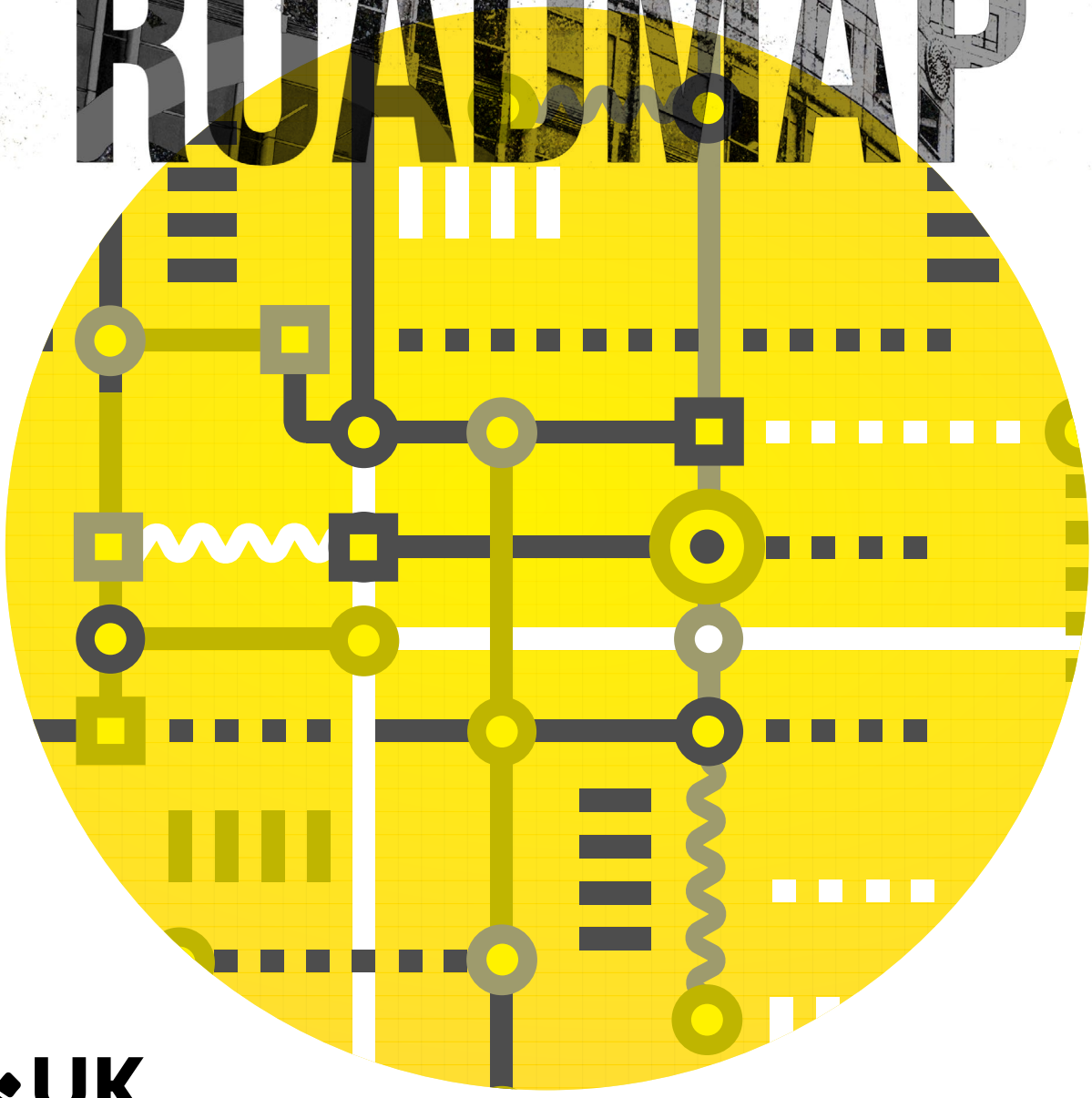
CLIMATE RESILIENCE ROADMAP



UK GBC

CONTENTS

Citation: The UK Climate Resilience Roadmap. UK Green Building Council, 2025, London, UK.

1 FOREWORDS

Climate change is placing unprecedented pressure on our communities, infrastructure, and buildings. As the impacts of global climate change intensify and become more frequent, the choices we make today will define the resilience of our built environment for decades to come.

There can be no meaningful society-wide resilience to climate hazards without a resilient built environment. Adapting to climate change and strengthening our resilience should be central to how the built environment sector redefines its value to society: by protecting people, homes, places of work, public spaces, and essential infrastructure.

We must move beyond reactive responses to the floods, storms, heatwaves, and other events that are the physical impacts of global climate change. Integrating climate resilience into every aspect of planning, designing, constructing, and operating buildings - from site selection and design choices to building maintenance and operation – is how we will make climate resilience and recovery from extreme events part of our standard practice rather than an afterthought.

Despite growing awareness, the built environment sector lacks clear goals, shared aims, and co-ordinated actions needed to deliver climate resilience at pace and scale. Responsibilities are often fragmented, expectations are unclear, and too few projects are designed or delivered with climate risks in mind.

The UK Climate Resilience Roadmap seeks to address this head on. It provides a framework for how built environment professionals can respond, outlining necessary interventions and policy shifts required to ensure the places where people live and work can withstand the impacts of extreme weather, rising temperatures, and shifting environmental conditions. I am extremely proud that Arup was able to play its part in supporting this publication; as this Climate Resilience Roadmap provides a shared vision to align organisations, professionals and policymakers behind clear goals and practical actions. The need for climate resilience is growing every more urgent and this roadmap offers a clear direction. Now is the moment for the built environment sector to deliver.

Jerome Frost OBE

CEO - Arup Group, UKGBC - Trustee

Our climate is changing, with storms and floods, oppressive heatwaves and wildfires becoming more frequent, intense and devastating. These changes are reshaping our environment and economy, and, without urgent action, these disruptions will become more severe, jeopardising livelihoods, long-term prosperity and lives.

For too long, and despite dire consequences, these warnings have gone unheard. Some 6.3 million properties in England are already at risk of flooding from rivers, the sea and surface water, rising to 8 million – or one-in-four properties in England - by 2050[1].

More than 3,000 heat-related excess deaths were recorded in the 2022 heatwave[2]. While awareness of the issue is growing, the response has been uneven. Some governments, businesses, and communities are rising to the challenge, recognising that climate resilience is not just about withstanding crises but about adapting, innovating, and thriving in a changing world.

The government announced £4.2 billion over the next three years for flood defences during the Comprehensive Spending Review and committed a further £7.9bn to flooding in its Infrastructure Strategy. While very welcome steps, the Infrastructure Strategy presents a massive opportunity to embed climate resilience and better preparedness across all government long-term investment decisions, creating long-term security and boosting resilience to communities, economy and growth.

The UK has a strong history of resilience and innovation, but we must now step-up our efforts if we are to adapt to an increasingly unpredictable climate. Rising temperatures, more intense storms and shifting rainfall patterns demand that we rethink how we plan, build, and protect our communities. We cannot effectively respond to a changing climate without transforming how we design, construct and maintain our cities and infrastructure. The challenge is considerable, but so are the opportunities: saving lives, ensuring the continued operation of essential infrastructure, investing in nature-based solutions, and creating a safer, more sustainable future.

The UK Climate Resilience Roadmap sets out a four-stage framework to prepare for these challenges. It provides a strategic approach for policymakers, organisations and individuals to act where it is needed most. By setting out clear goals and actionable recommendations, this Roadmap equips decision-makers with the tools to build resilience across the UK's built environment, ensuring communities and businesses can withstand climate shocks and adapt to new realities.

Achieving climate resilience will require unprecedented collaboration, and policymakers are key to understanding the issue and unlocking the mechanisms for change. The interdependent nature of this sector means no single organisation can address these risks alone. Implementing bold policy decisions and taking co-ordinated action will be essential. The cost of inaction will be far greater, measured not just in money, but in resources, lives and the long-term wellbeing of our communities. Investing in climate resilience today will pay dividends in the years to come, safeguarding our communities, the environment and our way of life.

Emma Howard-Boyd CBE

Former Environment Agency chair and lead on London's Climate Resilience Review

1 Environment Agency (EA), National assessment of flood and coastal erosion risk in England 2024

2 Office of National Statistics (ONS), Excess mortality during heat periods: 1 June to 31 August 2022

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EXECUTIVE SUMMARY

The UK's built environment is facing an urgent reality: climate hazards, including flooding, overheating, wildfires, drought, and storms, are no longer future threats but immediate dangers. Climate change is already causing deaths, injury, serious health impacts, and untold economic damage.

Over half of UK homes are already vulnerable to overheating, while millions of buildings are vulnerable to flooding, threatening lives, livelihoods, and economic stability. There is no climate resilience without a climate-resilient built environment. Without decisive action, these risks will only escalate, increasing damage, disruption, and inequality across the country.

The UK Climate Resilience Roadmap is more than a call to action. It provides a clear, evidence-backed strategy for adapting to climate hazards, ensuring that resilience is embedded into our national policies, into the strategies of each industry subsector, and into the design, planning, and operation of buildings. This is not just about protection—it's about transforming our built environment into a system that is adaptive, regenerative, and capable of thriving in a changing climate.

WHAT IS THE UK CLIMATE RESILIENCE ROADMAP?

Developed through deep collaboration with industry leaders, policymakers, and experts, the UK Climate Resilience Roadmap translates cutting-edge research, modelling, and real-industry insights into practical, scalable solutions. It serves as a framework for climate adaptation, equipping stakeholders across the built environment with the tools to manage risks and seize opportunities for long-term resilience. Recognising that adapting to climate hazards must go hand in hand with climate mitigation, the Roadmap emphasises integrated strategies that both reduce emissions and enhance climate resilience, building a sustainable and future-proofed built environment.

The Roadmap provides:

- A strategic vision that supports the needs of people and nature, fostering a climate-safe and resilient environment.
- A systemic approach to embedding climate adaptation across all industry subsectors, considering the connections between climate hazards and the vulnerabilities of physical assets, people and nature.
- A flexible and holistic four-stage process aligned with metrics and indicators that guide decision-making towards climate resilience, despite ongoing climate stresses, shocks and uncertainty.
- A set of national policy and industry aims, goals and recommendations strongly aligned to the key needs identified by each subsector.

By embedding climate resilience building into everyday decisions, and policies, the built environment can transition from reactive crisis management to proactive risk reduction and adaptation.

WHAT HAVE WE LEARNED?

The research underpinning the Roadmap has uncovered key insights into the current state of climate resilience in the UK's built environment:

- **The built environment should protect people from climate hazards, but it's not up to the task.** As climate hazards intensify, people, businesses and communities face growing risks from an unprepared sector.
- **The cost of inaction is real, is happening now and it is rising.** Without adaptation, climate-related damages will increase, leading to financial losses, disruptions, and widening inequalities. It's far cheaper to act now than to pay later.
- **There is no consistent industry-wide approach.** So far, the built environment industry has not had clear resilience metrics, making it difficult to measure risks, track adaptation progress, or integrate climate resilience into financial and regulatory frameworks.
- **Resilience is more than protection—it's an opportunity to create a healthier environment for all.** Strategically preparing for long-term resilience with a holistic, just and evidence-based approach—setting actions aligned with our vision for a climate-resilient built environment—can reduce risks, creating a safe environment for people, businesses, and nature to thrive. Prioritising preparation and early response allows us to protect lives and thrive during uncertain climate conditions.
- **We have the solutions, what's missing is a mindset shift.** The UK's built environment was designed for a climate that no longer exists. To protect people and businesses, we must scale up adaptation action with stronger policies and bold cross-sector collaboration.

KEY ROADMAP INSIGHTS & ACTIONS

A SYSTEMIC APPROACH:

Climate hazards are interconnected and boundaryless — resilience must span from individual buildings to urban systems, and from people to entire communities. A systemic perspective ensures long-term safety and relies on diverse industry roles and adaptive actions woven into every level. This approach is central to the Roadmap, particularly guided by our Vision for a Climate-Resilient Built Environment.

A FOUR-STEP PROCESS TO CLIMATE RESILIENCE:

The Roadmap offers a flexible, holistic four-stage cycle for embedding climate resilience into decision-making across organisations and project teams, regardless of their current level of knowledge or current action.

The four stages are:

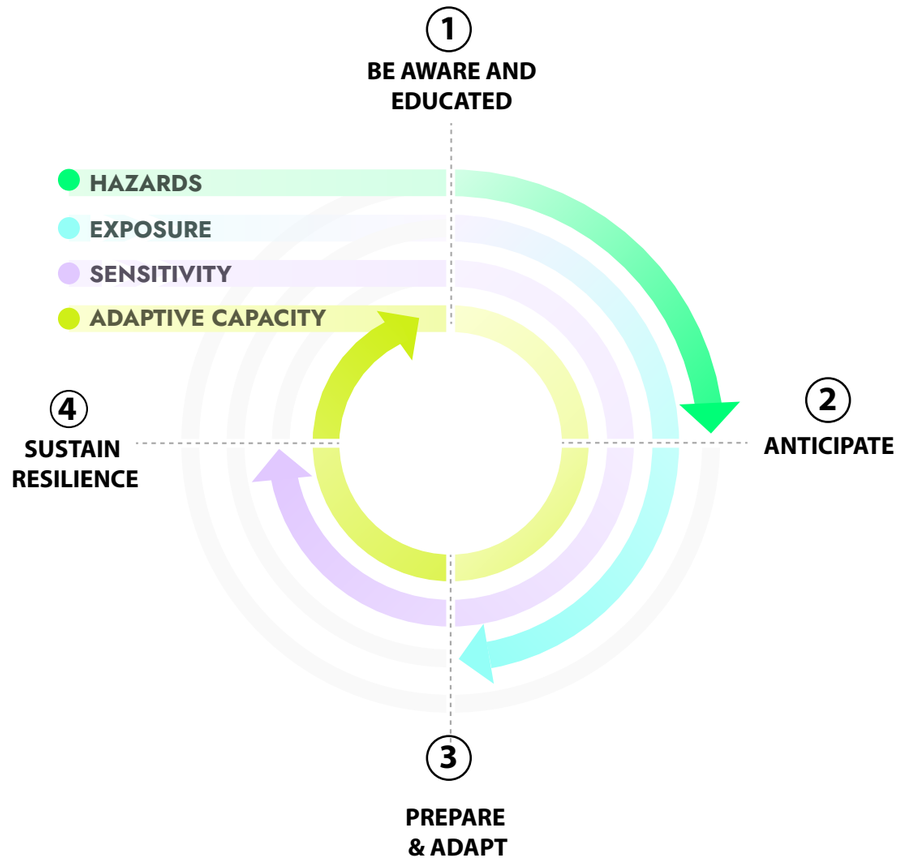
1. Be aware and educated

2. Anticipate

3. Prepare and adapt

4. Sustain resilience

Each stage contains aims, goals, and actions at both the industry and policy levels, ensuring decisions are guided by the best available information. By integrating these stages and following the vision for a climate-resilient built environment, every team and organisation can align their efforts and drive industry-wide progress. When followed, this process enables consistent, collaborative action towards resilience, fostering a unified movement across the sector.



POLICY RECOMMENDATIONS:

Bold, evidence-based recommendations drive action, helping stakeholders move from ambition to implementation.

Eight key policy recommendations are designed to help drive climate resilience up the political agenda. These recommendations are supported by enhanced detail in our policy report:

- **Put resilience at the heart of government by creating an Office for Resilience in the Cabinet Office and restoring the role of Minister for Resilience:** Due to the cross-cutting nature of resilience responses, the Office for Resilience should coordinate pan-departmental government work on instability caused by the climate and nature crisis, and other threats to lives and livelihoods. It should be represented by a Minister for Resilience who can advocate for it within government.
- **Prioritise climate resilience in spending decisions and mobilise private finance:** Climate hazards pose a threat to the UK's infrastructure and economic productivity. The Treasury should ensure that climate adaptation and resilience considerations are embedded into spending decisions and create an environment that encourages private sector investment.
- **Ensure all planning decisions deliver climate safety:** Update the English planning system with a new legal objective to deliver on the climate adaptation goals outlined in the Climate Change Act. This should be mirrored in the devolved administrations.
- **Ensure new buildings are fit for a more hazardous climate future:** Introduce a follow-on Future Homes and Buildings Standard (FHBS) by 2028 with new regulations to protect against increasing climate hazards, particularly overheating, flooding and water scarcity. This must be more ambitious than the current FHBS proposals.
- **Make existing homes and buildings climate safe:** Include climate resilience as part of a comprehensive national retrofit strategy, including government investment and regulation and incentives to mobilise private investment.
- **Protect all communities with trees, parks and ponds:** Update Local Plans so every area has targets and strategies to protect communities from flooding and overheating.
- **Require and empower local government to deliver on climate resilience policies:** Bolster current funding and capacity of local planning authorities to meet the statutory duty to embed climate resilience policies into their local plans; and to ensure delivery.
- **Create and incentivise a new generation of green professionals:** Create a strategy to deliver green jobs to include raising awareness of jobs in the sector, and ensuring good quality training is available.

INDUSTRY TOOLS AND RESOURCES:

Practical resources provide actionable processes and climate risk insights for the built environment. The resources included within the Roadmap are:

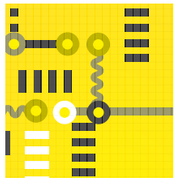
- An interactive GIS Vulnerability Web Map showcasing the built environment's vulnerability to climate hazards in five key areas across the UK
- Guides and checklists for asset owners and occupiers to integrate climate resilience into their organisational approaches
- Key actions and considerations for project teams, following the RIBA Plan of Work stages, to address the five key hazards considered within the Roadmap and support members with preparing the briefs for projects and helping them to identify what should be included in project documentation.
- A new, standardised set of resilience metrics that enables industry to assess risks, prioritise actions, and track adaptation progress.

WHY THIS MATTERS NOW

We cannot be complacent about the readiness of the UK's built environment to protect us from the changing climate. The choices made today will define the resilience of our cities, homes, and infrastructure tomorrow, and for decades to come. The UK Climate Resilience Roadmap offers the direction, evidence, and tools needed to drive this transformation—ensuring that climate resilience is not an afterthought, but a fundamental principle of how we design, build, and manage our spaces.

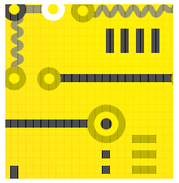
This is not just a report; it's a tool for bringing awareness and enabling action. The time to act is now.

KEY MESSAGES



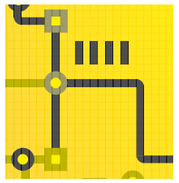
CLIMATE CHANGE IS ALREADY COSTING LIVES AND MORE WILL BE LOST WITHOUT URGENT ACTION.

Floods and heatwaves have already claimed thousands of lives across the UK. As the climate continues to change, health impacts will worsen. But we can save lives and improve public health by acting now to prepare our homes, communities and infrastructure for climate hazards.



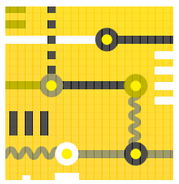
FIVE MAJOR HAZARDS THREATEN THE UK AND MUST BE TREATED AS A NATIONAL EMERGENCY.

Flooding, overheating, wildfires, drought and storms are intensifying. These risks are not abstract, they are real, growing, and already threatening the health and lives of millions of people and the reliability of critical infrastructure. Tackling them head-on must be a national priority.



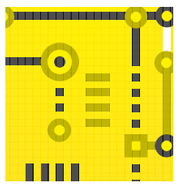
THESE HAZARDS ARE INTERCONNECTED, AND OUR RESPONSE MUST MATCH.

No single threat can be addressed in isolation. These risks compound and cascade, disrupting our economy, our health, and our communities. We must move from a reactive mindset to a proactive systems approach that treats climate resilience like the urgent and constant risk it is.



BUILDINGS ARE OUR FRONTLINE DEFENCE.

There is no climate resilience without a resilient built environment. Homes, workplaces, and public buildings must be understood as the first line of protection in a changing climate. Keeping people safe starts with how we design, build and adapt.



ACTING NOW IS THE ONLY RESPONSIBLE CHOICE.

Preparing in advance is not only safer, but also far cheaper than reacting later. Organisations and businesses must prepare now to ensure success or even survival in the decades to come. Delay will cost more in lives, money and disruption. Policymakers and the built environment sector must lead the way in embedding resilience across every project and policy.

KEY PRIORITIES

1 Embed the four stages of building climate resilience throughout the built environment lifecycle.

Climate resilience cannot be an afterthought, it must be integrated into every phase of design, construction, operation, and maintenance of our buildings. For policymakers, this means embedding climate resilience in all planning, regulations, and national policies, while design team members must make it a standard practice across their projects.

2 Adopt a systemic approach that connects people, nature and place.

The built environment does not exist in isolation, it is shaped by social, economic, and ecological systems. Climate resilience cannot be achieved through fragmented actions. Industry must move beyond short-term fixes and embrace a joined-up, long-term approach that integrates natural systems, places people at its heart, and aligns policy, design and construction. For government, this means centralising a pan-departmental approach to climate resilience oversight and delivery.

3 Prioritise vulnerable communities.

Climate hazards will hit the most vulnerable hardest, deepening existing inequalities. The entire built environment sector has a responsibility to protect those most at risk — whether through planning, investment, design, construction, or operation. This means ensuring that adaptation efforts are inclusive, equitable, and centred on the needs of the people and places that are often overlooked.

CALL TO ACTION

If we are to navigate and survive our present and future climate reality, we need to adapt now. This means a shift in mindset and urgent and genuine action.

The UK Climate Resilience Roadmap lays bare the built environment's exposure to extreme weather events and suggests ways to minimise impacts.

