(Welsh Government, 2021f).

In 2020:

Table 17: Percentage of working age adults and their level of qualification in Wales (Welsh Government, 2021f):

Qualified to:	Percentage of working age adults (18-64) in:	
	2019	2020
At least level 2	79.1	80.9
To level 3 threshold	59.4	62.3
Higher education or equivalent level qualifications (NQF level 4 or above)	38.8	41.4

(Welsh Government, 2021f)

- The proportion of adults with qualifications in Wales decreases as age increases.
- There were higher proportions of men than women with no qualifications in all age groups except for those aged 60 to 64.
- 7.8% of men held no qualifications compared to 6.7% of women in Wales
- Women in Wales were more likely to hold qualifications at or above Level 4.

The reason this is important for climate disadvantage is that those with less school leavers qualifications are likely to be less aware or concerned about the impacts of climate change. This is a concern for climate disadvantage as the trend in Wales indicates those with less qualifications fall within older age groups, whom are already more vulnerable and at risk to climate hazards such as heat stress and are less likely to be able to cope/recover from disaster events.

3.2.10 **Education: Digital skills**

In Wales during 2019-2020 (Welsh Government, 2019c):

- 90% of people used the internet
- 76% if people used the internet several times or more a day
- 73% of internet users demonstrated digital skills in the previous three months

There are 5 key skills listed in the digital inclusion framework (Welsh Government, 2019c):

Table 18: Percentage of those who demonstrated 5 digital skills in Wales in 2019 (Welsh Government, 2019c):

Education	Percentage who demonstrated all 5 digital skills
Qualifications at degree level or above	81
No qualifications	49

Satisfaction with life	Percentage who demonstrated all 5 digital skills
Very high	72
low	56

(Welsh Government, 2019c)

The likelihood of demonstrating all 5 digital skills decreases with age (Welsh Government, 2019c).

- During the COVID-19 pandemic more people used the internet several times a day.
- Similar patterns were observed for all age groups, sex and tenure types.

The reason this is important for climate disadvantage is that those with less digital skills are more likely to be vulnerable to climate change impacts due to reduced ability to access information regarding climate hazard events such as early warnings and key safety information.

3.2.11 **Social and community influences: People who volunteer**

In Wales the percentage of respondents to the NSW survey who reported being a volunteer was (Welsh Government, 2020d):

Table 19: Percentage of Volunteers in Wales (Welsh Government, 2020d):

Year	Percentage of Volunteers
2016-17	28%
2019-20	26%

(Welsh Government, 2020d).

The NSW survey found that a range of groups were linked to those who volunteered in 2019-20; people aged between 65-74; having good educational qualifications; being in good general health; living in owner-occupied accommodation; speaking Welsh daily (Welsh Government, 2020d).

- People who volunteered prior to COVID-19 were more likely to help during the pandemic than those who had previously not volunteered.
- 30% of those aged 65-74 volunteered compared to 27% of those aged 16 to 24 in 2019-2020.
- The likelihood of a person volunteering increased with the level of educational qualification achieved.
- 29% of owner-occupiers were volunteers compared to 15% of those living in social housing.
- People who are regular Welsh speakers volunteer more (37%) than those who are not (25%).
- 28% of those reported being in good health volunteered compared to 15% of those reported being in bad health. NSW (2020d) reported this to be a complex relationship, in that poor health may create a barrier to becoming a volunteer, whilst volunteering itself may provide health benefits.

Volunteering and COVID-19 (Welsh Government, 2020d):

- In June 2020, 10% of people stated they had volunteered to assist in the pandemic in the past 4 weeks. This fell to 5% in September 2020, with ¾ of those who had

volunteered stating they expected to carry on volunteering for at least 6 months or as long as necessary.

The reason this is important for climate disadvantage is that those who do not volunteer are less likely to have a strong network to support them in the event of a disaster related to a climate hazard such as flooding or support during heatwaves. This will reduce a person's/community's ability to recover post event, if a strong social or volunteer (support) network is lacking.

3.2.12 Social and community influences: Community cohesion

The Well-being of Wales report (Welsh Government, 2021c) found that:

Table 20: Proportion of adults surveyed in 2020-21 (Welsh Government, 2021c):

Community Cohesion	**Proportion of adults (16+) who agree:**
All three measures of community cohesion	Two thirds
All three statements about their local area (national indicators)	70%
Agree with at least 1 statement	95%
Satisfaction with local area	**Proportion of adults (16+):**
Satisfied with their local area and ability to get to or access facilities and services	87%

(Welsh Government, 2021c)

In 2018-2019 less than 60% of people in Wales stated that municipal services such as:

- Community centres, secondary schools, libraries, youth, or sports clubs were available in their local area.

80% stated public transport links, shops and pubs were all within a 15-to-20 minute walk from their home (Welsh Government, 2021c).

19% of adults surveyed in Wales agree that they felt they were able to influence decisions affecting their local area (Welsh Government, 2020e). This sense was stronger in a range of groups including people aged 16-24 years old; in people who felt their area had a strong sense of community; people satisfied with availability of local services.

3.2.13 Social and community influences: Social loneliness

In 2019-2020 there were stronger feelings of loneliness in a range of groups including; people aged under 65 years old; people who were in bad general health or had a mental illness; those in material deprivation (Welsh Government, 2020f).