Demonstrating the risks from devastating climate hazards, it challenges us to prepare and adapt our built environment so that we can protect people, communities, assets, livelihoods and the natural environment.

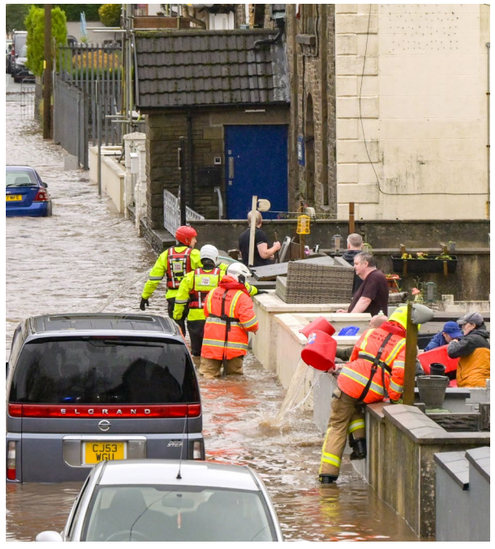
The sector is working hard to reduce greenhouse gas emissions and to lessen the severity and frequency of climatic impacts, but the resilience of the UK's built environment to climate change has not been adequately recognised, understood, or supported - by government or the sector itself.

That lack of readiness has already put people, buildings and nature in harm's way, but the roadmap presents an opportunity to change that. This is a moment to increase awareness of the issue, expand knowledge, and take bold, positive action that helps create a safe, comfortable, well-functioning built environment of the future.

The UK Climate Resilience Roadmap creates an opportunity to change mindsets and turn climate change into climate action. It invites us all to reconsider our relationship with nature and our climate, and for those in the built environment, this is an opportunity to reconsider how we plan, design, construct and operate buildings and infrastructure.

Acting on the recommendations in this roadmap will strengthen our ability to withstand and recover from extreme weather events. It will save lives, protect businesses, preserve our built structures and natural environments, and help secure a safe, sustainable and regenerative future.

We urgently need this mindset shift, now, and we need to act, now.



ABOUT THE ROADMAP

This report and its wider outputs are designed to directly address the urgent challenges to the UK's built environment from climate-related hazards.

The Roadmap aims to:

- Raise awareness of climate hazards and their impacts on built assets, people, and the natural environment.
- Promote understanding of the built environment's interconnectedness with natural and social systems. Outline a vision of climate resilience for the UK built environment sector.
- Provide aims, goals, actionable steps and recommendations for every stage of planning, designing, constructing, operating and managing built assets.
- Offer a clear structure for implementing climate adaptation within professional practice, and organisations.
- Equip policy-makers and professionals across the sector with the knowledge and tools they need to realise a climate-resilient future, and to empower them to act and to motivate others to do so.

There are four key outputs:

- **The UK Climate Resilience Roadmap Main Report** ("the Roadmap") – provides an overview of the Roadmap. It explains why urgent climate adaptation is essential for a healthy and safe built environment, sets out our vision for a climate-resilient built environment and provides key aims, goals, policies and actions to achieve this vision.
- **Technical Report** – provides the methodologies used for data collection, modelling to understand the UK built environment's vulnerability to key hazards, and other research undertaken to create the UK Climate Resilience Roadmap.
- **Policy Recommendations** – provides an overview of relevant findings and policy recommendations for the government (central, local, devolved administrations) to deliver a climate-resilient built environment.
- **GIS Vulnerability Web Map** – provides insights into key archetype locations in the UK and their current and future vulnerability to climate hazards.

SCOPE AND APPROACH

The UK Climate Resilience Roadmap's development recognises the critical importance of the ways in which the built environment interacts with the natural environment, as well as other key systems such as finance and policy. While the focus is on built assets, covering the design, delivery and asset management stages, the wider environmental and social context are also considered. Perspectives from the finance, investment and insurance sector are included, highlighting how adaptation finance and insurance can accelerate climate resilience efforts. The aim is to help industry professionals recognise the importance of these factors and drive greater engagement and action.

The knowledge, insights and tools that form the Roadmap have been co-created with a wide cross-section of the built environment sector.

A wide ranging Task Group, made up of policy-makers and subsector representatives and experts played a vital role in developing definitions, metrics and indicators, goals, actions, and policy recommendations.

A Steering Group representing industry organisations across various subsectors also provided strategic input throughout the process and acted as a review group for the Task Group's work.

Two separate public consultations were run on the draft proposals engaging with a wide range of stakeholders across and beyond the sector, and were supported by expert interviews.

- The first focused on initial outputs of the Roadmap including the vision, definitions, information on climate hazards and metrics and indicators.
- The second focused on the four stages of the Roadmap, including the aims, goals and high-level actions for policy-makers and stakeholders.

This collaborative approach ensures that the outputs of the Roadmap are grounded in the built environment sector's collective expertise, and aligned with and appropriate to its working practices, while increasing our ambition to the level urgently needed.

WHO IS THE UK CLIMATE RESILIENCE ROADMAP FOR?

The Roadmap is aimed primarily at the built environment sector. The key actors who can significantly accelerate climate resilience across the sector are:

- **Building owners/occupiers** including portfolio managers involved in the acquisition and management of existing assets.
- **Project team members** including developers, consultants, designers, architects, urban planners, and engineers.
- **Policy-makers**, including the government, the devolved administrations and local authorities.

In addition, the Roadmap aims to raise awareness among:

- Academic institutions
- NGOs / trade associations / professional institutions
- Investors (banks, funders, etc.)
- Facilities management teams
- Material and product manufacturers
- Infrastructure clients, owners and designers

NAVIGATING THIS REPORT

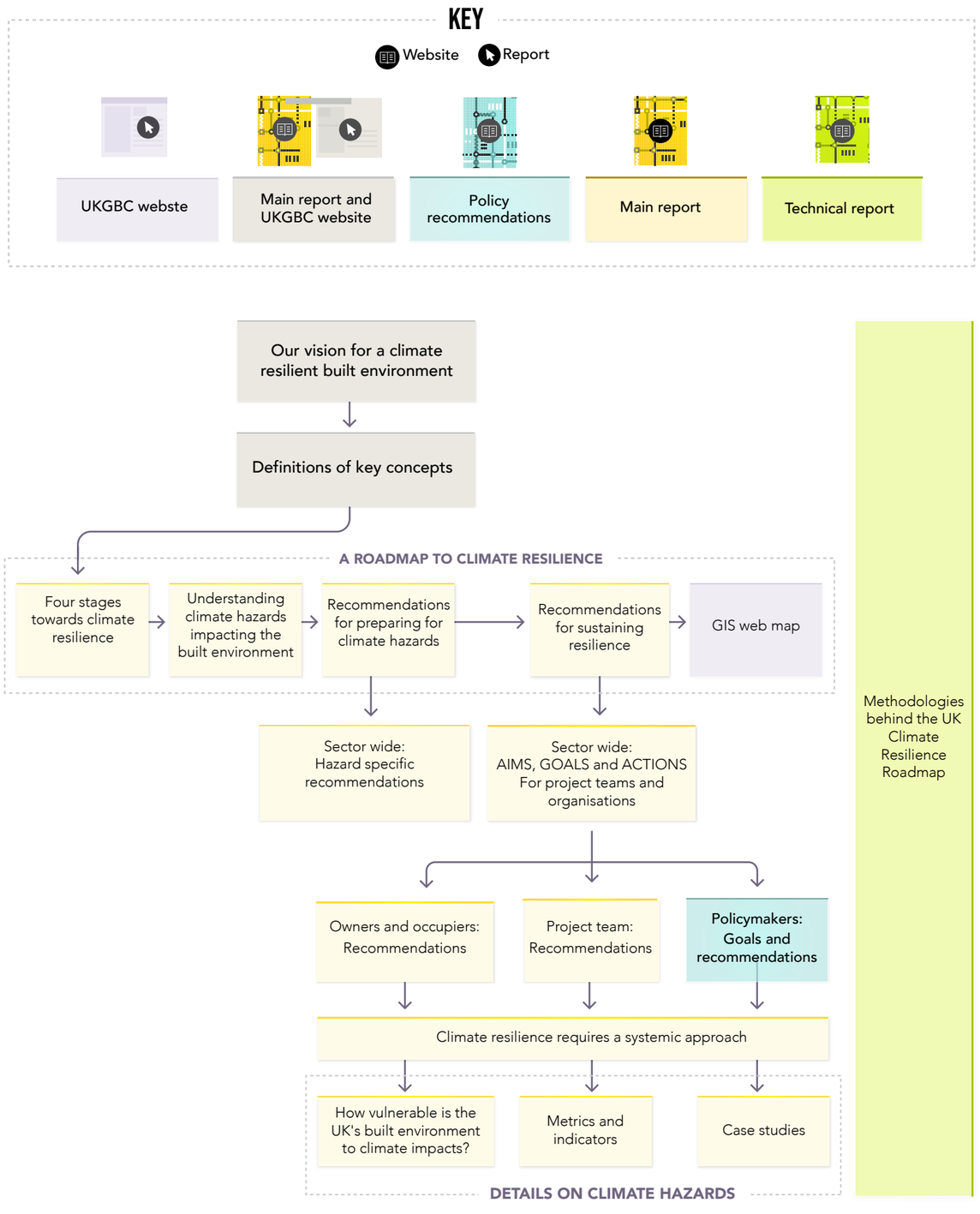
The first section of the Roadmap, **Climate Resilience for the UK built environment**, explains why action on climate resilience is critical, sets out key definitions, and explains our vision for a climate resilient built environment.

The main elements of the Roadmap are found within **A Roadmap to Climate Resilience**, which sets out a four-stage framework for building climate resilience. There is information on climate hazards and recommendations for preparing for climate hazards including key aims, goals, and high-level actions. There are also recommendations for sustaining resilience including recommendations for project teams, organisations and policy-makers.

The Appendices hold further detail on the climate hazards affecting the UK built environment and examples of metrics and indicators that can be used to track and measure progress. It also includes case study locations across the UK, for which specific vulnerabilities and responses to climate impacts are explored in more detail.

Recommendations for national government policy can be found within the separate Policy Recommendations document. Further supporting information, including the methodologies used and a full glossary, can be found in the Technical Report. The GIS Vulnerability Web Map illustrates the built environment's vulnerability to climate hazards in more detail.

Figure 1: A summary of how to use the UK Climate Resilience Roadmap, and where you will find key pieces of information.



3

CLIMATE RESILIENCE FOR THE UK BUILT ENVIRONMENT

ADAPTING TO THE INCREASING VULNERABILITY FROM CLIMATE HAZARDS

What is a Climate Resilient built environment?

Climate resilience refers to the ability of a system, community, or society exposed to climate hazards (such as extreme weather events, wildfires, and rising sea levels) to resist, absorb, accommodate and recover from these impacts. It is a proactive approach to managing climate risks which ensures that individuals, infrastructure and ecosystems can adapt and thrive in a changing climate.

Overheating and flooding are just two of the many hazards that the UK faces due to climate change. In the most recent UK-wide assessment, 34 out of 61 identified risks and opportunities received the highest urgency score [1]. All will impact the built environment, either directly or indirectly, due to the interconnections between housing, people, services, industries and the wider economy and more. They will also have a disproportionate impact on vulnerable groups, such as older people, people with disabilities and those who are economically disadvantaged.

The built environment encompasses buildings of all kinds, the managed landscapes between them, and civil infrastructure above and below ground[2]. It is what shelters us from the elements, delivers essential utilities, and it is the physical fabric of our society. It often mediates our interactions with the natural environment and both impacts and is impacted by ecosystems and natural processes.

The built environment is in a constant state of adaptation, in response to the needs and pressures of those more dynamic systems. The built environment is inevitably more static, and changes more slowly.

Our industry faces several adaptation challenges, driven by global, national and local forces. The Covid-19 pandemic highlighted the built environment's importance to our physical and mental-wellbeing and the ways it is currently failing. It also exacerbated the impacts of longer-term trends such as an ageing population and a crisis in affordable housing. Global conflicts and political upheaval at home and abroad have created market uncertainty, high inflation, and rising energy and materials prices. These all affect how we operate buildings and infrastructure, and our ability to deliver new projects.

Simultaneously, climate change requires a complete transformation of buildings and infrastructure to reach net zero emissions, as well as a coordinated, far-sighted approach to improve resilience to extreme weather events that will continue to increase in severity and frequency.

The UK Government has made reducing emissions to net zero by 2050 a legally binding goal[3] and it has recognised the crucial role that retrofitting buildings will play by reducing energy demand and switching to renewable sources. Equally urgent is the need to adapt the built environment to address the far-reaching impacts of these climate risks. Retrofitting is also an important consideration for adaptation, both to equip buildings to withstand flooding, heatwaves, storms and other climate hazards, and also to provide universal access to safe, healthy and resilient places.

What is a climate hazard?

A climate hazard is a natural or human-caused event that can impact people, damage built assets, disrupt services and affect businesses, supply chains and the environment. Examples include floods, heatwaves, rising sea levels and storms.

The case for change

In our current climate, over half (55%) of UK homes are at risk of overheating[4] and extreme heat events already pose a threat to vulnerable individuals.

During the summer of 2022, when the temperature in the UK exceeded 40°C for the first time, there were 3,271 heat-related deaths in England and Wales[5].

The latest estimate produced in 2021 for the UK-wide Climate Change Risk Assessment (CCRA) projected that annual heat-related mortality would more than triple by the 2050s, from 2000 to 7000 heat related deaths[6].

1.8 million people currently live in areas which face significant floodrisk[7].

Flooding has potentially devastating consequences for people and businesses, and flood damage costs the UK economy £1.3 billion annually[8].

The Joint Committee on the National Security Strategy predicts that one third of the English coast will be under flood pressure by 2050[9].

WHAT ARE THE BIGGEST RISKS TO THE UK BUILT ENVIRONMENT?

The Climate Change Act 2008 imposes a legal requirement on the UK government to ensure the country adapts to climate change and to publish a Climate Change Risk Assessment every five years. This sets out the risks and opportunities that climate change presents, in order to inform the National Adaptation Plans for England, Wales, Scotland and Northern Ireland.

The Climate Change Committee, an independent non-governmental body, produced its third assessment (CCRA3) in June 2021. The CCRA3 assessed 61 specific risks and opportunities in detail, assigning each an urgency rating based on extensive research and input from over 450 experts.

It identified eight priority areas, including the following risks that are highly relevant to the built environment:

- Risks to soil health from increased flooding and drought
- Risks to supply of food, goods and vital services due to climate-related collapse of supply chains and distribution networks
- Risks to human health, wellbeing and productivity from increased exposure to heat in homes and other buildings.

WHY LOCAL CONTEXT IS IMPORTANT FOR CLIMATE RESILIENCE

Understanding local context is central to climate resilience. The UK's diverse topography and geology has been formed over millions of years by geological activity, fluvial systems, glaciation, erosion and tectonic forces. These complex processes have resulted in distinct landscapes, which will respond differently to the hazards.

For example, upland regions in the north and west formed by igneous and sedimentary rocks are particularly susceptible to heavy rainfall and landslides[10]. Northern Ireland faces challenges related to karst landscapes, which are areas of soluble rock such as limestone that can include caves and underground drainage systems. Heavy rain can lead to impacts such as sinkholes and groundwater flooding[11]. Meanwhile, lowland areas in the south and east of England are formed primarily from younger, softer sedimentary rocks such as clay, chalk and sand, which are prone to flooding, subsidence and coastal erosion[12].

The UK has a temperate climate, that is also highly variable. This is largely due to mid-latitude westerly winds and the North Atlantic Current. Continental influences from mainland Europe and frequent changes in topography and land use over relatively short distances, as well as an extensive river system and long, fractal coastline, also contribute to this variability[13].

The factors playing a role in defining the intricacies of the local context highlights the importance of tailored climate resilience strategies, informed by regional geologies, people's and asset's vulnerabilities and their specific risks.

Figure 2: Map of the UK showing the 13 villages, towns and cities most vulnerable to climate Hazards.

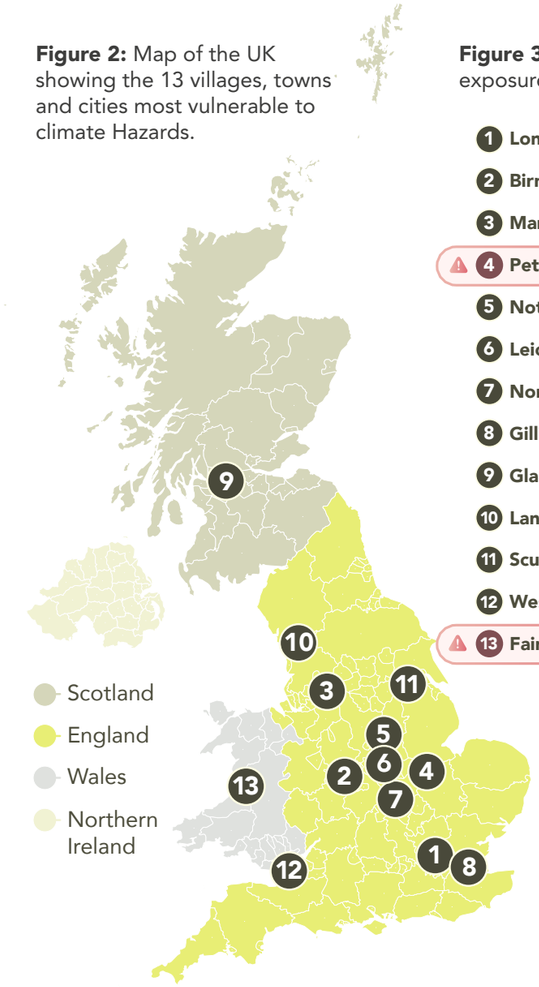


Figure 3: List of the UK's 13 most vulnerable places and their exposure to specific climate hazards.

1. **London,** Greater London
2. **Birmingham,** West Midlands
3. **Manchester,** Greater Manchester
4. ⚠ **Peterborough**, Cambridgeshire*
5. **Nottingham**, Nottinghamshire
6. **Leicester**, Leicestershire
7. **Northampton**, Northamptonshire
8. **Gillingham**, Kent
9. **Glasgow**, Glasgow City
10. **Lancaster**, Lancashire
11. **Scunthorpe**, Lincolnshire
12. **Weston-Super-Mare**, Somerset
13. ⚠ **Fairbourne**, Gwynedd*

STORMS · DROUGHT · WILDFIRES · OVERHEATING · FLOODING

⚠ **Projected likely uninhabitable by 2100 due to flooding.** [14 15]

VISUALISING A CLIMATE-RESILIENT BUILT ENVIRONMENT

A climate-resilient built environment is shaped through design, policies and management strategies that enhance preparedness, endurance and adaptability to climate-related impacts. These approaches help preserve and restore essential basic functions and structures while increasing awareness of hazards and capacity to adapt.

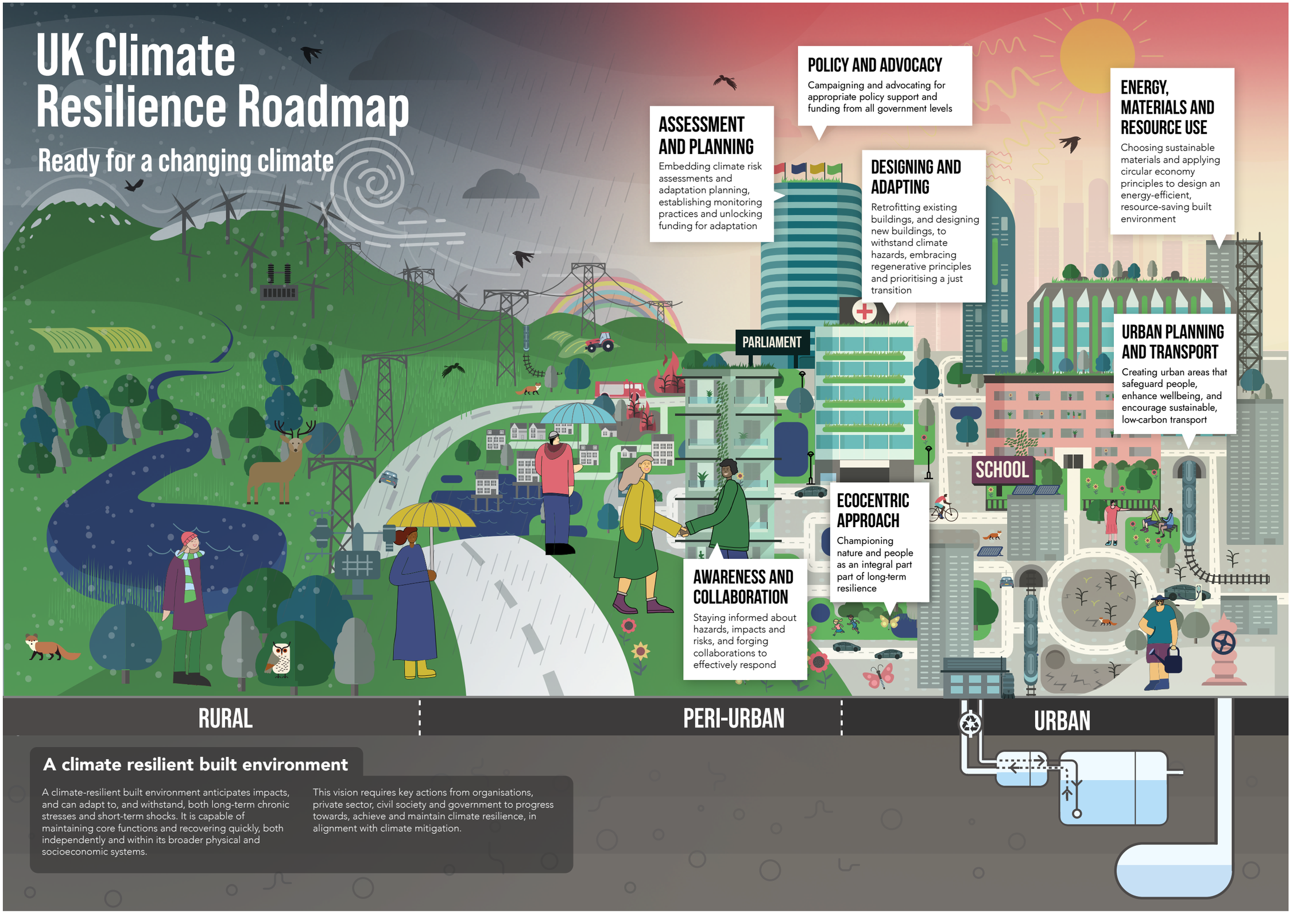
As part of the wider network of systems, a climate-resilient built environment is inter-connected with the diverse range of industries and landscapes. It extends beyond its immediate geographical boundary and sphere of influence, through shared aspirations and collaborative adaptation actions. This is guided by a systemic view and consistent principles.

CLIMATE-RESILIENT STAKEHOLDERS

Climate resilient built environment stakeholders are aware of climate-related hazards such as flooding, overheating, wildfires, storms and drought. They are prepared and have capacity to manage the challenges these hazards present, both chronic and acute, in the short and longer term. They also communicate and collaborate effectively, integrating solutions for mitigation and adaptation holistically throughout the built environment, today and over the long term. Climate-resilient decision-making groups are flexible, diverse, inclusive and equipped with the knowledge and skills to anticipate and respond to current and potential climate hazards.

Figure 4: A vision for a climate-resilient built environment.

Figure 4, created by the stakeholders involved in developing the UK Climate Resilience Roadmap, presents a vision defining what a climate resilient built environment could be, and how it could be achieved through a series of seven key principles for stakeholders.



UNDERSTANDING THE FINANCIAL PERSPECTIVE

Financial systems play a crucial role in shaping the built environment. These systems are inherently international, encompassing banking, private investments and supply chain dynamics. While our existing financial system can be a barrier to the long-term changes needed for climate resilience, it also holds the potential to drive positive transformation when leveraged effectively. Aligning financial incentives with long-term sustainability and regenerative goals can unlock significant funding for climate resilience and adaptation projects. This involves prioritising long-term value creation over short-term profits, encouraging investments in resilient infrastructure, and supporting organisations that prioritise sustainability. Mechanisms such as green finance, sustainable bonds and resilience-linked insurance premiums can help accelerate the transition to a climate-resilient built environment.

This section aims to raise awareness of the financial barriers to achieving climate resilience that exist within the current system. Later in the Roadmap, we offer examples and recommendations as a starting point towards developing a more regenerative system. While not exhaustive, UKGBC's work has identified key levers, which is essential when driving change in such a complex and interconnected system.

FINANCIAL BARRIERS TO ACHIEVING CLIMATE RESILIENCE

- **Short-term thinking:** While financial systems can still prioritise short-term profits, this does not align with the long-term nature of climate resilience and adaptation projects, or with the longer-term societal benefits that they bring. Complex contractual chains further reinforce quick returns over sustainable design.
- **Governance:** At the organisational level, one of the main challenges in scaling up climate resilience efforts is the role of governance structures in accessing and directing financial resources. Effective governance models are essential for unlocking critical funding for resilience and sustainability projects. However, many organisations still face barriers due to insufficient or ineffective governance, which can prevent them from tapping into available financial resources or strategically allocating them towards long-term climate adaptation goals.
- **Regulation:** There is an urgent need for stronger regulation and policy support to drive climate resilience in the built environment. Existing regulations do not adequately address climate resilience. This regulatory gap results in weak market signals, discouraging investment in long-term climate resilience. Without clear incentives or mandates, owners and developers are more likely to prioritise immediate financial returns.

DEFINITIONS OF KEY CONCEPTS

CLIMATE RESILIENCE

Non-specific

The ability of a system, community or society exposed to climate hazards to resist, absorb, accommodate and recover from the effects of a hazard. A climate-resilient system responds in a timely and efficient manner, including through the preservation and restoration of its essential basic structures and functions[16]

Built environment

The ability of buildings, infrastructure, natural ecosystems and society to first anticipate and prepare, then endure, adapt and recover from extreme weather events as well as long-term climate changes. A climate-resilient built environment is one in which essential basic functions and structures are maintained and restored to continue to provide a comfortable and healthy environment, and in which there is a strong awareness of potential risks, and active efforts to prepare.

CLIMATE ADAPTATION

Non-specific

Adjustments in ecological, social or economic systems in response to actual or expected climatic impacts and their effects. It refers to changes in processes, practices and structures to moderate potential damages or to benefit from opportunities associated with climate change[17].

Built environment

The actions taken to cope with current and anticipated climate change effects. It involves modifying and upgrading new and existing buildings and infrastructure, as well as supporting people and ecosystems to withstand changes in climate, reducing damage and harm from climate impacts, promoting longevity in the current building stock, and innovating across the supply chain.

RISK

The probability or chance that adverse consequences will occur, where something of value is at stake and where the occurrence and degree of an outcome is uncertain[18].

HAZARD

The natural or human-induced physical event or trend that may cause loss of life, injury, or other health impacts, as well as damage and loss to property, infrastructure, livelihoods, service provision, ecosystems and environmental resources[19].

VULNERABILITY

The conditions determined by physical, social, economic and environmental factors or processes which increase the susceptibility of an individual, community, asset or system to the impacts of hazards[20]. In the built environment, vulnerability is defined as the susceptibility of an asset to the adverse impacts of climate-related hazards[21].

4

A ROADMAP TO CLIMATE RESILIENCE

Creating climate resilience is a four-stage process involving increasing awareness of hazards, anticipating exposure, preparing and adapting to reduce sensitivity, and sustaining resilience through developing and maintaining adaptive capacity. This four-stage framework offers an iterative, adaptive pathway to a climate resilient built environment.

HOW CAN THE BUILT ENVIRONMENT SECTOR ACHIEVE THE VISION

The four-stage framework provides built environment stakeholders and policy-makers with clear aims and actions to achieve a climate-resilient built environment. It guides targeted efforts based on vulnerabilities, sensitivities, adaptive capacity and local context.

The Roadmap is:

- **Holistic and comprehensive**: applicable across the built environment taking into account the unique challenges faced by owners/occupiers, project teams, and policy-makers.
- **Flexible and scalable**: created from a thorough understanding of UK vulnerabilities across diverse hazards, asset types, and geographical contexts. The stages support the development of climate resilience knowledge and action at both organisational and geographical scales, providing guidance on tracking and measuring progress.
- **Evidence-based**: The stages are designed around the UK's baseline climate risks, using modelling of vulnerabilities under future scenarios and case studies to illustrate the most significant vulnerabilities (see Appendix C). In consultation with stakeholders across the UK built environment, this has enabled us to obtain a clear picture of the threats, and to identify the actions that are necessary to mitigate them.

ESSENTIAL CONCEPTS FOR CLIMATE RESILIENCE

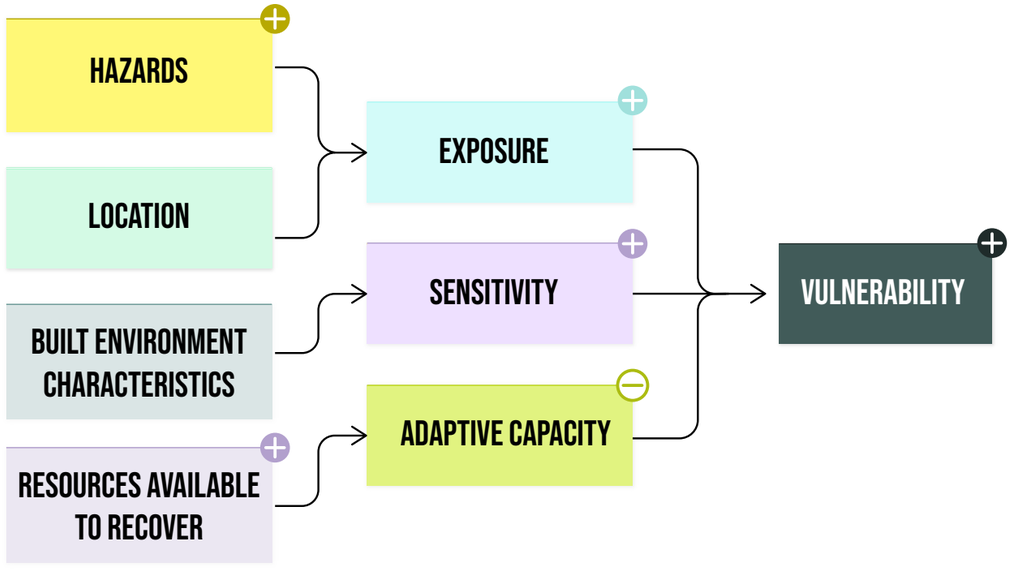
Within each of the four stages, essential concepts for addressing vulnerability to climate hazards and increasing climate resilience are introduced. The following table breaks down how vulnerability to climate hazards is composed of three key elements: exposure, sensitivity, and adaptive capacity (Table 1). The questions in the table help stakeholders recognise the key factors that make their organisations and projects vulnerable to climate hazards, considering both people and assets.

The accompanying image further illustrates how these concepts are interconnected and their critical role in shaping overall resilience.

Table 1: Identifying the key concepts that comprise vulnerability to climate hazards in the built environment.

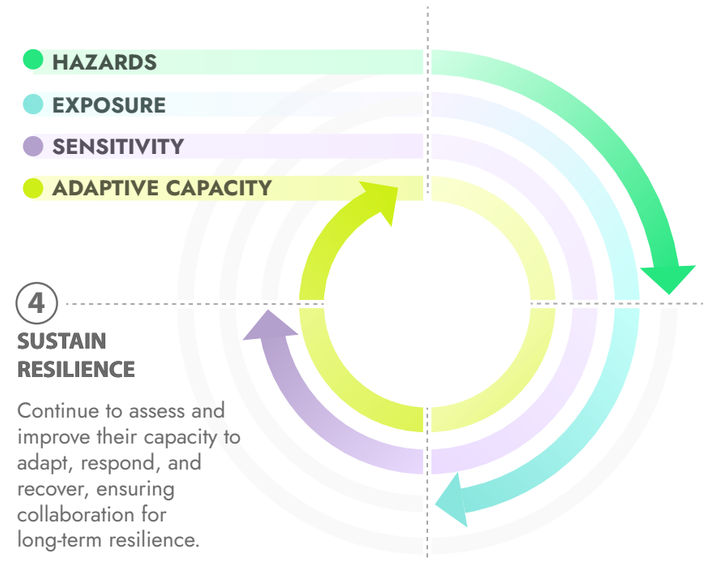
Vulnerability is a function of:	Definition for the Built Environment	Potential indicators
EXPOSURE	What is the density of people, buildings and infrastructure in areas that are vulnerable to climate hazards?	Presence of built assets and occupants (i.e. asset location, or number of habitable rooms)
SENSITIVITY	How predisposed are people, buildings and infrastructure to being affected by climate hazards and their impacts?	The degree to which built assets and their surroundings will be affected by hazards. (e.g. levels of insulation, permeability of landscapes)
ADAPTIVE CAPACITY	How effectively are people, buildings and infrastructure able to adapt to climate hazards and their impacts?	The ability of people using, living in, or owning built environment assets to adapt to potential hazard events. (e.g. access to the resources necessary to make adaptations)

Figure 5: The relationship between the key components that comprise vulnerability to climate hazards. Elements which increase vulnerability (when they increase) are depicted with a plus sign, and elements which decrease vulnerability (when they increase) are depicted with a minus sign



THE FOUR STAGES TO BUILDING CLIMATE RESILIENCE

Figure 6: This diagram illustrates the four stages of developing climate resilience. Its cyclical nature supports ongoing learning, improvement and adaptation, helping to build long-term resilience against evolving climate challenges.



1

BE AWARE AND EDUCATED

Understand climate hazards, potential vulnerabilities, and the responsibilities that come with creating resilience.

Stakeholders utilise ongoing monitoring and open-source information to inform organisational and project-level decisions that take into account local and national contexts.

2

ANTICIPATE

Anticipate climate hazards, assess risks, and inform future resilience planning by identifying exposure to these hazards, determining sensitivity to withstand them should they occur, and understanding the capacity to adapt to climate change.

Monitoring and data used at this stage is focused on the context local to a project and/or an organisation's operations, which determine the vulnerability of people and assets to climate hazards.

3

PREPARE & ADAPT

Implementing measures to support the adaptation of infrastructure, buildings and communities exposed to climate hazards.

Vulnerabilities are addressed directly by reducing sensitivity to climate hazards and enhancing the adaptive capacity of people and assets, especially through nature-based solutions.

4

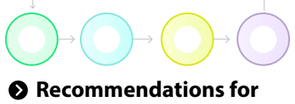
SUSTAIN RESILIENCE

Continue to assess and improve their capacity to adapt, respond, and recover, ensuring collaboration for long-term resilience.

Monitoring within this stage focuses on the adaptive capacity of assets and their users.

LINKS

Key Recommendations



Recommendations for sustaining resilience

By integrating these elements, the Roadmap offers an adaptable framework that enables stakeholders to identify the specific actions required for their context. This structured approach ensures a steady progression towards a resilient built environment, capable of addressing the ongoing and emerging climate challenges.

5

UNDERSTANDING CLIMATE HAZARDS IMPACTING THE UK BUILT ENVIRONMENT

Climate hazards can have devastating impacts on the built environment. While damage to buildings may be the most visible consequence, they can cause ongoing disruption to services, and threaten human life, nature and economic stability. These impacts stem from the interaction of climate hazards, exposure and vulnerability, which is why it is complex to address them effectively.

This section provides a foundation for understanding these core concepts and how they interact. This understanding is essential if built environment stakeholders are to take informed action and organisations, assets, and people are prepared and adaptive, while also supporting the resilience of the natural environment.

CLIMATE HAZARDS FACING THE BUILT ENVIRONMENT

This section summarises the key climate hazards for the UK built environment, providing further information about their risks and impacts. More detailed information regarding each hazard can be found in Appendix A.

These were selected due their prevalence and/or their expected increase in impact across the UK, using findings from the third Climate Change Risk Assessment[22] as a basis. They represent the most significant and immediate threats to the UK's built environment. We have prioritised them based on their frequency and severity, their potential impacts on human health, physical assets, economic systems and nature, as well as the feasibility of implementing adaptation measures. This approach ensures that the most urgent risks are addressed first, enabling more effective strategies to enhance climate resilience across communities and infrastructure.

While this report focuses on the five key hazards to the UK, others remain important, such as air pollution and coastal erosion. For a more comprehensive list of climate hazards, refer to the EU Taxonomy[23].

INTERACTIONS BETWEEN CLIMATE HAZARDS

Climate hazards can occur simultaneously, creating cascading effects that amplify their impact. For example, storms can intensify wildfires by generating strong winds that spread flames more rapidly, and they can cause severe flooding by bringing heavy rainfall. Rising temperatures can also trigger wildfires which in turn exacerbate the heat, creating a dangerous feedback loop.

Drought and flooding also have a complex relationship. Drought dries out the soil, reducing its ability to absorb water, making flash floods more likely even with moderate rainfall. Flooding erodes the soil, weakening its ability to support vegetation and leaving the land more vulnerable to further drying, reinforcing the cycle of drought and flooding.

Figure 7 shows a systems map of the five key hazards and their interconnections. Similar systems maps have been developed for each key hazard, which are shown throughout this section.

Five key hazards are considered throughout the Roadmap:

Figure 7: A systems map identifying links between the five key climate hazards affecting the UK built environment.

All hazards

Systemic Hazard Map

Key

CONNECTIONS

- Common interlinkages in cascading events
- Interlinkages between hazards
- Hazard intensification

PREDOMINANT SYSTEM AFFECTED

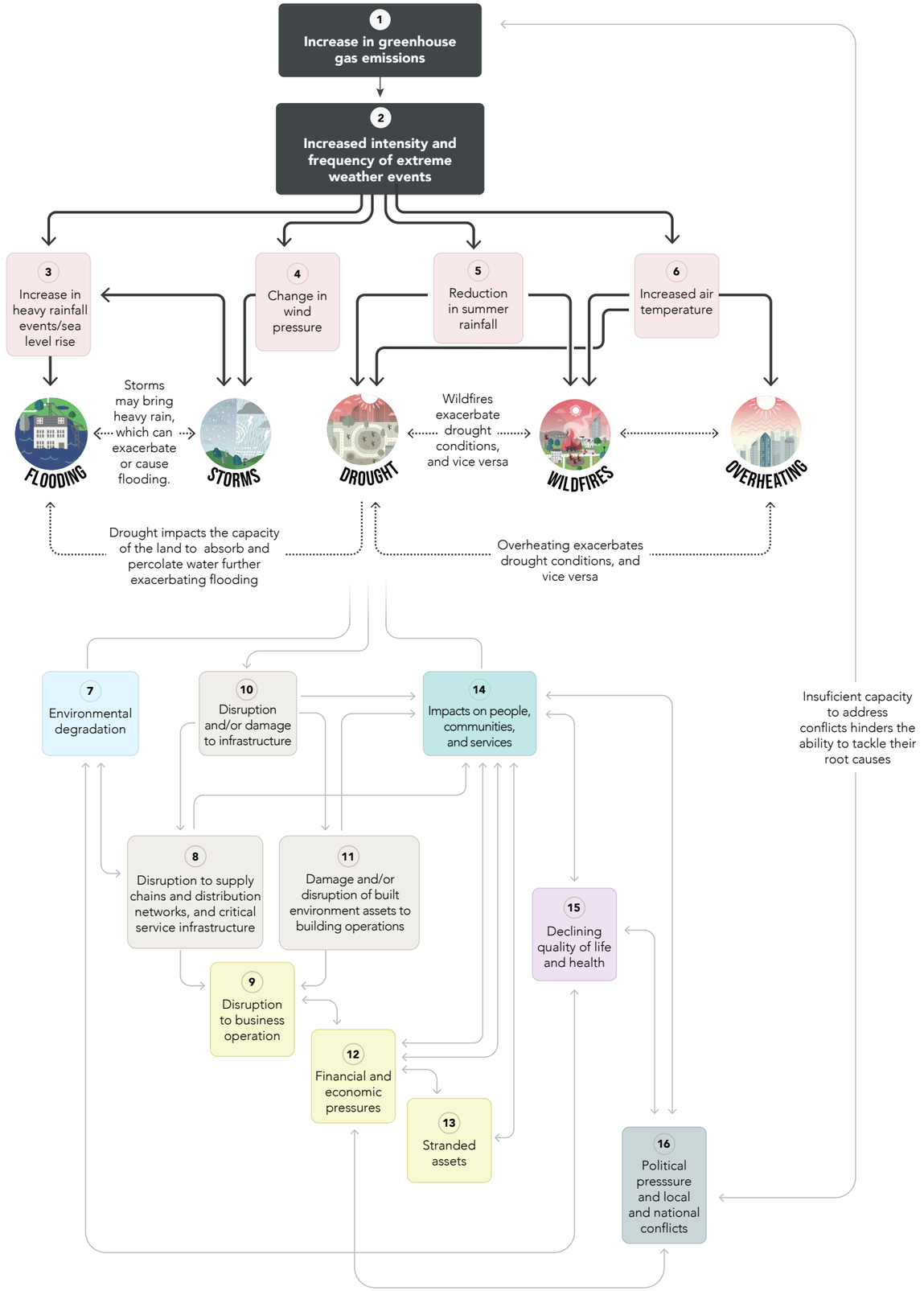
- Financial
- Social
- Built environment
- Health and wellbeing
- Climate
- Political
- Natural environment

PRECURSORS

- Precursors to climate hazards

ELEMENTS OF THE MAP

1. Increase in greenhouse gas emissions
2. Increased intensity and frequency of extreme weather events
3. Increase in heavy rainfall events/sea level rise
4. Change in wind pressure
5. Reduction in summer rainfall
6. Increased air temperature
7. Environmental degradation
8. Disruption to supply chains and distribution networks, and critical service infrastructure
9. Disruption to business operation
10. Disruption and/or damage to infrastructure
11. Damage and/or disruption of built environment assets to building operations
12. Financial and economic pressures
13. Stranded assets
14. Impacts on people and communities, and services including schools, healthcare, and businesses. Vulnerable communities and lower-income groups at greater ris
15. Declining quality of life and health
16. Political pressure and local and national conflicts



FLOODING

Rainfall patterns have always varied across the UK, between regions, seasons and years. This natural variability will continue, but climate change will affect both the frequency and intensity of rainfall, increasing the likelihood of flood events and their severity.

WHAT IS FLOODING?

Flooding refers to a situation where land that is usually dry becomes submerged by water, and it can occur inland, in coastal areas, or due to a combination of factors[24]. The UK is affected by three main types of flooding: fluvial, pluvial and coastal flooding.

- Fluvial flooding occurs when a river, lake or stream cannot cope with the water draining into it from the surrounding land, and overflows. This can also affect smaller rivers downstream, resulting in widespread damage.
- Pluvial, or surface water, flooding occurs when heavy rainfall overwhelms drainage systems, causing water to overflow into streets, buildings, and infrastructure. This type of flooding can happen anywhere, and is much more difficult to predict than fluvial or coastal flooding.
- Coastal flooding occurs when land along the coast is inundated by seawater. This is usually caused when storms coincide with high tides, and intense winds force water ashore, also called a "storm surge".