Table 21: Percentage of NSW survey respondents reporting feelings of Loneliness as of 2020 (Welsh Government, 2020f):

Reported feeling:	**Percentage of adults (16+) in Wales:**
Sometimes lonely	51%
Lonely	33%

(Welsh Government, 2020f).

Being within the younger age group showed a strong link with feelings of loneliness. 9% of those 65 and over report being lonely, compared to 19% of those aged 16-44 and 15% aged 45-64, as illustrated in Figure 7 (Welsh Government, 2020f).

Figure 7:

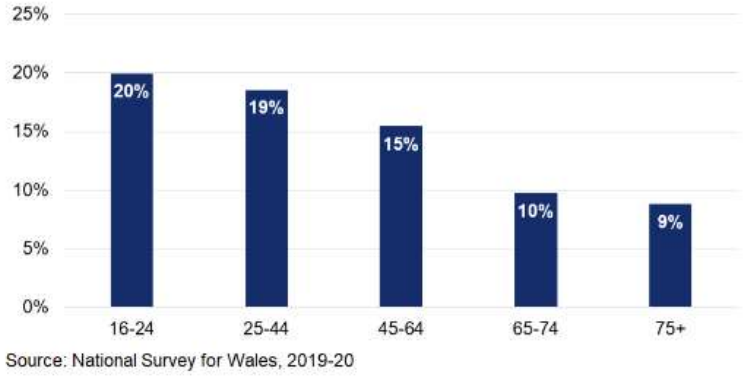


Figure 7: Reported loneliness by age in Wales from 2019-2020(Welsh Government, 2020f).

People who considered themselves to be of bad general health were more likely to express being lonely in comparison to those in good health (Welsh Government, 2020f):

Table 22: The relationship between general health and loneliness (Welsh Government, 2020f):

Health status	Percentage who felt lonely
Good or Very Good Health	11
Fair Health	24
Bad or Very Bad Health	35

(Welsh Government, 2020f).

52% of National Survey respondents in Wales agree there was a sense of community with their local area (Welsh Government, 2020g). The following factors were found by the NSW survey to be linked with community cohesion:

- Being older
- Having high mental well-being
- Feeling safe in different locations (i.e., walking in the area after dark)
- Being satisfied with the local area as a place to live
- Having a good understanding of the role of the local councillor and what they do for the local community
- Feeling able to influence decisions affecting the local area
- Feeling satisfied with the availability of local services and facilities.

The reason this is important for climate disadvantage is that community resilience can have a preventative effect, as it helps communities to cope with current situations and prepares people for future climate related disasters (Cianconi et al., 2020; Davies et al., 2019).

3.2.14 Living and environmental conditions: Housing conditions

The purpose of the housing domain is to identify inadequate housing in terms of physical and living conditions and availability (Welsh Government, 2019b). Living conditions are the suitability of the housing for its inhabitants in terms of health and safety and necessary adaptations (Welsh Government, 2019b).

Table 23: Tenure type by percentage of dwellings in Wales (Welsh Government, 2019d):

Tenure	Percentage of dwellings
Owner-Occupied	69%
Social Housing	18%
Private rented	13%

(Welsh Government, 2019d)

- Total number of dwellings in Wales has increased 5% and is estimated to be at 1.43 million as of 2019 (Welsh Government, 2020a).
- Owner occupied dwellings continue to represent the majority of the housing stock in Wales at 70% in 2019.(Welsh Government, 2020a).
- Private rental in Wales is becoming more common, 15% of all dwellings were privately rented in 2019 (Welsh Government, 2020a).

Housing conditions information, 36% of homes in Wales have a construction date that pre-dates that of 1945:

Table 24: Construction dates of dwellings in Wales (Welsh Government, 2019d)

Construction date	Percentage of dwellings
Pre 1919	26%
1919-1944	10%
1945-1964	16%
1965-1980	23%
1981-1990	7%
1991-2002	9%
Post 2002	9%

(Welsh Government, 2019d)

- 7% of homes in Wales reported having damp or condensation problems in one or more rooms.
- Wales has the oldest housing stock in the UK with 26% predating construction of 1919 (Woodfine et al., 2021a).

Out of the 26 elements assessed by the Welsh Housing Conditions Survey (Welsh Government, 2019e) in 2017-18, a higher proportion of social housing met the requirements for individual elements than other tenures.

- For 19 out 26 elements, more than 90% of social housing met the requirements
- For some elements, a high proportion of the Welsh housing stock were meeting all the requirements, such as being structurally stable and free from disrepair, free from damp, kitchens, and bathrooms in good conditions.
- Private rented housing was least likely to meet the requirements in relation to adequate space for storage or appliances, or to have adequate facilities for washing, drying or airing clothes.
- Owner-occupied housing was most likely to meet the standard for sufficient space for everyday living, with only around 53% to 56% of private rented and Registered Social Landlord dwellings meeting the requirements, compared to 68% of owner-occupied dwellings.

- Private rented sector had the lowest percentage of dwellings achieving the overall proxy measure for the Welsh Housing Quality Standard (WHQS) at 13%, this was 14% for owner-occupied dwellings.
- In Wales during 2017-18, overall, the percentage of all dwellings meeting the proxy measure for WHQS had improved from 14% to 17%.

In Wales the main types of heating fuels are as follows:

Table 25: Main types of heating fuel in Wales as of 2019 (Welsh Government, 2019d):

Main heating fuel	Percentage
Gas	82
Oil	10
Solid	2
Electricity	5
Other	1

(Welsh Government, 2019d)

- Some Welsh homes have become more energy efficient over the last decade with social housing having the highest percentage of dwellings in EPC bands C or above (Welsh Government, 2019e).
- Flats are generally more energy efficient than houses in Wales.
- Dwellings in rural areas tend to be less efficient than those of urban areas.
- 7% of dwellings used at least one type of renewable energy in 2017-18.
- 65% of dwellings in Wales are constructed of cavity masonry and 26% are constructed of solid masonry.
- 82% of households use gas to heat their homes.
- 66% of boilers in Wales, are condensing-combi boilers.

Over the course of 2019 to 2024, it has been identified that an additional estimated 6,200-8,300 new homes will be required in Wales.

Currently in Wales those in overcrowded housing stock are as follows (Woodfine et al., 2021b):

- 6% of social renters
- 5% of private renters

The reason this is important for climate disadvantage is that housing can have a significant impact on health and wellbeing. Those in residing in older and overcrowded housing stock in Wales are therefore more at risk of heat stress due to heatwaves. A recent study by Public Health Wales 'No place like home? HIA' (Woodfine et al., 2021a) has recently examined this more closely. Factors that may be affected by climate change now or in future, can be exacerbated or reduced by the standard of housing. This is not only regarding the quality of housing, but also to sufficient area of living space (reduced overcrowding) access to outdoor open and green space, which helps to moderate temperatures during heatwaves. Insulation of housing during winter can retain warmth but can also reduce overheating during warmer months. Some modern methods of construction can transmit heat to housing occupants quickly. Employing methods that aim to moderate temperatures through building design and fabric may help to mitigate the impacts of heatwaves. Housing tenure is also important for climate disadvantage as people in rented

accommodation including the private rented sector have less direct control over things like building fabric and heating sources.

3.2.15 **Living and environmental conditions: Homelessness**
2019-2020 almost 10,000 households in Wales were assessed as being a threat of homelessness, a decline of 7% compared to 2018-19. (Welsh Government, 2021c).

In October 2019, there were approximately 405 people estimated to be sleeping rough across Wales up by 17% on 2018.

Homelessness statistics for 2020-2021 in Wales (Welsh Government, 2021g):

- Number of households in Wales threatened with Homelessness (Section 66) decreased by 27% over 2020-21 to 7,290.
- 3795 households were identified as unintentionally homeless and in priority need (Section 75), an increase of 24% on 2019-2020 levels. 75% accepted off of settled suitable accommodation.

Households in temporary accommodation:

- Was up 60% on previous year to 3,729 households. This is the highest figure reported since the legislation was introduced in April 2015.
- Bed & Breakfasts accounted for the greatest proportion of temporary accommodation; 39%
- In Wales 53 households in every 10,000 were found to be eligible and threatened with homelessness in 2020-21. This is a decreased on 2019-2020 (73 in every 10,000).
- During 2020-21 the rate for Wales was 34.5 per 10,000 households. This is a decrease on the rate reported for 2019-20 (49 per 10,000).
- For Wales 95.5 cases per 10,000 households were assessed as homeless in 2020-21 an increase on the rate of 90.6 cases per 10,000 in 2019-20.
- During 2020-21 a total of 3,795 households were accepted as being eligible, unintentionally homeless and in priority need and were owed duty for accommodation. This is an increase of 24% on the 3,060 households recorded previously during 2019-20 ad is the highest number of cases reported since the start of the legislation in April 2015.

The reason this is important for climate disadvantage is that those experiencing homelessness have been identified by a recent Public Health Wales report ‘No place like home?’ to have been overlooked in disaster preparedness planning for climate change (Woodfine et al., 2021a). Those who are homeless are more at risk of experiencing or developing mental health problems and are at risk of disease and illness, and to be in poor health. Homeless people are vulnerable to climate impacts of heatwaves, poor air quality and flooding and have the least capacity to cope or recover from these events.

3.2.16 **Access and quality of services: WIMD access to services**
The purpose of the domain is to depict deprivation from a household’s relative ability or inability to access a range of services which are considered a necessity for day-to-day living (both physically and online) (Welsh Government, 2019b).

In Wales (Welsh Government, 2014):

- 88.4% of LSOA's classified as Less Sparse Others and 98% of those classified as Sparsest others in rural areas of Wales are situated in the most deprived 20% of areas in terms of access to services.
- In contrast to the overall index the LSOAs classified as Less Sparse Large Town are the classification with the lowest percentage of LSOAs in the most deprived 20 per cent for access to Services.
- This category has the highest percentage of LSOAs in the least deprived 20 per cent for the Access to Services domain. As well as there being more service points in towns and them being in closer reach for people living in towns, this result may also be a reflection of better public transport and road links (Welsh Government, 2014).

The reason this is important for climate disadvantage is that those with low access to and low-quality services such as health care provision, pharmacy's, public transport, and supermarkets will have a low capacity to cope with and recover from climate hazard impacts. Reduced access to services renders those in more deprived areas of Wales vulnerable to climate change.

3.2.17 **Access and quality of services: Number of residential care homes**
In March 2021 in Wales, there were a total of 1,329 residential services:

Table 26: Statistics on residential care facilities in Wales (Stats Wales, 2021e):

Adult and children service	**Number of places**	**Total settings**
Residential services	28,384	1329
Care home (adult and children's	154	21
Adult care home	25,466	1049
Boarding schools	1573	12
Children's care home	1002	237
Residential family Centre	39	2
Residential special schools	128	7
Secure accommodation	22	1

(Stats Wales, 2021e)

- In Wales, there was a total of 1,049 adult care homes and 237 children's care homes.