In addition, sewer flooding can occur when sewers become overwhelmed by heavy rainfall or blocked, leading to land, property and rivers becoming contaminated with raw sewage. Groundwater flooding occurs when the water table rises above ground level, most often in areas of permeable rock called aquifers.

HOW IS THE BUILT ENVIRONMENT AFFECTED BY FLOODING?

- Flooding can be devastating for those whose homes and businesses are directly affected, and it can cause knock-on effects to many more, through damage to critical infrastructure such as power, communication and transport networks, and disruption to the delivery of public services such as health and education.
- Flooding has negative impacts on wildlife and agriculture too. Waterlogging and flooding of fields and areas of vegetation can negatively impact ecosystems and crops, as well as increasing soil degradation and compaction[5].
- Floodwater can cause significant damage to building structures, finishes and contents, and necessitate a lengthy period of drying, cleaning and repairs.

FLOOD RISK AROUND THE UK

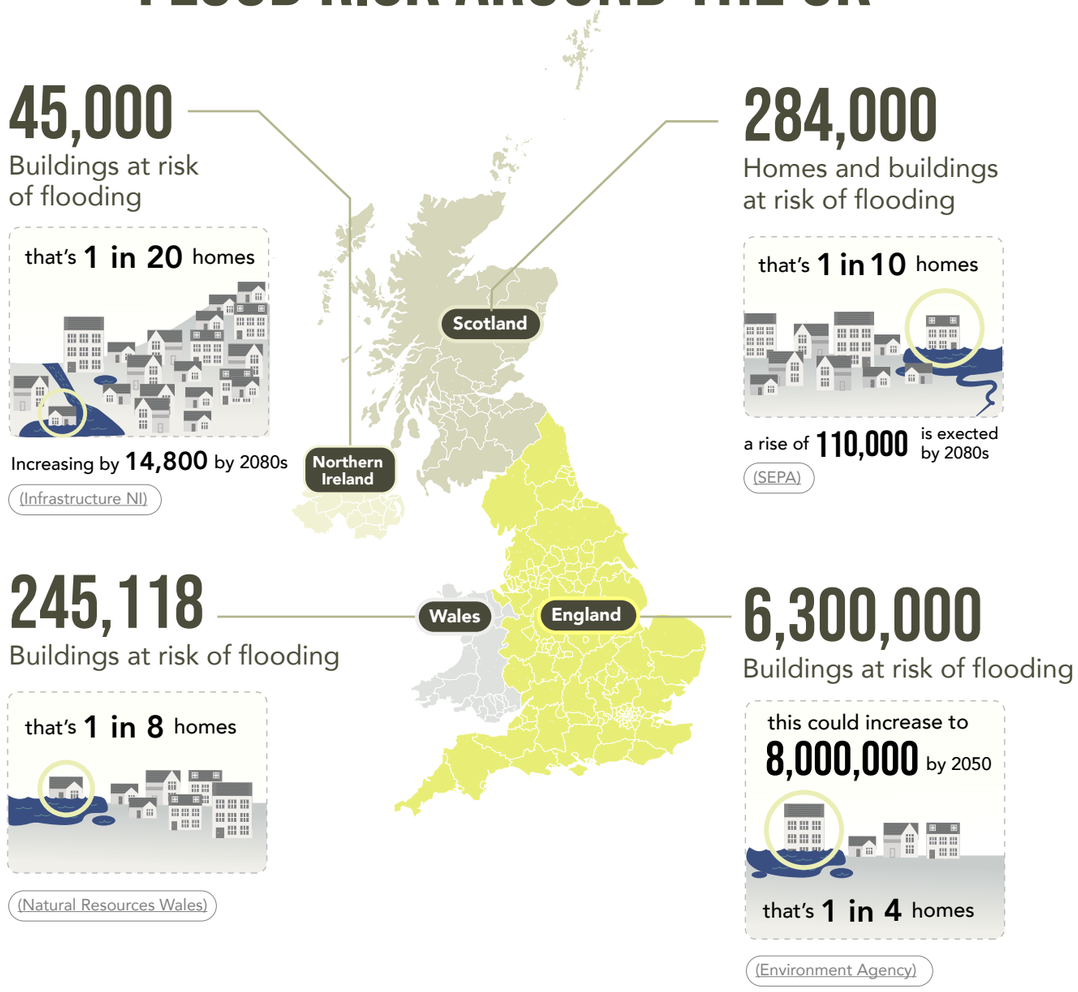


Figure 9: a systems map identifying links between flooding and its impacts.

Hazard map 1

Flooding

Key

CONNECTIONS

- Common interlinkages in cascading events
- Interlinkages between hazards
- Hazard intensification

PREDOMINANT SYSTEM AFFECTED

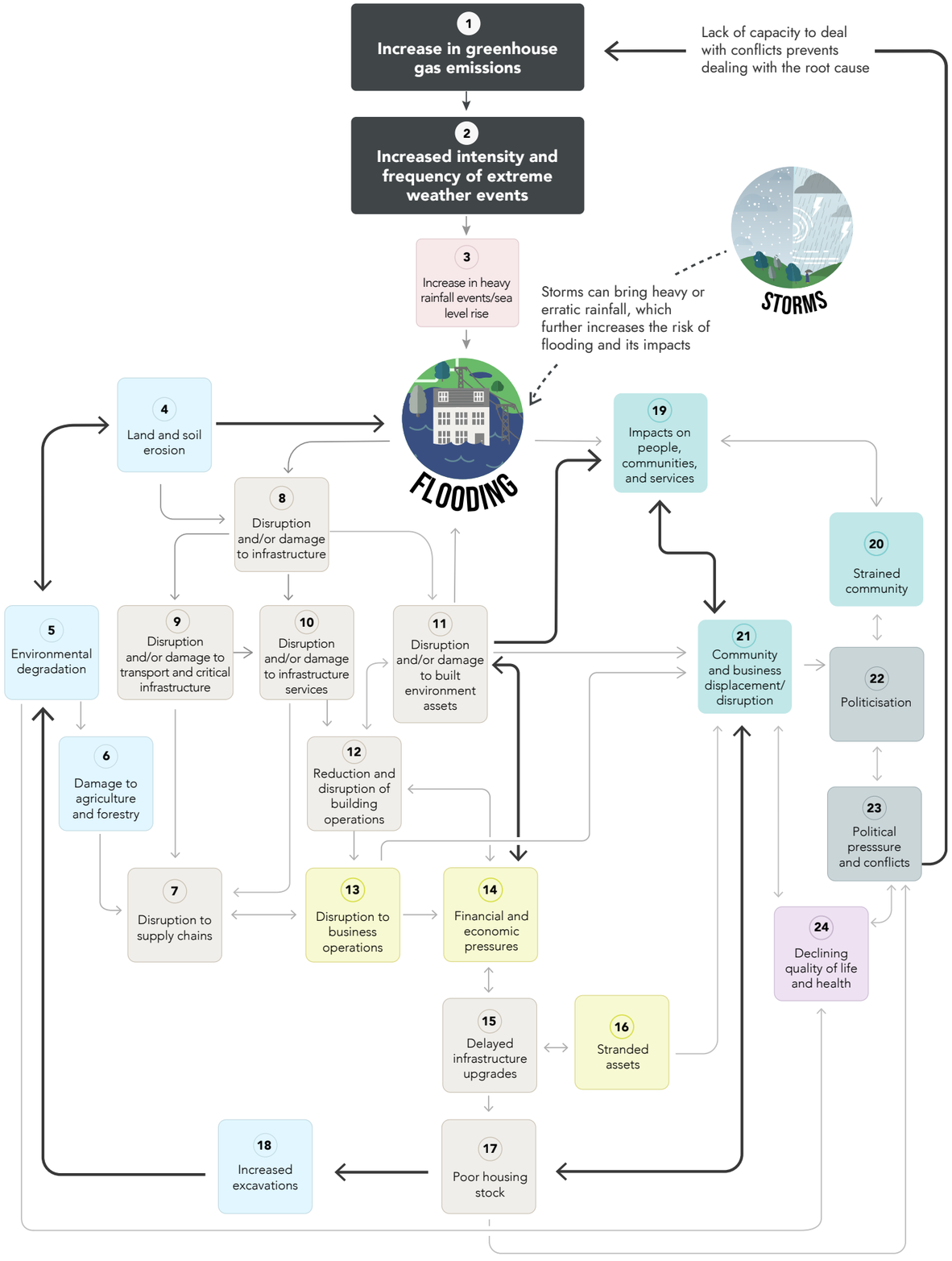
- Financial
- Social
- Built environment
- Health and wellbeing
- Climate
- Political
- Natural environment

PRECURSORS

- Precursors to climate hazards

ELEMENTS OF THE MAP

1. Increase in greenhouse gas emissions
2. Increased intensity and frequency of extreme weather events
3. Increase in heavy rainfall events and/or sea level rise
4. Land and soil erosion, including coastal erosion, subsidence, landslides and slope/embankment failures
5. Environmental degradation including loss of vegetation, habitats and biodiversity; disruption to wildlife; increase in species migration, including invasive species
6. Damage to agriculture and forestry, including crops, livestock, and timber resources
7. Disruption to supply chains and distribution networks
8. Disruption and/or damage to infrastructure
9. Disruption and/or damage to transport networks, bridges, pipelines and critical infrastructure from flooding and erosion
10. Disruption and/or damage to infrastructure services
11. Disruption and/or damage to built environment assets from flooding, including structural damage and building fabric
12. Reduction and disruption of building operations
13. Disruption to business operation and continuity (e.g. job loss)
14. Financial and economic pressures, including challenges in financing, investment, and insurance. Growth of unmortgageable properties, and declining asset/land values
15. Delayed infrastructure upgrades increase exposure to climate risks
16. Stranded assets
17. Poor housing stock
18. Increased excavations including new land reclamation areas
19. Impacts on people, communities, and services, including schools, healthcare, and businesses, by sea level rise, river flooding and surface water flooding. Vulnerable communities and lower-in-come groups at greater risk
20. Community responses and adaptation under increased pressure
21. Community migration and/or displacement. Business operation disrupted or forced to close
22. Politicisation of risk severity and misinformation
23. Political presssure, policy delays and lack of long-term climate planning. Conflicts between national policies and local adaptation needs and fragmentation
24. Declining quality of life, well-being, and mental and physical health



OVERHEATING

Historically, overheating has not been a major concern in the UK. In our temperate maritime climate, with its cold winters and mild summers, heating has always been a far higher priority than staying cool. That is now changing, as summers become hotter and heatwaves more frequent.

WHAT IS OVERHEATING?

Overheating is a complex climate hazard that is difficult to define and assess, as its impact varies based on individual perceptions, acclimatisation, and personal vulnerabilities (e.g., age, living conditions, health status and occupation). What may be mildly uncomfortable at home on a summer's day could be much less acceptable when we are at work or trying to sleep. The same temperature could be lethal in a hospital or a care home, or for someone with an underlying health condition.

The Chartered Institute of Building Services Engineers (CIBSE) defines overheating in relation to the average outdoor temperature over recent days, rather than a fixed limit, recognising that people can gradually adapt to warmer temperatures. A building is considered to overheat based on how much the internal temperature breaches the threshold, and for how long (see[25]). CIBSE has also published a stricter standard for residential buildings (TM59). This also uses an adaptive model for living spaces but sets a static upper limit for bedrooms: the temperature should not exceed 26°C for more than 1% of annual sleeping hours. In healthcare buildings, overheating is much more dangerous, and the definition is therefore much stricter: when the daily maximum temperature in a ward or clinical area rises above 26°C.

HOW IS THE BUILT ENVIRONMENT AFFECTED BY OVERHEATING?

- Overheating is dangerous to human health: prolonged exposure to high temperatures puts the human body under cumulative stress. This is particularly important to protect older people, children, and those with underlying illnesses such as heart disease, diabetes, asthma and dementia, who are most vulnerable.
- Overheating makes buildings uncomfortable for occupants, and impairs productivity and educational attainment – directly, as a result of higher temperatures in workplaces and schools, and indirectly as a result of poor-quality sleep affecting concentration and alertness.
- Hot weather can significantly impact natural environments by decreasing water availability - which leads to dehydration and the drying out of critical habitats like rivers, lakes, and wetlands - damaging or killing plants, disrupting food supplies for humans and wildlife, and degrading soil, increasing erosion and harming plant health.
- Overheating puts additional pressure on building systems, increasing operating costs, carbon emissions and requiring more frequent maintenance or replacement. Persistent high temperatures degrade building materials, particularly those that are heat-sensitive, such as plastics, sealants, and insulation materials.
- At an economic level, poor thermal performance could impact a building's marketability and asset value, especially as climate risk assessments become integrated into property valuations[26].
- Overheating presents a threat to the UK's climate mitigation efforts too.

Without rapid action to ensure buildings can remain comfortable using passive measures, occupants will turn to mechanical cooling instead, reversing progress on lowering energy use[27]. This increases demand on the National Grid, potentially jeopardising our ability to meet our needs fully from renewable sources.

Figure 8: a systems map identifying links between overheating and its impacts.

Hazard map 2

Overheating

Key

CONNECTIONS

- Common interlinkages in cascading events
- Interlinkages between hazards
- Hazard intensification

PREDOMINANT SYSTEM AFFECTED

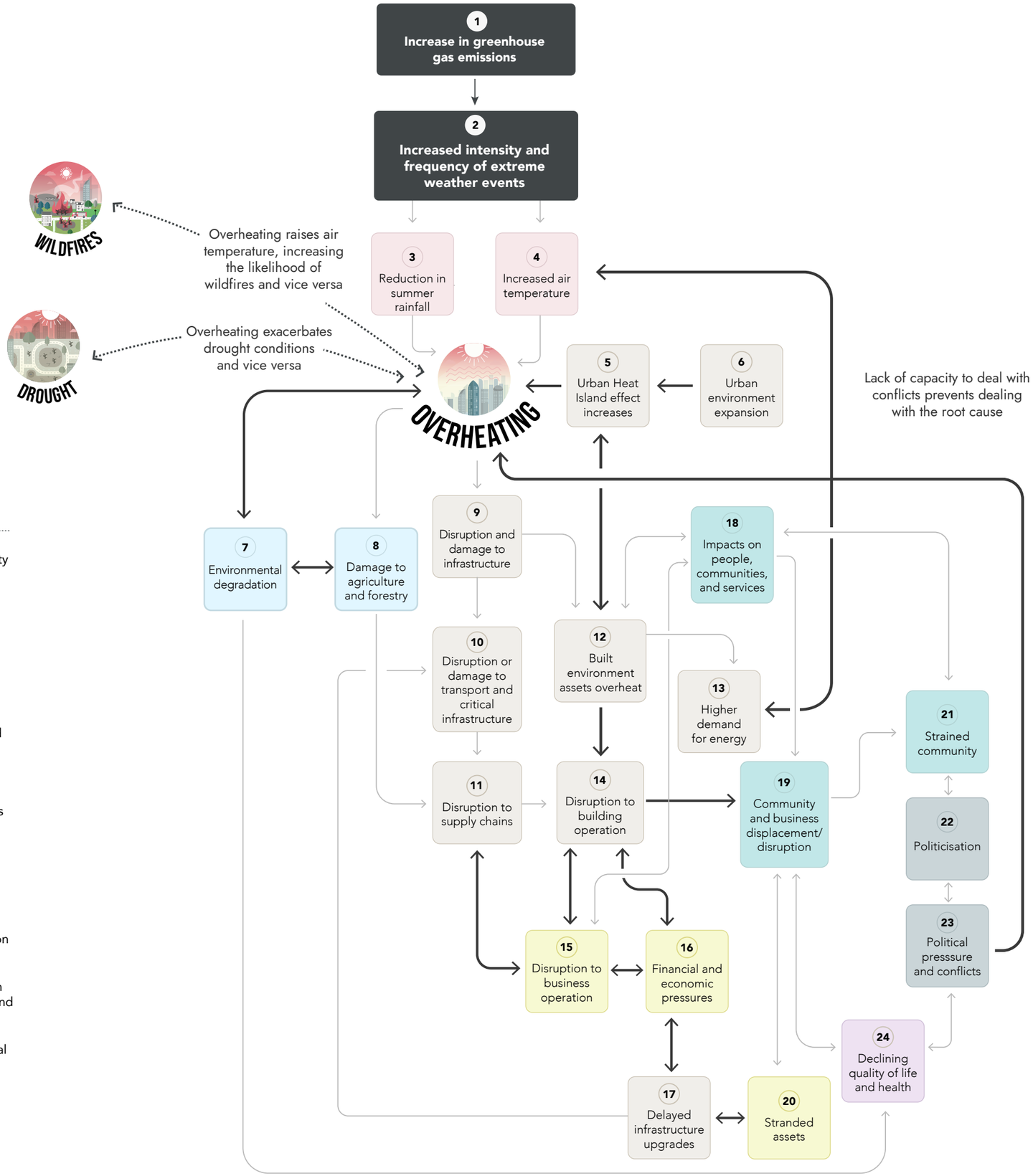
- Financial
- Social
- Built environment
- Health and wellbeing
- Climate
- Political
- Natural environment

PRECURSORS

- Precursors to climate hazards

ELEMENTS OF THE MAP

1. Increase in greenhouse gas emissions
2. Increased intensity and frequency of extreme weather events
3. Reduction in summer rainfall
4. Increased air temperature
5. Urban Heat Island effect increases
6. Urban environment expansion
7. Environmental degradation including loss of vegetation, habitats and biodiversity; disruption to wildlife; increase species migration, including invasive species
8. Damage to agriculture and forestry, including crops, livestock, and timber resources
9. Disruption and/or damage to infrastructure
10. Disruption or damage to transport networks, infrastructure services (IT, energy, water) and critical infrastructure
11. Disruption to supply chains and distribution networks
12. Built environment assets overheat
13. Higher demand in active methods of cooling
14. Reduction of operations of buildings and/or loss of functionality
15. Disruption to business operation and continuity
16. Financial and economic pressures, including challenges in financing, investment, and insurance, the growth of unmortgageable properties, and declining asset/land values
17. Delayed infrastructure and assets upgrades increase exposure to climate risks
18. Impacts on people and communities, and services including schools, and businesses and higher demand on helath care. Vulnerable communities and lower-income groups at greater risk
19. Community migration and business operations disrupted or forced to close
20. Stranded assets
21. Community responses and adaptation under increased pressure
22. Politicisation of risk severity and misinformation
23. Political presssure, policy delays and lack of long-term climate planning. Conflicts between national policies and local adaptation needs and fragmentation
24. Declining quality of life, well-being, and mental and physical health



STORMS

The location of the UK makes it especially prone to stormy weather. It is not yet known if climate change is making storms in the UK more frequent, but there is evidence that global warming is making the most powerful storms more intense[31].

WHAT ARE STORMS?

A "storm" has no official meteorological definition, but it typically refers to a deep and active area of low pressure associated with strong winds and precipitation[28]. The Association of British Insurers defines a storm as a period of violent weather with either: high winds with gusts of at least 55mph (89km/h), torrential rainfall of at least 25mm/hour, snow to depth of at least 30cm in 24 hours, or hail that damages hard surfaces or breaks glass[29].

HOW IS THE BUILT ENVIRONMENT AFFECTED BY STORMS?

- High winds cause significant damage to buildings and infrastructure, putting people's lives at risk from falling debris, and resulting in widespread disruption to travel, power and data networks.
- The greater potential for storms to cluster[30] also means that heavy rain could fall on saturated ground and add to high river levels, increasing the likelihood of flooding.
- In coastal areas, storm surges are caused by high winds forcing sea water onto the land, and generating large waves that can damage flood defences, buildings, and infrastructure. This is more likely to happen at high tide, and the risks are growing as the sea level around the UK rises.
- Storms can significantly affect the built environment in various ways, causing structural damage, flooding, and foundation erosion.
- High winds may damage roofs and break windows, while heavy rainfall can lead to water infiltration and mould growth. For those living in or using these buildings, storms pose significant threats, including injury from structural damage, health issues like mould exposure or contaminated drinking water, and threats from the disruption of critical resources such as heating, water supply and communication systems.

Figure 10: a systems map identifying links between storms and its impacts.