As of March 2021, the local authorities with the greatest number of residential care facilities were as follows:

Table 27: residential care facilities in Wales by Local authority (Stats Wales, 2021f):

Local authority	**Total number of settings**	**Number of places**
Carmarthenshire	111	2,383
Swansea	96	2,115
Cardiff	94	2,321

(Stats Wales, 2021f)

The reason this is important for climate disadvantage is that those in care homes are amongst the most vulnerable groups at risk of heat stress and extreme temperatures due to climate change.

3.2.18 Access and quality of services: Access to digital infrastructure

Access to digital infrastructure varies across regions of Wales and between service providers. Access to digital infrastructure is important for both homes and businesses in Wales.

In 2019, Wales was broadly in line with the rest of the UK in terms of access to superfast broadband speed (30Mbit/s or higher). At 93% of premises (Homes and businesses) in Wales compared to 94% across the UK (Welsh Government, 2020a):

- Access to full fibre services in Welsh homes and businesses was 11% in 2019, 1% higher than the UK national level.
- 31% of Welsh homes and businesses were able to access ultrafast fixed broadband speed. An increase of 2% from 2018 to 2019. This, however, remains lower than the UK rate of 52%.
- 15,600 homes and businesses (1%) in Wales did not meet the Universal Service Obligation minimum in 2019. This means that they were unable to access a download speed of 10Mbit/s and an upload speed of 1Mbit/s. This lower than 2018 figures but still greater than the UK national level of 0.5%.
- Mobile coverage in Wales is improving, however coverage from all 4 network operators remains lower than the UK national average. Ofcom data indicates 72% of indoor premises in Wales had 4G coverage in 2019 compared to 69% in 2018. Th UK level is 80%.
- 5% of Wales's geographic area is not covered by any operator.
- 90% of indoor premises in Wales were covered by all 4 operators in 2019 for telephone call services.
- 2% of Wales's geographic area was not covered by any operator in 2019 for this service.

The reason this is important for climate disadvantage is that limited access to digital infrastructure such as the internet or broadband signal renders populations more vulnerable/ exposed to the risk of climate hazards. As reduced ability to access or receive information/ early warning signals via text message, news alerts or online, reduces awareness of these hazards to vulnerable groups.

3.3 Health behaviours

3.3.1 Social media

In terms of use, across the UK 91% of adults aged 16+ use the internet at home, work or elsewhere. This figure is 89% in Wales, leaving 11% of people 'digitally excluded' (Welsh Government, 2019c).

Regarding social media usage, across the UK Twitter is the most popular among younger people aged 15-24 and those aged 25-34 make up the largest group using Facebook (Statista, 2022).

Problematic social media usage is higher amongst girls than boys of secondary school age, this increases with age (Welsh Government, 2021c). Reported experiences of cyber-bullying are higher amongst girls than boys (Welsh Government, 2021c).

In Wales adults (16+) (Ofcom, 2020):

- 95% use a mobile phone
- 11% only use a smartphone to go online
- 66% watch on-demand or streamed content
- 70% have a social media profile
- 51% correctly identify advertising on Google
- 13% do not use the internet

This is a material consideration for climate disadvantage is that since most warnings for climate hazards are put across via social media and online news pages. Therefore, being unable to access or not being able to use the internet renders you less able to prepare and respond to climate risks.

3.3.2 **Adults meeting physical activity guidelines**

Over the course of 2018-2019 it was report in Wales:

Table 28: Type of active travel taken by adults in Wales (Welsh Government, 2020a):

Active travel	**Percentage of Adults (16+)**
Walked more than once a week	57%
Cycled at least once a week	6%

(Welsh Government, 2020a)

- 70% of those in urban areas of Wales walked more than 10 minutes as a means of transport at least once a month compared to 56% in rural areas.

The report found that those situated in urban areas of Wales were more likely to walk frequently than those in rural areas:

Table 29: Percentage of those walking daily in urban and rural parts of Wales (Welsh Government, 2020a):

Location	**Percentage walking daily**
Urban	28%
Rural	17%

(Welsh Government, 2020a)

- This may be attributed to residents within urban areas of Wales, having more destinations accessible to them within a walking distance i.e., local shops, supermarkets and chemists in comparison to those within rural areas.

National Survey for Wales indicated 45% of children primary school aged travelled to school either by walking or cycling compared to 33% at secondary school level.(Welsh Government, 2020a).

In 2021 in Wales (Welsh Government, 2021c):

- 51% if adults (16+) were reported to be meeting physical activity guidelines (Welsh Government, 2021c).
- Over a third of children aged 11-16 walked or cycled to school. Those were from more affluent families were more likely to walk or cycle.

Active travel is a key recommendation by Public Health Wales, within a report titled 'Creating healthier places and spaces for our present and future generations' (2018), stated that:

"Being physically active benefits individual and population health and reduces the risks of obesity and chronic conditions" (Toner et al., 2018, p. 8)

In 2015 in Wales inactivity cost the Welsh NHS approximately £35 million (Public Health Wales, 2017; Toner et al., 2018):

"It is estimated that living in an activity-friendly neighbourhood can provide between 32% and 59% of the 150 minutes of weekly physical activity that is recommended for adults to maintain good health" (Toner et al., 2018, p. 8)

The reason this is important for climate disadvantage is that those not meeting recommended physical activity guidelines are more likely to develop chronic conditions and obesity, health conditions that render populations more vulnerable to incidences of extreme heat experienced during heatwaves. Physical activity levels may also be impacted by a changing climate.

3.3.3 Healthy lifestyles

National Survey results for adult (16+) lifestyle behaviours 2020-21 in Wales were (Welsh Government, 2022d):

Table 30: Percentage of adults with unhealthy lifestyle behaviours in Wales (Welsh Government, 2022d):

Lifestyle behaviours	Percentage of adults (16+)
Smoking	14
Drinking over weekly guidelines amounts (average weekly alcohol consumption above 14 units)	17
Being active for at least 150 minutes (week prior to the survey)	51.4
Eating 5 portions of fruit or vegetables	31
Overweight or obese	61 (25% obese)
Following fewer than 2 out of 5 healthy lifestyle behaviours	7

(Welsh Government, 2022d)

The five Healthy Lifestyle behaviours measured for adults (16+) in Wales during the National Survey for Wales survey were (Welsh Government, 2022d):

- Not smoking
- Average weekly alcohol consumption 14 units or lower
- Eating at least 5 portions of fruit and veg the previous day
- Having a healthy body mass index

- Being physically active at least 150 minutes the previous week

The survey found no significant change in lifestyle behaviours from 2016-17 to 2019-20. The 2020-21 survey in light of the COVID-19 pandemic was adapted, therefore changes were made to the mode of the survey and some questions in comparison to previous years. It is not possible to compare the results of the data for 2020-21 with that of previous years (Welsh Government, 2021c).

Diet and food systems hold important mitigative benefits for climate change, a virtuous circle exists here in that what is good for health is also good for the planet.

The reason this is important for climate disadvantage is that those who record fewer healthy lifestyle behaviours are more at risk of being in poorer health, which leads them to become more vulnerable and exposed to climate hazards such as heat stress from heatwaves, which can negatively impact those living with respiratory and chronic conditions.

4 Climate change factors

4.1 Beliefs, behaviours, and attitudes towards climate change

4.1.1 Things done to help the environment

The National Survey in 2018-2019 found that in Wales 'things done to help the environment' were as follows (Welsh Government, 2019g):

Table 31: Responses to the question 'Things done to help the environment' from the National Survey for Wales 2019 (Welsh Government, 2019g):

'Things done to help the environment'	**Percentage of those surveyed**
Recycled	98
Gardened for wildlife	43
Reduced the amount of energy used at home	51
Cut down on the amount they travel by car	33

(Welsh Government, 2019g)

- In 2018-2019 there was an increase of those in Wales buying eco-friendly products.
- Buying energy efficient appliances was least common amongst those aged 16-24.
- More women said they gardened for wildlife.
- Households classed as being materially deprived were less likely (34%) to buy locally-produced food than those living in non-deprived households (45%) (Welsh Government, 2019g).
- 6% of those surveyed stated they had volunteered to help protect the environment, double that of 2016-17. Those most likely to have volunteered had the following characteristics; educated to degree level or above, an internet user or were in good or very good health (Welsh Government, 2019g).

The following factors were associated to buying energy efficient appliances in Wales:

- being an owner-occupier.

- being educated to degree level or above.
- living in household where all adults are working7.
- being an internet user; and
- having high or very high life satisfaction.

The reason this is important for climate disadvantage is that being less aware of the impacts climate change poses or of means to which to combat or help mitigate effects of climate change, will enhance vulnerability, and reduce capacities to cope with the effects of climate change and its related hazards.

4.1.2 **Awareness of climate change**

As of 2020-2021, 98% of those surveyed in Wales think that the world's climate is changing. An increase from 93% when surveyed in 2018-19 and 2016-17 (Welsh Government, 2021c).

In 2021, the majority (95%) thought this change was partly or mainly due to human activity (Welsh Government, 2021c). It is of note that there were no variations found within the results when looked at by age, sex, urban/rural location, or material deprivation when it came to level of concern surrounding climate change (Welsh Government, 2021h).

There was, however, a difference found between levels of educational qualification (Welsh Government, 2021h):

Table 32: Percentage of those who thought climate was changing by level of education (Welsh Government, 2021h):

Level of Education	Percentage who thought climate was changing
No qualifications	89
A level or higher qualifications	95

(Welsh Government, 2021h)

- 37% thought that there had been a decrease in the variety of species in Wales.

In 2021-2022 the National Survey found that 69% of those in Wales thought climate was changing.

During 2018-2019 (Welsh Government, 2019g):

- 73% of those surveyed would support government policies to make more use of green energy supplies. This varied amongst the age groups (Welsh Government, 2019g).
- 80% aged 16-44 would support this policy compared to 57% of those 65+.
- Over half of those surveyed would support policies for safer footpaths, more cycle routes and spending on public transport.

4.1.3 **Levels of concern**

Concern surrounding climate change in Wales as of 2021-2022 (Welsh Government, 2022a):

- 34% were very concerned
- 39% were fairly concerned
- 9% were not concerned

In Wales concern about climate change varied but not significantly between three age groups and 67% of respondents in Wales already think that climate change is having an impact (Welsh Government, 2022a).