Hazard map 3

Storms

Key

CONNECTIONS

- Common interlinkages in cascading events
- Interlinkages between hazards
- Hazard intensification

PREDOMINANT SYSTEM AFFECTED

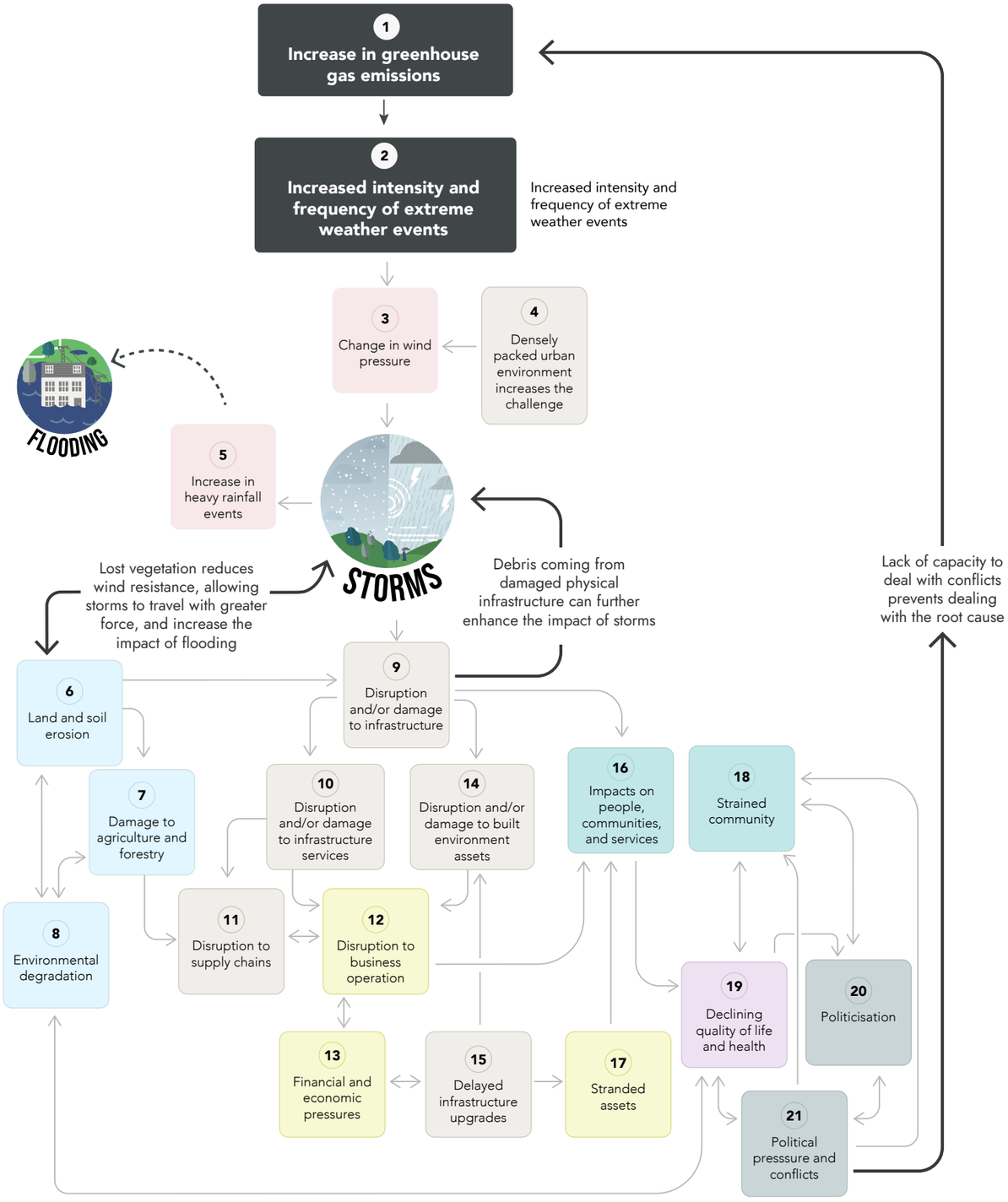
Financial | Social | Built environment | Health and wellbeing | Climate | Political | Natural environment

PRECURSORS

Precursors to climate hazards

ELEMENTS OF THE MAP

1. Increase in greenhouse gas emissions
2. Increased intensity and frequency of extreme weather events
3. Change in wind pressure
4. Interactive effects between densely packed buildings in urban environments
5. Increase in heavy rain events
6. Land and soil erosion, including coastal erosion, subsidence, landslides and slope/embankment failures
7. Damage to agriculture and forestry, including crops, livestock, and timber resources
8. Environmental degradation including loss of vegetation, habitats and biodiversity; disruption to wildlife; increase species migration, including invasive species
9. Disruption and/or damage to infrastructure leading to increased exposure to further damage
10. Energy, transport, and digital services are affected by high winds, lightning, and storm surges
11. Disruption to supply chains and distribution networks
12. Disruption to business operation and continuity (e.g. job loss)
13. Financial and economic pressures, including challenges in financing, investment, and insurance, the growth of unmortgageable properties, and declining asset/land values.
14. Disruption and/or damage to built environment assets and building operations, including building fabric, facade and structure leading to increased exposure to further damage
15. Delayed upgrades to buildings and infrastructure leading to increased exposure to climate risks
16. Impacts on people, communities, and services, including schools, healthcare, and businesses. Vulnerable communities and lower-income groups at greater risk.
17. Stranded assets
18. Community responses and adaptation under increased pressure
19. Declining quality of life, well-being, and mental and physical health
20. Politicisation of risk severity and misinformation
21. Political pressure, policy delays and lack of long-term climate planning. Conflicts between national policies and local adaptation needs and fragmentation



DROUGHT

Dry reservoirs, jagged cracks in baked earth, and expanses of parched grass in urban parks are all indicators of drought in the UK and were widespread in the summers of 2018 and 2022. Yet they will become more familiar, as global warming brings drier summers and higher temperatures[36].

WHAT IS DROUGHT?

Droughts are water shortage events, typically caused by lower-than-usual rainfall. Droughts are characterised in different ways, depending on their impact on the water cycle, the environment, and on human activities.

HOW IS THE BUILT ENVIRONMENT AFFECTED BY DROUGHT?

- Drought typically affects a larger area than other climate hazards, and its impacts can be varied, devastating, and expensive[32]. It affects human activities, buildings, food production, critical infrastructure, industry and ecosystems, and exacerbates other climate impacts.
- The risks of other climate hazards may be increased by drought, such as wildfires, which can spread very rapidly through dry vegetation. It also makes surface water flooding more likely in future summers, as prolonged dry spells make the ground less able to absorb sudden intense rainfall.
- Drought can hinder adaptation measures such as nature-based solutions to provide natural cooling and shade – urban green spaces, street trees and green roofs and walls risk drying out and ceasing to be effective if not well-maintained[33].
- Climate mitigation can also be threatened by drought as a lack of sufficient water reduces plant photosynthesis, and therefore absorption of carbon dioxide. During the summer 2018 drought across Europe, a net reduction of carbon uptake was observed in ecosystems across Europe [5].
- In clay soils, changing moisture content can cause alternate shrinkage and swelling, seriously damaging buildings and infrastructure, above and below the ground. Dry weather and high temperatures are a major cause of subsidence, and this risk will increase with climate change[34] [35].

Figure 11: a systems map identifying links between drought and its impacts.

Hazard map 4

Drought

Key

CONNECTIONS

- Common interlinkages in cascading events
- Interlinkages between hazards
- Hazard intensification

PREDOMINANT SYSTEM AFFECTED

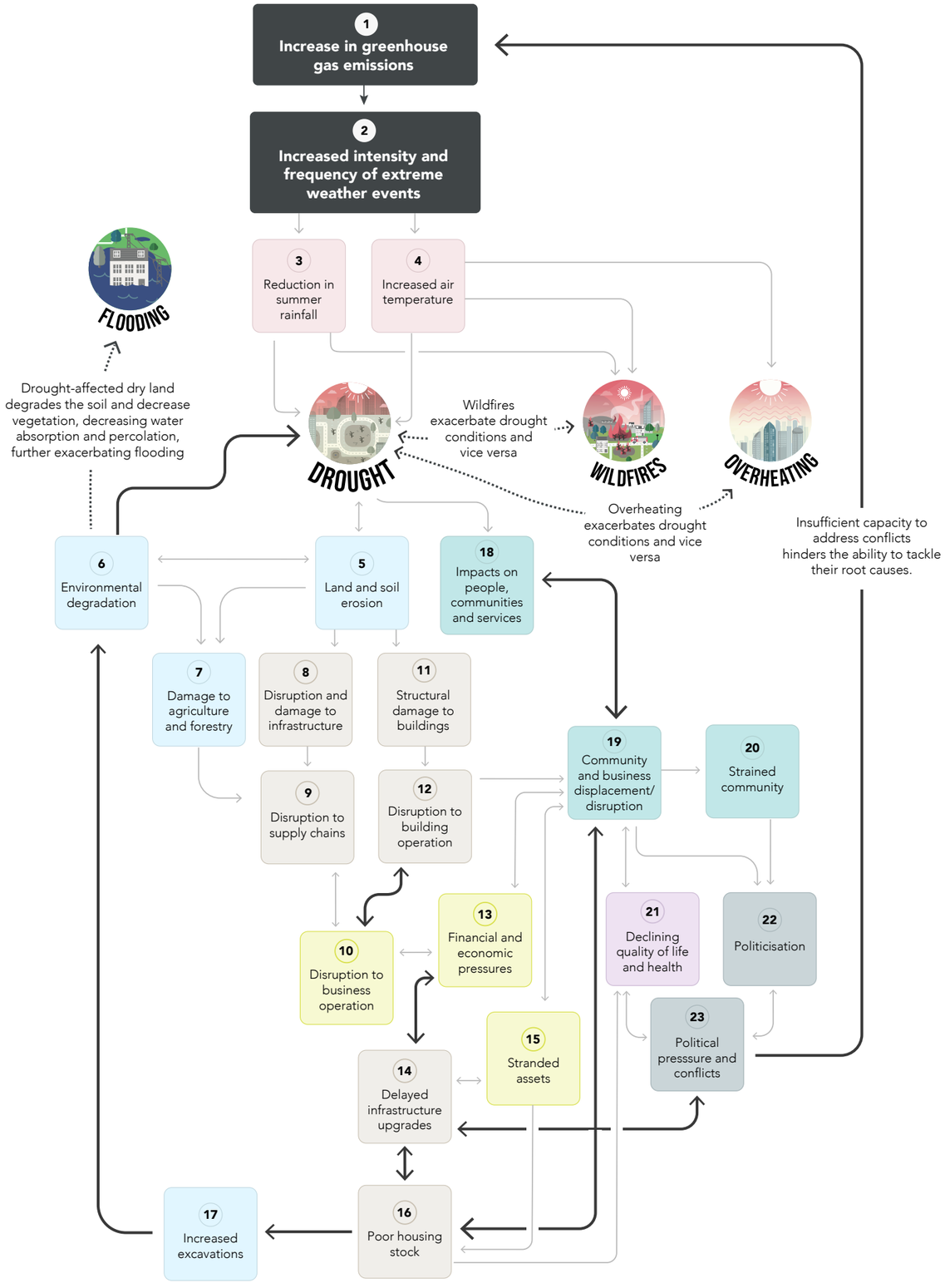
- Financial
- Social
- Built environment
- Health and wellbeing
- Climate
- Political
- Natural environment

PRECURSORS

- Precursors to climate hazards

ELEMENTS OF THE MAP

1. Increase in greenhouse gas emissions
2. Increased intensity and frequency of extreme weather events
3. Reduction in summer rainfall
4. Increased air temperature
5. Land and soil erosion, subsidence, landslides and slope/embankment failures
6. Environmental degradation including loss of vegetation, habitats and biodiversity; disruption to wildlife; increase species migration, including invasive species
7. Damage to agriculture and forestry, including crops, livestock, and timber resources
8. Disruption and damage to subterranean and surface infrastructure
9. Disruption to supply chains and distribution networks
10. Disruption to business operation and continuity (e.g. job loss)
11. Structural damage to buildings and damage to foundations, compromised structural integrity
12. Reduction and disruption of building operations leading to loss of functionality
13. Financial and economic pressures including challenges in financing, investment, and insurance, the growth of unmortgageable properties, and declining asset/land values
14. Delayed infrastructure, and assets upgrades increase exposure to climate risks
15. Stranded assets
16. Poor housing stock
17. Increased excavations including new land reclamation areas
18. Impacts on people and communities, and services including schools, healthcare, and businesses. Vulnerable communities and lower-income groups at greater risk
19. Community migration and/or displacement and business operations disrupted or forced to close
20. Community responses and adaptation under increased pressure
21. Declining quality of life, well-being, and mental and physical health
22. Politicisation of risk severity and misinformation
23. Political presssure, policy delays and lack of long-term climate planning. Conflicts between national policies and local adaptation needs and fragmentation



WILDFIRES

Globally, we are already witnessing an increase in wildfires. Carbon emissions from forest fires have risen by 60% since 2001[42], and modelling shows this is due to the longer periods of drought and hotter temperatures caused by climate change[43].

WHAT ARE WILDFIRES?

In the UK, wildfires are defined as "any uncontrolled vegetation fire which requires a decision, or action, regarding suppression". This includes fires in woodland, grassland, and shrubland areas, smouldering fires in peat bogs, and fires in built-up areas. In fact, the largest number of wildfire incidents in the UK do occur in close proximity to built-up areas. Even though these tend to be relatively small in burnt area, they present a significant threat to life, health, buildings, and infrastructure[37].

HOW IS THE BUILT ENVIRONMENT AFFECTED BY WILDFIRES?

- Wildfires pose significant threats to the built environment through intense heat, fire and smoke damage. Buildings can suffer extensive damage, especially if constructed with flammable materials or lacking fire-resistant features.
- Wildfires may weaken structural integrity, melt or burn façades, and destroy critical infrastructure such as electricity networks, roads and water services.
- Smoke and soot can infiltrate buildings, leading to long-term damage to indoor air quality and ventilation systems.
- People in these buildings face immediate dangers such as injury from fires, along with long-term respiratory and health issues from toxic smoke exposure.
- The destruction of homes and workplaces often results in displacement, loss of possessions and financial hardship.
- As well as putting lives at risk and destroying homes and businesses, wildfires release smoke and toxic chemicals into the atmosphere, causing widespread, long-lasting air pollution that endangers health.
- Wildfires spread furthest in the countryside, where they destroy agricultural land, and natural habitats and ecosystems that may take decades to recover, if at all[38].

Wildfires and climate change: a vicious circle

Wildfires do not just damage natural landscapes and wildlife, they also turn our precious carbon sinks into sources of emissions.

Peat soils in particular are one of the world's largest reserves of organic carbon, covering only 3% of the Earth's surface but storing more than twice as much carbon as in all of its forests. The UK is one of the world's top ten countries for peatland area.

But peatlands are particularly prone to wildfire[39], and particularly slow to regenerate[40]. When natural peatlands are disturbed and the soil is exposed to air, carbon locked away for millennia is released into the atmosphere.

Already only 20% of the UK's peatlands remain in a near-natural state[41]. An increase in drought and in wildfires due to climate change threatens them further – and could jeopardise our ability to prevent catastrophic levels of warming.

Figure 12: a systems map identifying links between wildfire and its impacts.

Hazard map 5

Wildfires

Key

CONNECTIONS

- Common interlinkages in cascading events
- Interlinkages between hazards
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1. Increase in greenhouse gas emissions
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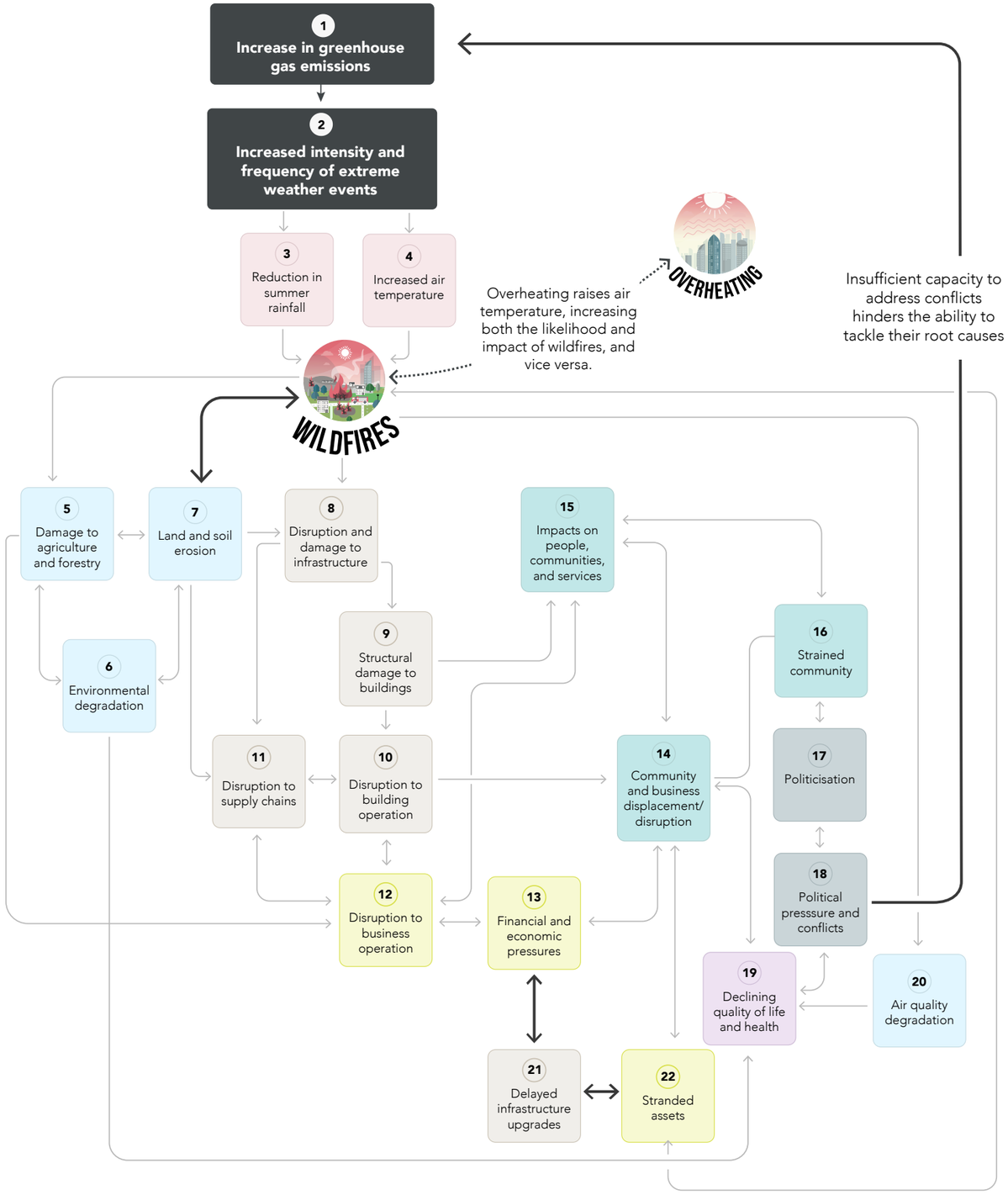
5. Damage to agriculture and forestry, including crops, livestock, and timber resources
6. Environmental degradation including loss of vegetation, habitats and biodiversity; disruption to wildlife; increased species migration, including invasive species
7. Land and soil erosion, subsidence, landslides and slope/embankment failures
8. Disruption and/or damage to infrastructure subterranean and surface infrastructure
9. Disruption and/or damage to built environment assets including building fabric and core infrastructure
10. Reduction of operations of buildings and/or loss of functionality, or total asset loss
11. Disruption to supply chains and distribution networks
12. Disruption to business operation and continuity (e.g. job loss)
13. Financial and economic pressures, including challenges in financing, investment, and insurance, the growth of unmortgageable properties, and declining asset/land values
14. Community migration and/or displacement and business operations disrupted or forced to close
15. Impacts on people and communities, and services including schools, healthcare, and businesses. Vulnerable communities and lower-income groups at greater risk
16. Community responses and adaptation under increased pressure
17. Politicisation of risk severity and misinformation
18. Political presssure, policy delays and lack of long-term climate planning. Conflicts between national policies and local adaptation needs and fragmentation
19. Declining quality of life, well-being, and mental and physical health
20. Air quality degradation
21. Delayed infrastructure and asset upgrades increase exposure to climate risks
22. Stranded assets



6

RECOMMENDATIONS FOR PREPARING FOR CLIMATE HAZARDS

This section outlines recommendations for enhancing climate resilience in the built environment, addressing both physical design strategies and organisational approaches. It provides specific guidance on how buildings can be designed and adapted in relation to our five key hazards: flooding, overheating, storms, drought and wildfires.

FLOODING

Flooding presents a major threat to the built environment, with increasing rainfall intensity, rising sea levels, and more frequent extreme weather events heightening the risk to buildings and infrastructure. This section outlines design recommendations for mitigating flood risk at site and building level, and provides guidance for built environment stakeholders on integrating flood resilience into planning, operation, and long-term decision-making.

KEY RECOMMENDATIONS FOR ADDRESSING FLOOD RISK

DESIGN RECOMMENDATIONS AT SITE LEVEL

- Conduct a detailed flood risk assessment (FRA) or flood consequence assessment (FCA) which considers different sources, predicted flood levels, duration of flood event, frequency and depth of flooding[44].
- Amend design strategies to consider the predicted flood water depth[45].
- Use the sequential test to locate new development in low-risk flood areas where possible, with non-dwelling areas such as roads and amenity spaces sited on lower ground[46].
- Create high ground using landscaping to reduce flood risk while maintaining flood management systems and encouraging drainage away from buildings[47].
- Ensure site drainage is sufficient to prevent surface water flooding and overloading of downstream systems[48].
- Incorporate nature-based solutions, such as sustainable urban drainage systems (SuDS), rain gardens, trees and green roofs to reduce flooding and provide co-benefits for biodiversity and stormwater runoff[49].
- Incorporate flood-resistant barriers such as boundary walls and fences[50].

DESIGN RECOMMENDATIONS FOR BUILDINGS

- Use materials that resist floodwater entry, such as water-resistant concrete and flood repairable materials that allow for easy replacement of flood-damaged sections[51].
- Install measures such as flood doors and windows, air bricks and one-way valves to prevent water entry[52].
- Use water-resistant materials such as dragon board aqua board, and ceramic tiles to waterproof walls and floors. Replacing timber floors with treated water-resistant materials also reduces water absorption[53].
- Elevate utilities such as electrical meters and appliances to prevent damage during floods[54].

RECOMMENDATIONS FOR BUILT ENVIRONMENT STAKEHOLDERS

LOCAL PLANNING AUTHORITIES AND REGULATORY BODIES:

- Develop a comprehensive flood risk assessment to identify flood vulnerable areas.
- Ensure high risk areas are well adapted with a combination of flood defences, well-maintained drainage infrastructure, and nature-based solutions such as sustainable urban drainage systems (SuDS) to manage flooding[55].
- Set targets to increase the amount of green and blue infrastructure, especially in areas that are vulnerable to flooding.
- Require all new homes to meet flood resilience standards, with specific guidelines for flood-resistant materials and site selection[56].
- Ensure commercial properties follow similar regulations for flood resilience, including flood-resistant materials and design for minimising damage[57].

BUILDING OWNERS AND OCCUPIERS

- Develop and maintain an emergency flood response plan, ensuring occupants understand evacuation routes and emergency contacts.
- Carry out regular maintenance of flood barriers, drainage systems, and water-resistant features to ensure they remain effective[58,59].
- Ensure all essential utilities (such as gas and electricity meters) are elevated above the expected flood level[60].
- Consider installing flood-resistant fixtures such as flood doors and waterproof flooring and using materials such as closed-cell insulation and lime plaster[61].
- If flooding occurs, ensure flood-affected materials are replaced quickly with minimal damage[62].
- Develop flood-specific contingency plans for business operations, focusing on recovery and re-occupation[63].

INSURANCE PROVIDERS

- Offer discounts or incentives to building owners who carry out flood risk assessments and implement resilience measures[64].
- Provide policies that cover the cost of flood repairs and replacement of flood-damaged materials[65].
- Encourage homeowners to invest in flood insurance, particularly in flood-prone areas, with coverage that includes flood-resilient repairs and property modifications[66].
- Offer specialised coverage for commercial buildings, ensuring that flood resilience measures are factored into insurance premiums.

EDUCATION PROVIDERS

- Provide educational resources for developers, designers, and building owners about the importance of flood resilience and the available solutions[67].
- Promote understanding of flood risks through community outreach, highlighting the role of nature-based solutions and other sustainable solutions in reducing flood risk[38].
- Train workers in technical skills related to flood resilience, including modelling, design and installation of flood-resistant measures[68].
- Educate homeowners on practical flood resilience measures they can implement, such as installing water-resistant materials and flood doors[69].
- Offer advice on choosing appropriate flood insurance policies that cover both flood repair and preventative measures.
- Encourage businesses to understand the impact of flooding on operations and educate them on risk reduction measures, such as ensuring flood resilience through planning and design[70].
- Educate property managers of non-domestic buildings on maintaining flood resilience measures and incorporating emergency flood management plans.

OVERHEATING

Overheating poses a significant hazard to the built environment and its occupants, with more frequent heat waves, the likelihood of buildings becoming uncomfortably or dangerously hot increases. A baseline overheating analysis conducted by Hoare Lea (see the Technical Report) highlighted the vulnerability of the existing building stock to future climate conditions. Additional thermal modelling was carried out to assess a range of adaptation measures.

Informed by this analysis, this section presents design recommendations to mitigate overheating, informed by this analysis, and provides guidance for different built environment stakeholders on embedding resilience into decision-making processes and long-term planning.

KEY RECOMMENDATIONS FOR ADDRESSING OVERHEATING RISK

IMPLEMENT PASSIVE ADAPTATION MEASURES

Passive interventions should be considered first, to reduce overheating without additional energy consumption. The most effective passive measures identified by the thermal modelling were:

- Reducing solar heat gains with external shading, by reducing glazing areas, or replacing clear glass with solar control glass.
- Increasing ventilation rates, through measures such as increasing window opening areas or converting fixed windows to be openable.

EXAMPLES OF PASSIVE ADAPTATION TO HEAT STRESS

Highly glazed buildings: Buildings with large areas of glazing, particularly those facing south, east, or west, are at higher risk of overheating due to increased solar radiation. For new buildings, designers should consider reducing glazing areas where possible, whilst maintaining a balance with appropriate daylight access.

Solar shading: For both new and existing buildings, solar shading (such as external sliding shutters, roller shutters, or canopy awnings) can significantly reduce overheating by limiting solar radiation transmission into buildings. These should be explored as part of a broader overheating mitigation strategy.

Restricted window openings: Buildings with restricted window openings, such as hospitals, schools, and care homes, are at higher risk of overheating. Ventilation rates can be increased through incorporating high-level windows that can fully open, ensuring compliance with safety standards while improving airflow and reducing overheating.

Other passive measures include:

- Reducing internal heat loads by managing equipment usage.
- Exposing thermal mass, where feasible, to enable night cooling with natural ventilation.
- Incorporating blue and green infrastructure to reduce the urban heat island effect.
- Operational or behavioural influences such as closing blinds to reduce solar gains during summer days and opening windows at night. Encouraging occupants to manage night ventilation can also provide the added benefit of cooling building structures and help to mitigate daytime overheating.

Assess active measures if passive adaptation is not sufficient

In some cases, active measures such as mechanical cooling or increased ventilation rates may be necessary to reduce internal temperatures, though these interventions will result in higher energy consumption and can increase operational costs. These should only be considered when passive measures alone are insufficient.

The most effective active adaptation measures identified within the thermal modelling were:

- Introducing mechanical cooling e.g. comfort cooling combined with mechanical ventilation or air conditioning
- Using mechanical ventilation for night cooling.
- Using mechanical ventilation systems with tempering capabilities to reduce the supply air temperature without active cooling, such as a mechanical ventilation with heat recovery (MVHR) system.

RECOMMENDATIONS FOR BUILT ENVIRONMENT STAKEHOLDERS

Developers and designers

- For both new buildings and retrofits, future climate projections should be reviewed to anticipate potential temperature increases over the lifetime of the building.
- A climate-resilient design should be prioritised, adopting a passive-first approach.

Local planning authorities and regulatory bodies

- Planning policies and building regulations must require climate-resilient construction to prevent overheating.
- Promote the inclusion of green infrastructure to mitigate urban heat islands and enhance local microclimates.
- Review guidance on safe window openings, as current restrictions often limit natural ventilation and exacerbate risk of overheating.
- Provide public guidance on climate adaptation and advance heatwave warnings.

Building owners and occupiers

- Building owners should assess both current and future risk of overheating, collaborating with occupants to improve resilience and incorporate passive and active measures where needed.
- Critical building services, such as ventilation systems, should be regularly maintained to mitigate overheating.
- Passive measures should be prioritised over active measures to minimise energy consumption and the potential for increased operational costs.
- Owners and occupiers should consider temporary, rapidly deployable measures that they could prepare in advance of hot weather[71].

Insurance providers

- Insurance providers should require heat resilience measures as a condition of coverage, to drive sector-wide adoption.
- Climate resilience works should be carried out by qualified contractors to ensure effective implementation

Education providers

- Integrate climate resilience education into school and college curricula, using practical examples.
- University courses in architecture, planning, and engineering should include climate change and climate resilience elements and/or modules.

STORMS

Increased storm intensity and frequency pose significant risks to buildings and infrastructure, leading to potential damage from high winds, heavy rainfall and flooding. This section presents design recommendations for enhancing storm resilience, and guidance on incorporating storm resilience into planning, insurance and education settings.

KEY RECOMMENDATIONS FOR ADDRESSING STORM RISK

- Strengthen infrastructure by retrofitting roofs and securing power lines[72].
- Reinforce coastal defences to reduce damage from storm surges.
- For new builds, give greater consideration to siting, orientation, design and materials that can withstand high winds and gusts[73].
- For retrofits, incorporate features such as stronger doors and windows[74].

RECOMMENDATIONS FOR BUILT ENVIRONMENT STAKEHOLDERS

Local planning authorities and regulatory bodies

- Enhance forecasting systems and coordinate emergency response efforts.
- Establish community-based preparedness programmes to improve local storm resilience[75].

Building owners and occupiers

- Develop an emergency preparedness plan that includes planning for high winds[76].
- Conduct regular maintenance checks on external facades, roofs, roof-mounted structures and building services for loose or damaged materials that could be at risk from high winds and gusts.

Insurance providers

- Offer risk-based pricing and incentives to building owners who install for storm-resistant measures.

Education providers

- Promote storm-resistant building codes and professional training for contractors.

DROUGHT

Drought conditions are intensifying due to changing climate patterns, putting pressure on water resources and affecting building operations. This section outlines design recommendations for addressing drought risk and provides guidance for stakeholders on integrating drought resilience into planning, building operation and long-term strategies.

KEY RECOMMENDATIONS FOR ADDRESSING DROUGHT RISK

- Implement water-saving measures such as greywater recycling and rainwater harvesting, where feasible.
- Use water-efficient fixtures and promote water-retentive landscaping.
- Design drought-tolerant landscaping to reduce the need for irrigation or watering.

RECOMMENDATIONS FOR BUILT ENVIRONMENT STAKEHOLDERS

LOCAL PLANNING AUTHORITIES AND REGULATORY BODIES

- Improve regional water-sharing agreements and reduce water leakage.
- Develop flexible water management policies for drought conditions.
- Require water stress risk assessments in Local Plans or supplementary planning documents.
- Work with industry to define "water-positive" development, and develop policies and regulations to encourage, and eventually enforce it, as water scarcity becomes an increasing threat.

BUILDING OWNERS AND OCCUPIERS

- Promote water-saving behaviours and smart irrigation systems to reduce water consumption.

WILDFIRE

As wildfires grow more frequent and severe, they pose a growing threat to buildings, infrastructure and the natural environment, particularly in areas prone to dry conditions and elevated temperatures. This section presents design recommendations for reducing wildfire risk, based on wildfire modelling undertaken by Hydrock now Stantec, focusing on landscape and fuel management. It also offers guidance for stakeholders on integrating wildfire risk reduction into planning, policy development, and long-term asset management strategies.

KEY RECOMMENDATIONS FOR ADDRESSING WILDFIRE RISK

- Ensure that fire-resistant materials, defensible spaces, and fire-safe landscaping have been designed in, especially in high-risk zones.
- **Commercial buildings:** Incorporate fireproof design, and ensure fire suppression systems are updated regularly.
- **Public buildings:** Install advanced fire suppression systems and develop clear evacuation procedures.
- **Healthcare facilities:** Ensure backup power supplies are protected and use fire-resistant materials in wildfire-prone regions.

RECOMMENDATIONS FOR BUILT ENVIRONMENT STAKEHOLDERS

LOCAL PLANNING AUTHORITIES AND REGULATORY BODIES

- Conduct risk analysis and mapping of the local area to identify the highest risk areas[77,78].
- For high-risk areas, create evacuation decision-making models and organise evacuation drills to prepare communities[79,80].
- In rural areas, support land management practices that minimise fire risk, such as rewetting and rewilding, through environmental land management schemes.
- In urban areas, provide guidance on managing green spaces and municipal waste to minimise fire risk.

BUILDING OWNERS AND OCCUPIERS

- Stay informed about wildfire risks by using climate data to predict changes in fire patterns and incorporating this into emergency preparedness plans[81,82].
- Following a wildfire event, adopt management strategies such as reducing flammable vegetation and working to restore ecosystems[83].

EDUCATIONAL RECOMMENDATIONS

- Promote understanding of wildfire risks, including practical fire prevention measures such as clearing dry vegetation, and encourage fire-safe behaviours.

7

RECOMMENDATIONS FOR SUSTAINING RESILIENCE

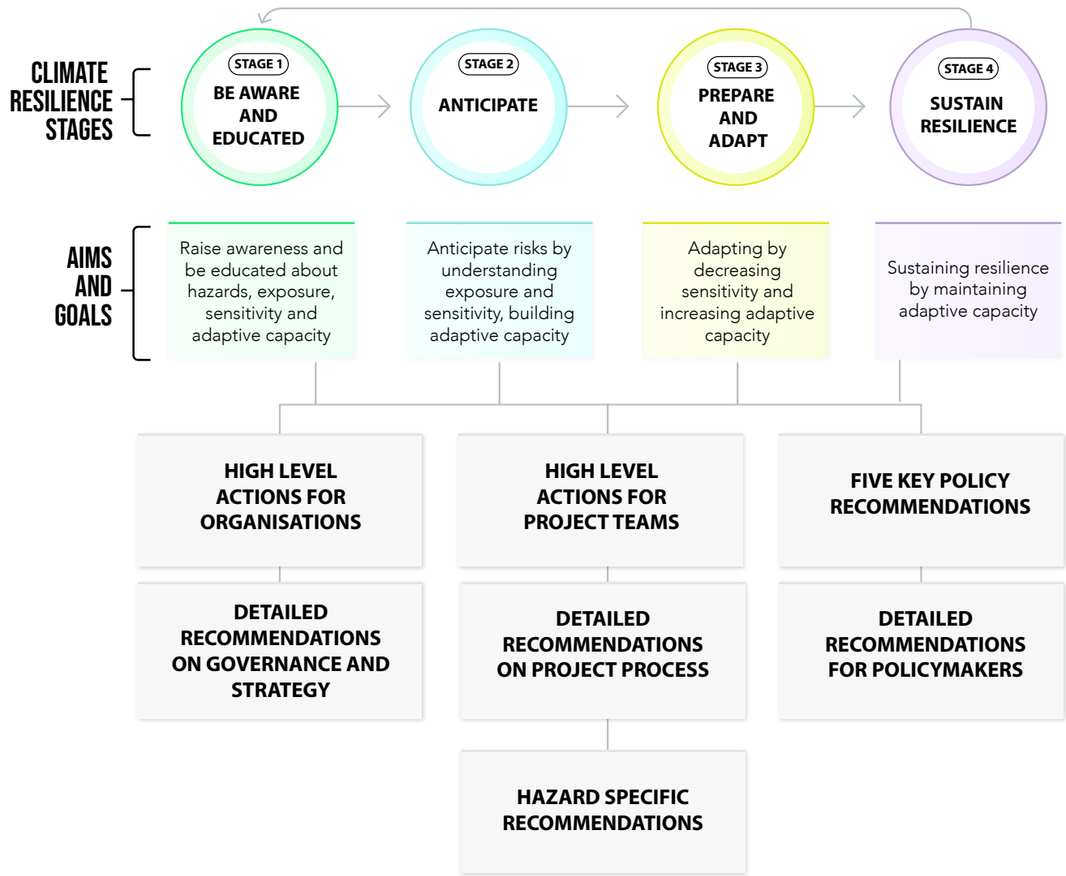
This section offers detailed recommendations for integrating climate resilience for organisations, project teams, and policy-makers.

Additionally, it offers recommendations for organisations seeking to integrate climate resilience into their organisational strategy, following the four pillars of the Task Force on Climate-Related Financial Disclosures (TCFD) framework. This section also highlights critical actions for project teams to consider at each stage of the RIBA Plan of Work, to ensure climate resilience is embedded throughout project lifecycles. Finally, it explores recommendations for financing climate resilience in the built environment.

HOW THE STAGES ARE STRUCTURED

Industry-level aims, goals, and high-level actions are proposed for each stage to allow ongoing progress, in a structured yet flexible way. Figure 13 shows the role of these elements at each of the four stages, and how they inform high-level and detailed recommendations, to guide the industry and create a policy environment that supports progress on climate resilience across the built environment.

Figure 13: Diagram showing the connection between the aims, goals and actions for each one of the four stages of the climate resilience framework (see Figure 6).



STAGE ONE: BE AWARE AND EDUCATED

1.1 AIM:

All stakeholders are actively informed of climate hazards, vulnerabilities, and potential cascading impacts. Through ongoing education, everyone understands their role in resilience and can anticipate future hazards, enabling well-informed, timely decisions.

1.2 GOALS

Table 2: Industry goals under the first stage of building climate resilience - be aware and educated.

BE AWARE AND EDUCATED	Organisations	Project teams	Policy-makers
INCREASING AWARENESS AND KNOWLEDGE OF HAZARDS, EXPOSURE AND SENSITIVITY	Individuals are aware of relevant climate-related hazards, and the exposure and sensitivity of people, assets and the natural environment.	Stakeholders involved in the design, construction, management and ownership of new homes, buildings and developments, and in retrofitting existing ones, are educated about relevant climate hazards, their impacts on long-term, chronic climate stresses and short-term climate shocks, and the exposure and sensitivity of assets, as well as the regulations required to facilitate climate resilience.	Central Government, devolved administrations and local authorities, including public authorities responsible for urban resilience and climate adaptation, are aware of and educated about climate-related hazards and their impacts on long-term, chronic climate stresses and short-term climate shocks, as well as exposure, sensitivity and adaptive capacity. They understand how each of these could affect the places they are responsible for, including vulnerable populations and priority areas.
INCREASING AWARENESS AND KNOWLEDGE OF ADAPTIVE CAPACITY	Stakeholders are aware of the adaptive capacity required to ensure resilience and sustained functionality in response to long-term, chronic climate stresses and short-term climate shocks, and of how to increase adaptive capacity, including the finance and resources needed to achieve climate resilience.		Devolved administration and local authority stakeholders are aware of the policies required to increase the adaptive capacity of people and the built environment.

1.3 ACTIONS

Table 3: Industry actions under the first stage of building climate resilience - be aware and educated

Organisations	Project teams
☐ Implement mandatory climate-related hazard awareness and education programmes for employees, especially decision-makers, ensuring that each understands the key climate hazards of long-term chronic climate stresses and short-term climate shocks where they operate. ☐ Encourage knowledge-sharing sessions to foster a culture of awareness and action across and beyond the organisation. ☐ Use open data platforms and databases on climate hazards to stay informed about current and future climate scenarios locally and nationally. ☐ Share any relevant data your organisation holds to raise industry and public awareness and empower communities to respond effectively to climate hazards. ☐ Review documented lessons from past climate resilience projects to inform improvements. ☐ Share insights across the industry to increase awareness and knowledge of challenges.	☐ Ensure individuals responsible for the design, planning and execution of projects have undertaken relevant climate-resilience training. This should cover climate-related hazards, both long-term chronic climate stresses and short-term climate shocks, the exposure and sensitivities of people and assets, as well as relevant regulations, so that each individual understands how to integrate climate resilience into their work at every stage of the building lifecycle.

STAGE TWO: ANTICIPATE

2.1 AIM:

All built environment stakeholders have the resources to assess risks of both long-term, chronic climate stresses and short-term climate shocks taking into consideration vulnerabilities, cascading impacts, and the potential unintended consequences of decisions.

2.2 GOALS

Table 4: Industry goals under the second stage of building climate resilience - anticipate.

	Organisations	Project teams	Policy-makers
UNDERSTANDING EXPOSURE & SENSITIVITY	Stakeholders conduct climate risk assessments for their operations, considering exposure and sensitivity to long-term, chronic climate stresses and short-term climate shocks, both present and future.	Stakeholders involved in design, construction, refurbishment and retrofitting contribute to project climate risk assessments.	A national assessment of hazards arising from climate change is undertaken at regular intervals, including progress on adapting to both long-term, chronic climate stresses and short-term climate shocks. Central and devolved governments ensure that climate resilience is appropriately considered within legal, planning and financial systems and that local authorities are given sufficient information and resources to prepare.
	Stakeholders identify how their decisions may impact not only individual projects but also broader climate resilience strategies, while leveraging the co-benefits of resilience measures. They take steps to avoid unintended negative consequences for people and the natural environment that could arise from implementing climate resilience measures.		
	All stakeholders measure and monitor exposure, understanding the sensitivity of buildings and people to long-term, chronic climate stresses and short-term climate shocks, both present and future, on an ongoing basis, using an iterative process.		
DEVELOPING ADAPTIVE CAPACITY	Organisations investigate options for developing and enhancing their adaptive capacity, including the availability of adaptation finance.	Stakeholders involved in design, construction, refurbishment and retrofitting investigate options for developing and enhancing physical and social adaptive capacity through the delivery of the project, including adaptation finance.	

2.3 ACTIONS

Table 5: Industry actions under the second stage of building climate resilience - anticipate.

Organisations	Project teams
☐ Develop and integrate climate risk assessments into organisational strategies, ensuring that adaptation and resilience are considered at all stages. ☐ Develop and integrate a climate hazard monitoring system to assess the exposure and sensitivity of the organisation, its assets and people to current and future climate hazards. Use this information to inform strategies and operational decisions. ☐ Organisations including investors subject to climate-related financial disclosure requirements should initiate development of comprehensive adaptation and transition plans, incorporating both adaptation and resilience strategies for future-proofing investments.	☐ Use metrics and indicators to monitor climate hazards relevant to the project location. ☐ Integrate climate risk assessments into health & safety protocols for new buildings, ensuring that climate hazards are considered during the design, construction and operation phases. ☐ Engage with local authorities, communities and experts throughout the planning and development process to ensure alignment on local climate hazards, fostering broader climate resilience and addressing community vulnerabilities. ☐ Consider and leverage the co-benefits of nature-based solutions as a key step towards supporting climate resilience in buildings.
☐ Assess and identify risks to current and planned assets based on local climate hazards, integrating resilience measures that increase adaptive capacity at asset management and investment strategy level.	☐ Conduct comprehensive assessments of adaptation strategies and finance options to increase the adaptive capacity of projects and organisations, ensuring the integration of climate resilience measures into design, construction and retrofitting.

STAGE THREE: PREPARE AND ADAPT

3.1 AIM:

All stakeholders within the built environment work to decrease sensitivity to hazards and increase adaptive capacity by incorporating behavioural, strategic and physical climate adaptation measures into built structures, to support communities, environments and organisational strategies. Local authorities and government bodies drive the implementation of these measures through local and national adaptation plans. Stakeholders collaborate to apportion responsibilities and advance the shared goal of climate resilience.

3.2 GOALS

Table 6: Goals under the third stage of building climate resilience - prepare and adapt.

<table>
<tr><th></th><th>Organisations</th><th>Project teams</th><th>Policy-makers</th></tr>
<tr><td rowspan="2">DECREASING SENSITIVITY</td><td>All stakeholders use insights collected from monitoring the sensitivity of buildings and people to adapt for long-term, chronic climate stresses and short-term climate shocks, both present and future.</td><td>All new homes, buildings and developments are designed with adaptation measures tailored to their level of risk, to reduce sensitivity to long-term, chronic climate stresses and short-term climate shocks, both present and future.</td><td rowspan="2">All existing homes and buildings are adapted with measures tailored to their level of risk, to reduce sensitivity to long-term, chronic climate stresses and short-term climate shocks, both present and future.