The reason this is important for climate disadvantage is that reduced awareness/ concern surrounding climate change will reduce people's knowledge on how best to cope or adapt to climate change and will expose more to climate hazards.

4.2 Inequalities in environmental conditions

In terms of environmental inequalities, lower socio-economic groups, such as those living in the more deprived areas of Wales are exposed to a greater range and intensity of environmental burdens, including (Welsh Government, 2019b):

- Poor housing and air quality
- Higher rates of crime
- Lack of green spaces and places for children to play
- Greater risks to safety from traffic
- Exposure to negative effects of climate change.

The physical environment domain from the WIMD report is broken down int three sub-domains, which are weighted as follows:

- Air quality: 40%
- Flood risk: 40%
- Green space: 20%

Air quality is comprised of three indicators measuring the population weighted against average concentrations of key air pollutants.

Flood risk is based upon the proportion of Welsh households at risk of flooding from rivers, sea or surface flooding and is sourced from Natural Resources Wales dataset 'Flood Risk Assessment Wales's'(Welsh Government, 2019b).

Green space is comprised of two equally weighted indicators:

- Proximity to accessible natural green space; the number of households in an area that are within a 5-minute walk or 300m of natural green space.
- Ambient green space score: measuring the ambient greenness of the are using Normalized Difference Vegetation Index (NDVI) score within a 300m surrounding area of each residential dwelling.

Those living in the least deprived areas, over 70% of the Welsh population, experience none of the unfavourable environmental conditions listed compared to less than 30% of those living in the most deprived areas. Approximately 45% of those in Wales in the most deprived areas experience at least 2 of the unfavourable environmental conditions listed, compared to less than 5% of those in the least deprived areas.

Inclusion of risk of flooding from surface water has resulted in higher levels of deprivation due to flooding observed in certain local authorities, in particular that of Merthyr Tydfil and Rhondda Cynon Taf. Natural green space is considered to have a positive impact on people's well-being (Welsh Government, 2019b).

The reason this is important for climate disadvantage is, that within urban areas, reduced access to green/ open space renders communities more vulnerable to heat related impacts of climate change. This is due to urban areas having a higher capacity to retain heat due to the urban heat island effect.

4.3 Types of hazards

In Wales, 26 risks associated with climate change have increased within their urgency score since the previous Climate Change Risk Assessment was conduction according to the most recent report (Netherwood, 2021).

In summary the following risks that have a high future magnitude score and where more action is required (after considering existing adaptation measures) are as follows (Netherwood, 2021):

- Impacts on the natural environment, including terrestrial, freshwater, coastal and marine species, forests and agriculture.
- Increase in the range, quantities and consequences of pests, pathogens and invasive species negatively impacting Welsh ecosystems.
- More frequent flooding and coastal erosion causing damage to infrastructure services, including energy, transport, water and ICT.
- Increased severity of and frequency of flooding to homes, communities, and businesses.
- Impact on coastal businesses due to sea level rise, coastal flooding, and erosion
- Impact of extreme temperatures, high winds and lightning on transport networks.
- Impact of increasing high temperatures on people's health and well-being.
- Disruption to delivery of health and social care services due to frequency of extreme weather events.
- Impacts internationally may affect the UK such as; risks to food security/availability, safety and security, risks to international law and governance change that will affect the UK, international trade routes, public health and the multiplication of risks across systems and geographies.

4.3.1 Heatwaves

Heatwaves are climatic hazard which threaten health, well-being, and productivity. The most severe heatwave in the UK was that of the 2003 European heatwave. The 10-day period of extreme heat is thought to be the warmest for up to 500 years. The highest temperature ever recorded in the UK was during this period in Faversham in Kent at 38.5°C (House of Commons Environmental Audit Committee, 2018). This figure has been exceed by a record temperature of 38.7◦C being recorded at Cambridge Botanic Garden during the summer of 2019 (Press Office, 2019).

Heatwaves here are defined as a period of unusually hot weather (relative to usual weather for that area and normal temperatures for that season), that places a toll on human health and activities as well as agriculture. They are associated with increased excess mortality. In 2003, the European heatwave results in over 20,000 heat-related deaths across Europe; 2,193 in the UK. Excess mortality rate was 17% across England and Wales, and 40% in London. The average number of heat-related deaths in the UK is expected to more than triple to 7,000 a year by 2050 (House of Commons Environmental Audit Committee, 2018).

In Wales, this is projected to at least quadruple by 2080 as illustrated in Figure 8 (Graham et al., 2018):

Figure 8:

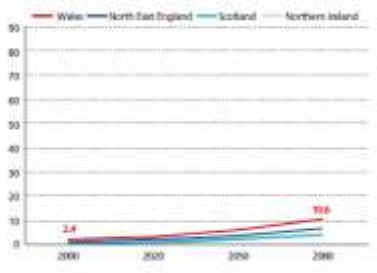


Figure 8: Heat related deaths, crude rate per 100,000, all persons, all ages, 2000-2080 (Graham et al., 2018)

Findings from the House of Commons Environmental Audit Committee (2018) found that:

- Heatwaves cause deaths related to respiratory and cardiovascular disease.
- Older population groups are, vulnerable and suffer increase fatalities from cardiac and respiratory disease during heatwaves. In 2003 excess mortality in those 75+ increased by 22%.
- Those with chronic illnesses such as diabetes, heart conditions or respiratory disease are at risk as well as those with disabilities, infants and living in urban areas and overheated buildings.
- High temperatures are associated with increased air pollution, high levels of ozone are formed rapidly in strong sunlight and there is an increased concentration of fine particles in hot, still air conditions. This poor quality can exacerbate pre-existing or underlying respiratory conditions.
- Heatwaves can impact mental health; higher rates of suicide have been observed in previous UK heatwaves.
- Social isolation is a factor, older people living alone, and homeless people are at increased risk.
- Women are more likely to die from heat-related illness, reasons for this are unclear.
- Children cannot control their body temperatures as efficiently as adults and are therefore at increased risk of ill health.
- Heatwaves can have negative effects on critical national infrastructure such as transport, digital systems, and water supply, leading to economic and public health consequences.
- The UKs water supply is expected to reduce by 4-7% and this will be exacerbated by increasing demand for water during heatwaves particularly in cities (House of Commons Environmental Audit Committee, 2018).

Average Land Temperatures in Wales over the past decade (2010-2019) have been 0.9◦C warmer than the period of mid-1970s to mid-2010s. There have been greater incidences of hot summer maximum temperatures, peaking at 31◦C during the 2019 heatwave (Netherwood, 2021).

UK model projections indicate (Netherwood, 2021):

- Heatwaves are expected to increase in their intensity and length, the heatwave season will increase in duration resulting potentially significant heat risks to health come spring and early summer.
- CCRA3 technical report suggests climate change is likely to increase heat-related mortality, heat stroke and heat exhaustion indoors.
- In Wales heat-related deaths could increase from a baseline of 2.4 per 100,000 persons per year to 6.5 per 100,000 by the 2050s, over doubling in risk.
- Current evidence suggests climate related risks to health and well-being from heat may be higher than previously understood.
- "2018 and 2019 heatwaves in parts of the UK revealed a lack of planning in current systems"(Netherwood, 2021, p. 80).

The UK Climate Risk Independent Assessment (CCRA3) Technical report (Kovats, and Brisley, 2021) in relation to heatwaves found that:

- High temperatures are increasingly affecting health and well-being but there has been little progress in addressing the increasing risks from overheating through buildings standards or incentives to retrofit.
- Higher rates of warming may lead to interruptions of household water supplies which would have health, social and economic impacts, particularly for vulnerable households.

Current risk in Wales:

> *"Hajat et al. (2014) estimated that in 2020 there would be around 3.5 heat-related deaths per 100,000 population (which with a population of 3.15 million equates to 110 heat-related deaths per year)" (Kovats, and Brisley, 2021, p. 23).*

Future risk in Wales:

> *"Hajat et al. (2014) estimate that heat related deaths will increase to around 100-450 per year by 2050 and 170-510 per year by the 2080s in the scenario of 4°C global warming by 2100, assuming no population growth".* (Kovats, and Brisley, 2021, p. 27)

The reason this is important for climate disadvantage is that heat stress associated with incidences of prolonged extreme heat (heatwaves) will impact the most vulnerable groups, such as the elderly, women and children, those in poor health, living with respiratory and chronic conditions and those living in overcrowded and poor housing in urban environments with a lack of access to green open space.

4.3.2 **Flooding**

Public Health Wales defines flooding as an overflow of water that submerges land that is usually dry. There are 4 types of flooding that can affect Wales: Fluvial, Coastal, Groundwater and Surface Water flooding. Likelihood of flooding is expected to increase as climates change, with intensified and more frequent extreme weather events. Flooding like that of winter 2019 in Wales may become more common in occurrence.

The latest flood risk data for Wales for 2021 highlighted there were (Welsh Government, 2021c):

- 42,000 properties in Wales at high or medium risk of flooding from rivers.
- Over 60,000 properties are at high or medium risk of tidal (coastal) flooding.

- Figure above cover both residential and non-residential properties. Out of these 20,000 benefits from river flood defences and 9,600 from tidal defences.
- Approximately 54,000 properties in Wales are at high or medium risk of surface water flooding (caused from rainwater saturating ground and overflowing of drainage systems).
- NSW found almost ½ of people are concerned about flooding in their local area and 86% are concerned about flooding in other parts of Wales.
- Heightened concern about flooding may be attributed to extensive flooding witnessed in winter 2019-20 in Wales.
- Latest flood risk assessments show 245,000 Welsh properties are at risk of flooding from seas, rivers and surface water.

National Survey results for Wales indicate that 62% of the Welsh population are at least 'Very' or 'Fairly' concerned about flooding in other parts of Wales (Welsh Government, 2022a).

- In contrast levels of concern regarding flooding to respondents' own property or to their local area was relatively low at 18%.
- Responses indicated that the local authorities with the greatest level of concern about flood risk to their own properties were Denbighshire (23%) and Conwy (21%).

Levels of concern about flooding differed between urban and rural locations:

Table 33: Level of concern surrounding Flood risk in Wales (Welsh Government, 2022a):

Flood risk to:	Level of concern	
	Urban	**Rural**
local area	43%	49%
Property	11%	13%
Flooding in Wales	84%	82%

(Welsh Government, 2022a)

- Those in urban areas were less concerned about flooding to their own property and local area when compared to rural parts of Wales.