All shared and public spaces are adapted to reduce sensitivity to present and future long-term, chronic stresses and short-term climate shocks, appropriate to their level of risk, prioritising the integration of nature-based solutions and green and blue infrastructure.</td></tr>
<tr><td colspan="2">All stakeholders collaborate to explore, develop and secure diverse financial mechanisms to reduce sensitivity to long-term, chronic climate stresses and short-term climate shocks within organisations and on projects.</td></tr>
<tr><td rowspan="2">INCREASING ADAPTIVE CAPACITY</td><td>Accessible finance mechanisms that support climate adaptation initiatives are enacted and scaled up, enabling climate adaptation measures to be implemented within organisations and on projects.</td><td>Local authorities have the resources and skills needed to adapt priority areas that are vulnerable to climate impacts, while also ensuring there is sufficient capacity to respond quickly to hazards and facilitate rapid recovery of affected areas.</td></tr>
<tr><td colspan="3">All stakeholders have adopted a shift in mindset and embraced behavioural changes that strengthen climate resilience and cross-sector collaboration, recognising their shared responsibility, while upholding regenerative and just perspectives in developing and implementing climate adaptation measures.</td></tr>
</table>

3.3 ACTIONS

<table>
<tr><th>Organisations</th><th>Project teams</th></tr>
<tr><td colspan="2">☐ Organisation and project leaders should adopt a resilience-oriented mindset, focusing on behavioural changes that enable them to prepare for and adapt to climate hazards and their impacts.

☐ Maintain channels of conversation with built environment subsectors, sharing challenges, solutions and best practice to support climate resilience.

☐ Organisations should collaborate with public, private and community stakeholders to secure funding to reduce sensitivity to climate hazards. Collaborative partnerships using funds such as green bonds can address climate stresses and shocks in the short and long-term.</td></tr>
<tr><td>☐ Develop a response plan to manage and mitigate the effects of acute climate shocks and the ongoing, worsening impacts of chronic climate hazards, informed by monitoring and open, shared data.

☐ For existing developments, organisations should use climate risk assessments and modelling tools to identify vulnerabilities and evaluate cost-effective, scalable adaptation options, prioritising solutions with multiple co-benefits.

☐ Implement and scale up adaptation finance options to increase the adaptive capacity of organisations.</td><td>☐ Integrate climate resilience and adaptive capacity into new and retrofitted buildings from the outset, with measures tailored to local climate hazards and needs. This process should prioritise methods of construction that minimise energy use, and which are aligned with circular economy principles, such as avoiding the use of virgin materials.

☐ Ensure that adaptation finance for projects is requested and accessed by establishing clear processes for identifying relevant opportunities and integrating them into organisational strategies.</td></tr>
</table>

STAGE FOUR: SUSTAIN RESILIENCE

4.1 AIM:

All stakeholders within the built environment collaborate to maintain adaptive capacity, following appropriate principles and practices to continually improve climate resilience.

4.2 GOALS

Table 8: Goals under the fourth stage of building climate resilience - sustain resilience.

	Organisations	Project teams	Policy-makers
MAINTAINING ADAPTIVE CAPACITY	Incorporate lessons learned, insights and feedback from climatic changes and extreme hazard events into risk assessments and adaptation plans and strategies. Continue to collaborate across sectors, strengthening systemic approaches to and actions for climate resilience. Monitor the vulnerability of the built environment to long-term, chronic climate stresses and short-term climate shocks, using clear metrics and indicators of adaptive capacity. Respond to climate-related hazards by implementing adaptation and response plans that increase adaptive capacity, and by taking actions that support the recovery of the built environment following hazard events. Work to restore and maintain the adaptive capacity of aspects of the built environment affected by long-term, chronic climate stresses and short-term climate shocks.		The UK's climate adaptation strategy is led, and maintained, by central and devolved governments with roles and responsibilities made clear.

4.3 ACTIONS

Table 9: Actions under the fourth stage of building climate resilience - sustain resilience.

Organisations	Project teams
☐ Integrate lessons learned from past long-term, chronic climate stresses and short-term climate shocks into risk assessments and adaptation strategies, to ensure continuous improvement in climate resilience planning.	
☐ Actively collaborate across sectors to foster systemic approaches to climate resilience, sharing knowledge, resources and expertise to strengthen collective action.	
☐ Metrics and indicators should be used across organisations and on projects to monitor vulnerability on an ongoing basis.	
☐ Execute adaptation and response plans that increase the adaptive capacity of the built environment, focusing on measures that address present and future climate hazards.	
☐ Data and guidance on solutions should be openly shared and kept up to date.	
☐ Prioritise restoring and maintaining the adaptive capacity of the built environment to withstand the long-term, chronic climate stresses and short-term climate shocks, ensuring resilience over time.	

RECOMMENDATIONS FOR ORGANISATIONS

Integrating climate resilience into the operations of asset owners and occupiers is essential for long-term risk reduction. This section offers practical recommendations for strengthening organisational approaches to climate resilience, specifically aimed at those managing multiple assets or portfolios.

The recommendations are presented as a set of checklists and guides, enabling organisations to conduct self-assessments and identify areas for improvement. Designed to be actionable, these resources also align with the requirements of IFRS S2 on climate-related disclosures.

The recommendations cover governance, strategy, risk management, and metrics and targets. These key elements are relevant to the four stages of the Roadmap process:

KEY RECOMMENDATIONS

1

BE AWARE AND EDUCATED

Understanding how climate resilience can be integrated into governance structures using the governance rating system.

2

ANTICIPATE

Establishing a risk management process using the risk management framework.

3

PREPARE & ADAPT

Using the strategy checklist to create a climate resilience strategy for mitigating, minimising or managing climate-related risks.

4

SUSTAIN RESILIENCE

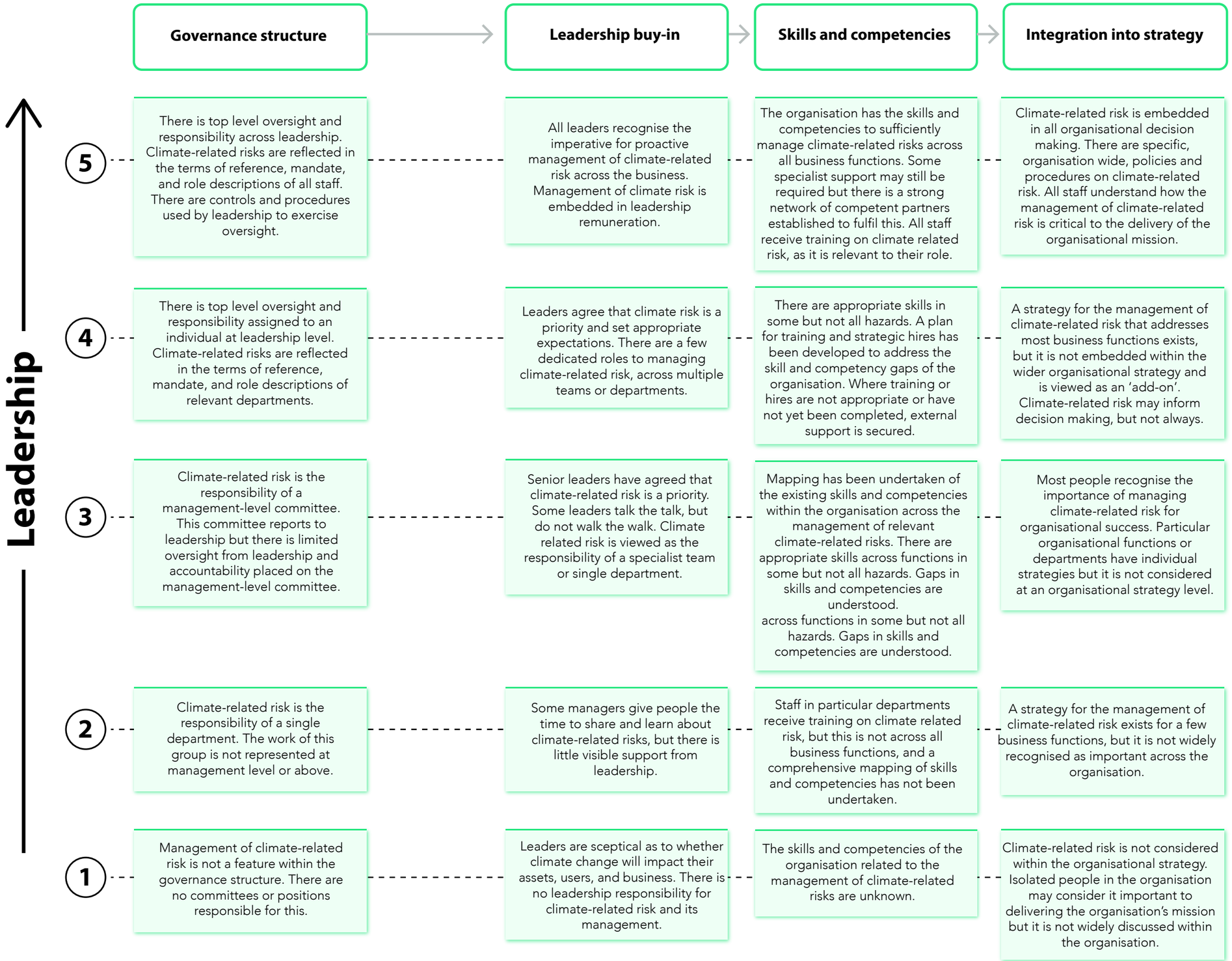
Using the principles for metrics and targets to continue to measure progress on increasing resilience to climate hazards.

GOVERNANCE

Figure 14 provides organisations with a framework for assessing their leadership in climate resilience, and identifying strengths and areas for improvement.

It is structured as a five-level rating system covering key elements of governance: governance structures, leadership buy-in, skills and competencies, and integration into organisational strategy.

Figure 14: A five-level rating system for assessing leadership on climate resilience within organisational governance



Key recommendations

1. Be aware and educated
2. Anticipate
3. Prepare and adapt
4. Sustain resilience

STRATEGY

Figure 15 provides a structured approach for developing a climate resilience strategy that is impactful, achievable and appropriately resourced. It guides organisations through key steps and considerations, such as scenario analysis, defining timeframes and establishing roles, responsibilities and accountability.

Figure 15: Checklist for incorporating climate-related risks into organisational strategy.

STRATEGY CHECKLIST

Develop a strategy for mitigating, minimising or managing climate-related risk that is impactful, deliverable and resourced.

- In the preparation of the strategy the organisation has **undertaken scenario analysis to inform the identification and prioritisation of climate related risks**. Scenarios are constructs; they need not represent a full description of the future, but rather to highlight central elements of a possible future and be used to challenge conventional wisdom and enhance critical thinking. IEA (International Energy Agency) or IPCC (Intergovernmental Panel on Climate Change) scenarios may be the basis for these.
- The strategy should **establish clear timeframes**. These timeframes will be informed by organisational needs and context. Organisations might consider aligning with national reporting cycles and disclosure requirements. This would mean that strategies should set long term objectives (e.g. 2050-2080) and high-level strategies over this period. More detailed strategies should be developed over periods of five-year intervals, and progress evaluated progress annually or at least every two years.
- The strategy **describes the climate-related risks** that could reasonably be expected to affect the mission and portfolio of assets for which the organisation is responsible. This should include the nature of the hazard and the impact on business performance, asset condition, user wellbeing and safety, and natural systems.
- The strategy should document how the entity is resourcing, and plans to resource, the activities, and planned sources of funding to implement the strategy. In addition, the strategy should **identify the roles, responsibilities and accountability** for delivering the strategy.
- The strategy should **identify the metrics and targets** the organisation has set in relation to climate-related risk. It should transparently document quantitative and qualitative information about the progress made within the reporting period against these.
- The strategy should **document the key assumptions** made in the analysis of risk and management plan. Including assumptions about the methodology followed, climate scenarios and time horizons considered, vulnerability, developments in technology, or otherwise.
- The strategy should contain **information about how the entity has responded to, and plans to respond to, climate-related risks** in its strategy and decision-making. This may include the approach to stakeholder engagement, acquisitions and disposals, the roadmap for asset upgrade works, or the development of in-house skills and competencies.
- The strategy is both suitably technical and diligent but is also **understandable** to a range of non-technical users as well as appropriate for financial reporting and disclosure. This may require multiple documents, for different stakeholders, to be produced.

RISK MANAGEMENT

Figure 16: Framework for identifying, assessing and responding to climate-related risks.

Figure 16 provides a structured framework for identifying, assessing and responding to climate-related risks, ensuring that they are effectively managed over time. It guides organisations through six key stages: defining objectives, identifying appropriate hazards, assessing potential impacts, prioritising impacts, developing response strategies, and establishing ongoing monitoring processes.

Those managing portfolios have processes to identify, assess, prioritise and monitor climate related risks.

DEFINE

- Establish the level of detailed needed for the assessment to be fit for purpose.
- Specify the range of assets at risk, developing architypes if needed.
- Identify the vulnerabilities and needs of users and the built and natural environment at risk.
- Determine the time horizon of the assessment. Consider the lifetime of assets and contracts.
- Establish the availability of financial, human and technical resources and information required to complete the study.
- Determine the future climate scenarios that will be considered within the study. The latest available data sets from the Met Office (UKCP18) are based on RCPs. The difference between SSPs and RCPs is explained here.

IDENTIFY

- Identify the hazards that could, over the selected time horizon and within the multiple climate scenarios, impact the asset(s).
- The C40 Cities City Climate Hazard Taxonomy could be utilised as a starting point for understanding hazards.
- For each of the hazards identified as relevant to the assessment consider producing an ‘impact chain’ to better understand the factors that drive risk. Annex C of BSI EN ISO 14091: Adapting to Climate Change provides guidance on how to prepare ‘impact chains’.

ASSESS

- For each asset/architype, an assessment of the following should be undertaken for each climate scenario and at intervals across the time horizon adopted: Exposure of the asset to the hazard, Sensitivity of the asset to the hazard, Potential impact (without adaptation).
- Indicators could be set for each hazard to help determine the magnitude of the exposure and sensitivity.
- The assessment should be undertaken based on the best information available to the organisation.
- Organisations may have their own due diligence processes in place. In which case, consider reviewing the requirements of this to systems such as BSI EN ISO 14091. Where these do not exist already in the organisation consider aligning with this.

PRIORITISE

- Based on the outcomes of the previous stage, the impacts across each architype should be prioritised.
- Impacts where there is high exposure, high vulnerability and low existing adaptive capacity should be classed as highest priority.
- Co-benefits should be considered, such as ecological improvements from nature-based solutions or community strengthening from emergency response planning.
- Cost implications of not responding to climate change impacts should also be considered.

RESPOND

- Across the impacts, the organisation should then prepare a programme of actions to avoid, mitigate, or manage the expected impact across the asset typologies.
- Actions should be coordinated with decarbonisation activities and may include capital project works, revision of design codes, alterations to acquisitions and disposal strategy, or capacity building.
- Recognising the uncertainty of climate change, an adaptive approach should be taken. Whereby possible future actions are identified but not initiated until a future time when a particular threshold is reached, providing more certainty of the climate may change and magnitude of risk expected. See BSI EN ISO 8631.
- The programme of actions should be accompanied by an implementation plan that identifies the specific tasks, responsibilities and timeframe for delivering these.
- Costing of the implementation plan should be considered in the context of avoided costs associated with climate change impacts.
- Consider how climate-related risks are coordinated with the organisations wider transition planning. The Transition Plan Taskforce Disclosure Framework provides a benchmark for the preparation of climate transition plans.

MONITOR

- The organisation should establish processes and related policies that ensure the continuous monitoring and disclosure of climate impacts on assets.
- Metrics should be established which enable the effectiveness of mitigation and management responses to be monitored.
- Progress should be reported into the leadership who have oversight and fed into decision making and strategy.
- The organisation should embed the process for identifying, assessing, prioritising and monitoring climate-related risks into the entity’s overall risk management process.
- The vulnerability assessment should be reviewed and updated periodically, in line with strategy timelines. This may include reviewing appropriateness of the initial scope of the assessment.

METRICS AND TARGETS

Figure 17 provides guidance on setting meaningful metrics to track and communicate progress, including key principles for their development and examples of commonly used metrics and indicators. Additional examples can be found in Appendix B to support organisations in selecting the most appropriate for their needs.

Figure 17: Principles for setting metrics and targets.

METRICS AND TARGETS

Establish metrics and targets to track performance and communicate this externally.

Principles for setting metrics and targets

1. **Encourage cross-organisational participation** in the creation of metrics and targets, to develop shared ownership.
2. **Don't set too many targets** such that the management of these becomes unwieldly. Focus on selecting a smaller number of metrics orientated around critical objectives.
3. **Anticipate and plan for change** by allowing flexibility in both the metric and target. How the climate will change is uncertain and relies on global collective action.
4. **Empower people** through designing metrics such that the contribution of individuals is obvious and meaningful in their day-to-day work. Teams will need to be given the tools, structure and support to deliver these.
5. **Design accountability structures** that ensure the targets are embedded throughout the organisation.

Example metrics from IFRS S2 Appendix B Industry-based Disclosure requirements

Water Management

1. Water withdrawal data coverage as a percentage of (1) total floor area and (2) floor area in regions with High or Extremely High Baseline Water Stress, by property subsector.
2. Like-for-like percentage change in water withdrawn for portfolio area with data coverage, by property subsector
3. Description of water management risks and discussion of strategies and practices to mitigate those risks

Management of tenant sustainability impacts

1. (1)Percentage of new leases that contain a cost recovery clause for resource efficiency-related capital improvements and (2) associated leased floor area, by property subsector
2. Percentage of tenants that are separately metered or sub-metered for water withdrawals, by property Subsector
3. Discussion of approach to measuring, incentivizing, and improving sustainability impacts of tenants

Climate change adaptation

1. Area of properties located in 100-year flood zones, by property subsector
2. Description of climate change risk exposure analysis, degree of systematic portfolio exposure, and strategies for mitigating risks

Example metrics adapted from Annex E of BSI ISO 14091 Adaptation to Climate Change

Hazard

1. Temperature: Number of nights with $T_{(min)}$ above 25°C
2. Precipitation: Number of months with rainfall below 50 mm
3. Wind: Increase in average wind speed OR number of storms above a certain wind speed

Exposure

1. Distribution of assets in flood-prone areas
2. Distribution of assets affected by serious mean temperature rise
3. Distribution of assets affected by sea level rise

Sensitivity

1. Water demand (m^3) per asset (m^2)
2. Existence of early warning systems
3. Percentage of population that is vulnerable (e.g. young or elderly people)

Adaptive capacity

1. Percentage of income available for climate adaptation measures
2. Assessment of training needs for addressing climate change
3. Resourced climate change adaptation plan of action

RECOMMENDATIONS FOR PROJECT TEAMS

This section provides those commissioning, designing and constructing built assets with a framework for ensuring developments are prepared for and resilient to the impacts of climate change. It sets out the process and actions that a project team should undertake during the brief writing, design development and construction stages.

This is intended as a starting point, given the complexity of the topic and many interdependencies that exist. Consideration should be given throughout to vulnerability, stakeholder engagement and the protection and regeneration of natural systems.

Organisations across the built environment will be at different stages of embedding resilience in their work, but this resource has been designed to be relevant and useful to the broadest possible cross-section. For some, it may be useful in its entirety; for others, only parts will be novel.

Figure 18 maps the key actions and considerations across the RIBA Plan of Work for each of the five key hazards considered within the Roadmap.