According to the UK Climate Change Risk Assessment (CCRA3) '*Summary for Wales*' (2021):

- Climate change will increase the number of properties at risk of flooding from all sources; flooding could occur in areas that have previously not been at risk.
- Across Wales an estimated 148,000 are living in areas of significant risk of flooding from rivers, the sea and surface water.
- 2,216 properties in Wales are at risk of coastal erosion if defences are not maintained in the next 100 years.
- Expected annual damages from flooding for residential properties in Wales is currently £94.5 million.
- Flooding cost around £71 million between November 2011 and March 2014 in Wales.
- Flood risk will be exacerbated and locked in unless building within the flood plain is avoided and priorities developed in flood risk areas incorporate appropriate resilience measures and sustainable drainage systems (Netherwood, 2021).

The UK Climate Risk Independent Assessment (CCRA3) Technical report (Kovats, and Brisley, 2021) found:

- Flood risk to people from rivers, surface water and coastal flooding remains a high magnitude for risk at current at future in the UK.
- The majority of the total present and future flood impacts are in England due to its larger population, however, economic impacts on a per capita basis are higher in Wales. Expected to be £316 EAD per person in Wales by 2080 under a 4◦C high population growth future (Sayers et al., 2020).
- The most socially vulnerable experience flood disadvantage in Wales (Sayers et al., 2020).

Current risk as of 2021 in Wales is:

- Across Wales over 245,000 properties are at risk of flooding according to Natural Resources Wales 'Flood Risk Assessment Report of 2019', at a return period of 1 in 1000 years.
- In February 2020 flooding across Wales affected 3,310 properties.
- An estimated £8.1 million worth of damage was caused to coastal defences in Wales during storms of 2013 and 2014 according to NRW (2014) cited in (Kovats, and Brisley, 2021, p. 54).

The reason this is important for climate disadvantage is that flooding will disproportionately affect areas of Wales, impacting vulnerable groups the hardest, as they will have a reduced capacity to cope and recover post-event.

4.3.3 Coastal communities and flooding

Development of a coastal community typology for Wales OCSI (Oxford Consultants for Social Inclusion (OCSI), 2016). There are 1,308 LSOA's situated in Welsh coastal areas.

Table 34: Typical locations for each typology depicted in the colour key for the Map shown (Oxford Consultants for Social Inclusion (OCSI), 2016, p. 12):

Typology category	Example locations
A1 Coastal retreats: Market towns	Areas in and around: Conwy, Pwllheli, St Asaph, Fishguard, Barmouth
A2 Coastal retreats: Rural tourism	Large concentrations in North West Wales (Gwynedd) including Harlech, Criccieth, Tal-y-bont, Nefyn, Abersoch. Approximately half are located in smaller settlements with populations less than 300 people.
A3 Coastal retreats: Rural chic	Predominantly rural areas with some concentrations in historical small towns including St Davids and some in small seaside villages Benllech, Trearddur. More than 90% located in smaller settlements with populations less than 1,500.
B1 Coastal challenges: Structural shifters	Areas in and around: Maesteg, Barry Port, Llanelli parts of Newport, Bridgend, Swansea, Flint, Barry
B2 Coastal challenges: Resorts and ports	Areas in and around: Holyhead, Milford Haven, Pembroke Dock, Rhyl, Caernarfon, Amlwch
B3 Coastal challenges: Striving communities	Social housing estates in larger towns and cities including Swansea, Cardiff, Newport and some presence in smaller towns including Neath, Port Talbot, Flint, Llanelli, Barry and Cwmavon
C Cosmopolitan coast	Areas in and around: Central Cardiff, parts of university towns: Bangor and Aberystwyth. Also present in parts of smaller seaside resorts Tenby, Llandudno, Porthcrawl
D1 Coastal fringe: Prosperous suburbia	Predominantly commuter towns close to larger towns for example Cowbridge, Pentyrch and Penarth (Cardiff), Murton (Swansea), Gresford (Wrexham)
D2 Coastal fringe: Working hard	Areas in and around: Broughton, Penyffordd, Rhoose, Pencoed parts of Buckley.

(Oxford Consultants for Social Inclusion (OCSI), 2016, p. 12)

Coastal challenges: striving communities (B3 category) are characteristically more likely to (Oxford Consultants for Social Inclusion (OCSI), 2016, p. 16):

- Receive unemployment benefits such as job seekers allowance
- Be receiving incapacity benefits and likely to have a limiting long-term illness
- Be living in social rented accommodation and less likely to be owner-occupiers
- To have no school leavers qualifications and are less likely to have higher level educational (degree) level qualifications
- Have children living in poverty and or in workless households
- Have households without access to a car

Overall employment rate is slightly higher in coastal areas than across Wales:

- More likely to be employed in part time roles in coastal areas.
- Highest part-time employment rates are found in typology B2, resorts and ports and B3, striving communities.

The UK Climate Risk Independent Assessment (CCRA3) Technical report '*Chapter 5: Health, Communities and the Built Environment*' (Kovats, and Brisley, 2021) found that:

- Sea level rise and coastal change are likely to threaten the viability of some communities.
- Some evidence of vulnerability of specific communities along the West coast of Wales is already available, however, there remains no long-term assessment of viability across the UK.

The reason this is important for climate disadvantage is, coastal areas of Wales and those communities situated along rivers will be more at risk of flooding due to climate change and enhanced frequency of extreme weather rainfall events. The impact of flooding will be disproportionately felt amongst communities who are more exposed. In addition, where decisions on coastal management are not to defend an existing settlement, the impact can be felt financially, with house prices in these areas falling and reduced insurance, meaning that these communities will have a reduced capacity to cope.

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