Figure 18: Guidance for project teams on embedding climate resilience at each of the RIBA Plan of Work stages

	0 Strategic definition	1 Preparation and briefing	2 Concept design	3 Spatial coordination	4 Technical design	5 Manufacturing & Construction	6 Handover	7 Use
STAGE OUTCOME	The best means of achieving the client requirements confirmed.	Project brief approved by the client and confirmed that it can be accommodated on the site.	Architectural concept approved by the client and aligned to the project brief.	Architectural and engineering information spatially coordinated.	All design information required to manufacture and construct the project completed.	Manufacturing, construction and commissioning completed.	Building handed over, aftercare initiated and building contract concluded.	Building used, operated and maintained efficiently.
CROSS-CUTTING ACTIONS FOR CLIMATE RESILIENCE	Embed clear requirements within the project brief for climate risk assessments to be undertaken, including determining the future climate scenarios against which you wish the design to be tested. When procuring consultants, require teams to demonstrate a holistic approach to climate resilience, including consideration of vulnerability, stakeholder engagement and nature protection.	Ensure that project budget and design fees allow for iterative design development and incorporation of resilience measures. Ensure that climate resilience is embedded within the project RACI matrix. Establish the design life of the building. Undertake robust screening to identify possible climate risks and impacts to be addressed in subsequent stages.	Assess climate-related vulnerability, risks and impacts across the lifetime of the proposed development, ensuring that multiple climate scenarios are evaluated. Develop strategies to avoid, mitigate or manage impacts under these scenarios, including strategies to be integrated into the current design and future actions to be taken when there is greater certainty on impacts. The project team should identify how the building can be made flexible and adaptable to accommodate any future actions. Recognise that climate risks are interconnected, and multiple hazards may occur simultaneously, potentially causing cascading events. As design responses to multiple hazard events are not always feasible or appropriate, a combination of physical and management strategies should be considered. Consider and account for potential co-benefits of solutions, such as ecological or community benefits.	Consider working with nature as a first priority to harness its inherent capacity to mitigate and provide adaptive solutions to climate risks. Embed key climate risks within any value-engineering exercises. The impact of proposed cost-saving measures should be assessed against these and the impact they may have on occupant wellbeing and productivity, business continuity and future remedial actions.	Ensure that construction management plans and site management plans account for potential climate risks. Risks should be identified that may impact construction works and sequencing, or supply chain issues, but also the health and safety of workers. Ensure that the construction is undertaken in line with the approved design.	Produce a technical Building User Guide (BUG) prior to handover to ensure facilities management teams understand how to operate and maintain installed resilience measures and strategies. Produce a non-technical BUG prior to handover with a clear explanation of each climate hazard and how users can respond. Set out where the design allows for future flexibility within the BUG or O&M manuals, clearly highlighting potential maladaptations.	Commission a post-occupancy evaluation (POE) that includes an assessment of installed resilience measures and occupant satisfaction, as relevant to the key climate hazards. Ensure regular maintenance and repair of the asset is undertaken, including establishing clear roles, responsibilities and accountabilities for managing climate risk across the asset. Consider ongoing assessment of vulnerability and stakeholder needs as the occupancy changes. Consider reporting actions taken and their effectiveness as part of wider ESG reporting activities (including TCFD/IFRS disclosures). Establish metrics that enable the effectiveness of mitigation and management responses to be monitored (see Appendix B).
MANAGING RISK TO ASSETS FROM FLOODING	Undertake an initial assessment of the flood risk to the site, using publicly available datasets from the Environment Agency.	Appoint a consultant to provide appropriate flood risk design advice covering the as-built project and construction stages, and to undertake a flood risk assessment (FRA).	Undertake a site-specific assessment that includes appropriate allowances for climate change, as per Environment Agency and local authority guidance for the location. Consider flood risk from all sources and the impact that the development with have on flooding elsewhere. Embed measures to reduce or manage flood risk into the design, such as safe evacuation routes, spatial allowance for safe refuge, provision of flood storage areas and flood warning systems. Consider the potential of nature-based solutions and natural systems, as well as the associated co-benefits.	Ensure FRA requirements are embedded throughout the design and construction process. Integrate the required strategies into the spatial coordination, technical design, and manufacturing and construction of the building.	Consider recovery of the asset following a flood event, including protection of critical infrastructure, location of electrical sockets at high level, and flood-resistant materials that will not need replacement. Coordinate with the contractor to ensure that any design changes do not impact the proposed flood control measures. Consider the likelihood and impact of a flood event during construction, both on-site or impacting the supply chain, and take appropriate measures to reduce the associated risks.		Embed key elements of the FRA within the BUG and other documents as appropriate, to ensure that building users are aware of the flood risk and the required response measures. Integrate the flood warning and evacuation plan into building safety processes and documentation.	Update the flood warning evacuation plan on a regular basis in line with changes to the building and/or updates to local or national flood management approaches. Ensure that there is a robust plan for maintenance works in place with roles and responsibilities clearly outlined so that flood measures are appropriately maintained and not compromised by other works.

MANAGING RISK TO ASSETS FROM HIGH TEMPERATURES

0 Strategic definition

Require the appointment of a specialist to assess overheating risk within the brief. Clearly identify the need to test the building against multiple future climate scenarios and align with industry best practice (e.g. CIBSE TM59, CIBSE Guide A, Part O). Ideally, identify the relevant datasets that the project team will be required to use in later stages of the project.

Undertake an initial site assessment to identify

1 Preparation and briefing

the feasibility of natural ventilation strategies, as relevant to the context of the building. This may include a site opportunities and constraints assessment (for example, covering acoustics, security and air quality).

Establish the relative vulnerability of building users and any specific consideration that should be given to the impacts of heat on their wellbeing (e.g. older people, children).

2 Concept design

Use relevant design guidance and methodology (e.g. CIBSE TM59, CIBSE Guide A, Part O) to inform the design. Stress-test the development against multiple CIBSE Design Summer Year (DSY) weather files for current and future years, ensuring that the most recent data is used, to determine the risk of overheating.

Develop strategies that demonstrate compliance with overheating performance criteria over the projected life of the building, under the

3 Spatial coordination

climate scenarios specified in the brief. These strategies may be either installed within the initial construction stages, or the design may allow for future flexibility so that they can be installed in future years. The strategy should work for the initial design life of the building systems and elements, and ensure it is able to accommodate future systems or elements. For air-conditioned spaces, especially where there are business-critical services, ensure plant sizing allows

4 Technical design

for potential future temperatures.

Consider the potential of nature-based solutions and natural systems, as well as the associated co-benefits.

Within the context of the building design life, establish the design life for relevant building systems and elements.

Undertake a comparative review of the thermal loading guidelines provided in the National Annex to Eurocode 1, BS EN 1991-1-5 relative to the

5 Manufacturing & Construction

projected changes in external temperatures under multiple climate scenarios. Use the outcomes to inform the basis of design.

Iteratively test the design proposals against the thermal comfort criteria as the design development progresses. Ensure that there is coordination between the project team and contractor so that any proposed changes do not impact the proposed (current or future) overheating mitigation strategies.

6 Handover

Complete post-construction testing and inspection of the building fabric including air-tightness testing, thermographic surveys and site inspections. Rectify any defects identified during post-construction testing and inspection prior to building handover.

Develop a schedule of commissioning in line with the relevant standards, and appoint a project team member to monitor and programme pre-commissioning, commissioning, testing and, where necessary, re-commissioning activities on behalf of the client.

7 Use

Undertake actual measurements of indoor temperatures throughout the year within the POE process, and ask building users about their perceived thermal comfort,

including their ability to control their environment.

Test all building services under full load conditions (i.e. heating equipment in mid-winter, cooling and ventilation equipment in mid-summer) and under part

load conditions (in spring and autumn) under high and low occupancy. Recommission systems as required.

Produce a management plan that includes actions and strategies for high temperatures.

This may include early warning systems, signage, awareness raising, and coordination with the security strategy, as well as emergency response strategies.

Ensure that there is a robust plan for maintenance works in place with roles and responsibilities clearly outlined.

MANAGING RISK TO ASSETS FROM STORMS (wind, rain, snow)

0 Strategic definition

Undertake an initial assessment of the risk to the asset from storms.

Assess whether a more detailed risk assessment is required using the building consequence

1 Preparation and briefing

class together with an assessment of future storm frequency and intensity due to climate change.

Ensure the brief requires a further specialist study as appropriate.

2 Concept design

Develop the initial design in line with relevant British Standards, accounting for any project specific requirements that should be highlighted through the brief and a workshop.

Review the National Annexes of the relevant British Standards to assess whether the design requirements for wind speeds (Part 4) and

3 Spatial coordination

precipitation loads (Part 3) are in line with future climate projections, over the lifetime of the building.

Where there is significant deviation, facilitate a conversation to determine the basis of design for the project, including long-term risk and liability.

Respond to the wind, rain and snow loading

4 Technical design

requirements established through the previous stage during design development. This should consider the risk to others and the surrounding area from the asset being subject to storm damage. If wind tunnel testing is required, include

allowances for future climate change within the testing programme.

5 Manufacturing & Construction

Ensure that construction is undertaken in line with the approved design. Critically, where wind tunnel testing has been undertaken, changes should not invalidate these tests. Where they are invalidated, further testing of the proposed changes will be required.

6 Handover

Include details of any assumptions made about how the building will be adapted within the BUG and O&M manuals.

7 Use

Develop management plans that cover refuge, evacuation and early warning systems. Life safety as well as building protection and business continuity should be considered.

MANAGING RISK TO ASSETS FROM DROUGHT

0 Strategic definition

Undertake an initial assessment of the risk to the site associated with drought or interruption of water supply. Consider the water supply company, historic interruptions and the risk of subsidence, as well as both internal and external water requirements.

1 Preparation and briefing

Ensure that the brief requires a specialist to be appointed to undertake a further study at RIBA Stage 2 if a risk to the project from drought, subsidence or water supply interruption has been identified.

2 Concept design

Appoint a consultant to review the risk to the project associated with subsidence, drought or water supply interruptions if the initial assessment deems appropriate. Include consideration of climate change impacts on: building and landscape water demands, appropriate demand reduction measures, potential alternative water supplies, potential for water storage on-site, a review of water supply company Drought Plan, local water capacity or supply issues and risk of subsidence.

Consider the potential of nature-based solutions and natural systems, as well as associated co-benefits.

3 Spatial coordination

Ensure the requirements of the water supply and subsidence risk assessment are embedded throughout the design and construction process. Integrate the required

4 Technical design

strategies into the spatial coordination, technical design, and manufacturing and construction of the building.

Coordinate with the contractor to ensure any design changes do not impact proposed drought management measures.

5 Manufacturing & Construction

Consider the likelihood and impact of water supply interruption, both on-site or impacting the supply chain, during construction and take appropriate measures to reduce the associated risks.

6 Handover

Embed key elements of the risk assessment within the BUG to ensure that the building users are aware of the risk and response measures.

Ensure that water systems are integrated into the commissioning schedule.

7 Use

Update the risk assessment as required in line with changes to the building or landscaping, updates to water supply company documentation, or other relevant changes.

Ensure that maintenance works include alternative water supply and/or storage systems, and that water usage during maintenance is accounted for.

Continue to monitor water consumption as part of the POE process.

MANAGING RISK TO ASSETS FROM WILDFIRE

0 Strategic definition

Undertake an initial assessment of the wildfire risk to the site, including weather patterns and extreme events, topography, and presence of fire fuels. Areas that border wilder, vegetated areas typically contain more significant fire fuel.

1 Preparation and briefing

Consider past wildfire events in the local area and the risk from areas adjacent to the site due to potential impacts such as a reduction in air quality due to wildfire smoke.

2 Concept design

Consider the exposure of the asset to wildfire risk over the life of the proposed development, where the initial assessment deems appropriate, including projected temperature increases and changes in rainfall patterns under multiple future climate scenarios.

Consider the siting and positioning of the building mass to create defensible space between vegetated areas and the asset, where there is an increased risk of wildfire at plot adjacencies.

3 Spatial coordination

Choose ignition-resistant construction materials, both within the asset and any defensible spaces, with particular attention to the design of the exterior walls and roof.

Consider selecting less flammable plant species within the project boundary.

Ensure appropriate and multiple access routes for fire and other emergency services have been designed in throughout the proposed development, including

4 Technical design

access requirements to the building as well as to utilities for emergency services.

Where there is a risk of wildfire in the local area, consider the installation of outdoor air quality monitoring. In the event of a local wildfire, this data could be used to determine whether to issue an alert to users or implement a work-from-home policy, or to inform the operation of the building's ventilation systems.

5 Manufacturing & Construction

Coordinate with the contractor to ensure any design changes do not impact the risk to the building or occupants in the event of a wildfire.

Consider the likelihood and impact of a wildfire event during construction, both on-site or impacting the supply chain, and take appropriate measures to reduce the risks associated with this.

6 Handover

Develop fire fuel-reduction management strategies where there is an increased risk of wildfire.

Develop strategies to raise awareness among site users, as well as information on the actions they can take to minimise the risks of wildfire.

Develop a wildfire response strategy within the emergency response plan for the building, including a plan for evacuation and safe refuge, and clear roles and responsibilities

7 Use

Conduct continuous engagement with communities and neighbouring landowners to ensure appropriate land management that minimises wildfire risk.

RECOMMENDATIONS FOR FINANCING CLIMATE RESILIENCE

Financial systems play a pivotal role in determining how projects are funded, prioritised and scaled. Whereas traditional finance models often focus on short-term returns, achieving climate resilience requires us to look further into the future. Developing a strong investment case that highlights societal and environmental benefits can help shift the focus from immediate profits to long-term goals.

This section explores levers that built environment stakeholders could use to unlock investment and help steer financial systems in a more climate-resilient direction. It also considers existing solutions that could be used to drive change. Finally, it recommends a set of high-level actions that stakeholders in both the built environment and the financial sector must take to increase financing for resilience and adaptation.

LEVERS FOR UNLOCKING INVESTMENT

Metrics: The disconnect between the frameworks and metrics used at asset, portfolio and fund levels presents a challenge to investment in climate resilience. The development of transparent, consistent metrics for assessing the adaptive capacity of buildings, projects and organisations, ideally integrated with net-zero commitments, could drive change by aggregating asset-level considerations so that they become meaningful to investment funds.

Governance: Changes to governance structures within organisations, to ensure clear accountability, strong decision-making and robust reporting, can exert a significant influence[84]. Aligning action with financial incentives and ESG goals is vital for communicating progress on climate resilience to stakeholders, making it easier to secure the investment needed.

Drivers such as recruitment and retention and reputation management often motivate companies to take climate action, and this can strengthen market signals for change, even in the absence of policy mandates[85]. Cooperative stakeholder models, long-term stewardship approaches and transition plans are pathways for organisations to reinvest profits into community and climate-focused initiatives, shifting from being purely profit-driven to better align their purpose with societal needs.

Leaders who embrace climate resilience to mitigate portfolio risks can share best practices, fostering a culture of sustainability and demonstrating the long-term value of early action.

Regulation: Regulatory levers, including government policies and incentives, are crucial for fostering climate resilience. For example, the requirement for commercial buildings to display an Energy Performance Certificate (EPC), and by 2030 to achieve a minimum B rating, has encouraged organisations to prioritise retrofitting to avoid "stranded assets". Governments can also set regulations to define what should qualify as a green loan or bond, into which climate resilience should be integrated.

Another example of regulation is the impending incorporation into UK law of the International Financial Reporting Standard S2, which builds on the Task Force on Climate-related Financial Disclosures (TCFD) recommendations. This requires companies to disclose their climate-related risks and opportunities. By increasing transparency around how organisations are addressing climate risks, it incentivises them to integrate resilience into corporate strategies and drives investment in climate adaptation projects.

Strategic investment: Governments can stimulate wider investment by targeting funding towards projects that generate social impact, including through resilience and adaptation. Examples include public-private partnerships, blended finance models, green loans and bonds, and impact funds. These investments are vital for societal wellbeing and can result in many financial and non-financial co-benefits.

Insurance: Linking resilience standards to insurance premiums could provide a strong motivation for organisations to improve adaptive capacity. This would highlight the consequences of failing to address climate-related risks, without overemphasising economic systems.

For more recommendations on policies and regulations, see the Policy Recommendations document.

SOLUTIONS FOR FINANCING CLIMATE RESILIENCE

Green Cities and Infrastructure Programme: An initiative of the UK's Centre of Expertise in Green Cities and Infrastructure, which accelerates the delivery of sustainable urban development and resilient infrastructure. The programme partners with public and private entities to deploy innovative financial mechanisms that drive investments in climate-compatible projects, including in cities across the UK. It focuses on developing infrastructure that supports growth in sustainable activities while promoting resilience against climate risks[86].

Data and Analytics Facility for National Infrastructure (DAFNI): This platform provides computational tools to plan and stress-test infrastructure against future risks, to ensure investment decisions account for climate shocks[87].

Empowering local communities: Local communities are key to driving climate resilience, as interventions must be location specific. Community-driven funding models, such as local investment funds, create opportunities for people to shape their environments and enhance resilience according to local priorities. In practice, this might involve implementing nature-based solutions, such as restoring wetlands or forests, or enhancing green infrastructure. Mechanisms such as bioregional banking and resource-backed tokens, although at an early stage of development, offer new ways to assign financial value to natural systems, and align financial incentives to environmental stewardship. Impacts and funding for resilience are not all equal and need to be considered so all benefit equally. These models not only help to build stronger, more resilient local economies, but reinforce larger-scale financial systems that prioritise sustainable solutions.

RECOMMENDATIONS TO INCREASE FINANCE FOR RESILIENCE AND ADAPTATION

Financing the adaptation of the built environment is a complex challenge. To achieve meaningful progress, the following high-level actions are essential on the part of stakeholders in both the financial sector and the built environment:

- Foster transparency in financial and project data to build trust and accountability.
- Integrating resilience metrics could guide investments and measure long-term climate impact.
- Create financial models that incentivise and reward sustainability rather than short-term profit.
- Establish governance structures that promote reinvestment in local communities and climate initiatives.
- Explore alternative financial instruments that support adaptation efforts, such as green bonds and sustainability-linked loans.
- Leverage regulatory frameworks to encourage climate adaptation and resilience across sectors.

CLIMATE RESILIENCE REQUIRES A SYSTEMIC APPROACH

Climate risks are interconnected, influencing global, social and environmental systems. As these risks grow more intertwined and unpredictable, our responses must become adaptive and coordinated. Building climate resilience requires long-term, collaborative and convergent actions across sectors.
A climate-resilient mindset embraces this complexity, tackling shared challenges through unified strategies.

The built environment is part of an interconnected system that includes the natural world, social and economic factors, and global networks. It is a static object constantly shaped by external pressures, including climate hazards beyond our control. These hazards will continue to change over this century and beyond, their magnitude determined by how rapidly global greenhouse gas emissions peak and fall. The risks will also evolve, as a product not only of extreme weather, but by how we chose to live together: by the social and economic structures we put in place, and the way we plan, design and construct buildings, infrastructure and urban environments.

In a resilient system, the capacity to respond to shocks and disturbances depends on the relationships and learning processes across the entire system - in this case, the whole industry. Achieving true climate resilience requires leveraging these interconnections within the built environment rather than relying on isolated actions. We must work for people, with and for the rest of nature, fostering collaboration across industry sectors. By moving away from short-term quick fixes and reactive approaches, and embracing regenerative, collaborative practices, we can address both current challenges and future needs.

The Roadmap advocates for a systemic perspective and the leveraging of natural ecosystems for climate adaptation to create solutions that benefit both society and the planet by:

- Considering the built environment as a system that combines, but is not limited to, its physical assets, the people who use its spaces, and the nature and land within and surrounding it.
- Bringing together all the diverse perspectives of all the stakeholders of the built environment and harnessing their collective expertise.
- Addressing the role of governance and leadership in driving systemic change, ensuring collaboration across sectors, and embedding long-term resilience thinking into policy and practice.

- Sharing aligned built environment sector aims, goals, actions and recommendations to foster a systemic perspective, driving both behavioural and technical solutions while promoting collaboration and innovation.
- Aligning and connecting policy recommendations with evidence-based industry insights to support systemic change.

Ultimately, building resilience will require embracing a holistic perspective that integrates the mind, heart, and hands of all stakeholders to create solutions that support both human well-being and environmental health. By working together toward a shared goal, our combined efforts are amplified, driving meaningful and lasting change.

> *"Resilience is not about the ability of individual parts to survive, but about the ability of the whole system to adapt and reorganize when things go wrong."*
>
> - Donella Meadows [88]

About her: Donella Meadows is considered one of the most influential systems thinkers of the 20th century for her pioneering work in system dynamics, co-authoring The Limits to Growth, and her clear explanation of systems in Thinking in Systems.

8

FUTURE OF THE ROADMAP

UPDATES AND OWNERSHIP

The UK Climate Resilience Roadmap represents a first-of-its-kind approach, bringing a holistic perspective on the vulnerability of both assets and people to climate-related risks. It explores how nature can be integrated as a fundamental part of climate adaptation, moving beyond traditional risk assessments toward system-wide resilience.

UKGBC is committed to monitoring government and industry progress and tracking resilience action. As climate resilience evolves in the UK, the Roadmap will be further refined through collaboration with industry to ensure its continuing relevance and applicability across the built environment sector.

ONGOING DEVELOPMENT

Following the publication of the UK Climate Resilience Roadmap, the next steps will focus on developing Stakeholder Action Plans for key subsectors within the built environment. These plans will provide clear, actionable guidance to help stakeholders achieve the aims and goals set out in the Roadmap and effectively implement its recommendations.

COLLABORATION AND FUTURE RESEARCH

To strengthen the impact of the UK Climate Resilience Roadmap and drive future research into climate resilience, UKGBC is eager to collaborate with industry organisations, NGOs, and policy-makers who are actively working in this space. Partnership and knowledge-sharing are essential for advancing research, sharing best practices, and developing innovative solutions that enhance climate resilience across the built environment. We welcome opportunities to work together on further research and collective action to ensure a more climate-resilient future.

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APPENDIX A

DETAILS ON KEY CLIMATE HAZARDS

This section of the Appendix provides additional context and information on the five key hazards outlined within the Roadmap. It includes definitions, causes, impacts on the built environment and beyond, as well as key facts and statistics on the UK's past and present exposure to these hazards.

FLOODING

Climate change will not only intensify the likelihood and severity of floods, but also challenge our intuitions and assumptions about flooding. For example, surface water flooding can suddenly hit areas far from rivers or the coast, and periods of drought can exacerbate flood risk, by making the ground less able to absorb heavy downpours.

Most of all, we will have to abandon a belief that we can hold back the rising waters indefinitely and just build higher and higher barriers to defend human settlements. The Environment Agency, which is responsible for flood management in England, has long stressed that it is neither technically feasible not affordable to fully protect all buildings[89]. Instead, its goal is to minimise the harm caused by flooding, applying a risk-based approach that considers both how likely flooding is to occur, and how severe its impacts will be.

This will present us all with difficult choices, on what to defend and where to retreat, and how to make space for fluctuating water levels in our towns, cities and landscapes.

However, it is important to remember that floods are part of nature too. Humans have always lived alongside water and understood that it presents dangers as well as opportunities.

Our growing flood risk is not only the product of climate change but of changes in land use, construction practices and inadequate water management. There is much we can do to address it, and an urgent need to adapt both urban environments and landscapes, and our approaches to planning, design and construction.

HOW DOES CLIMATE CHANGE INTENSIFY FLOODING?

Flooding is primarily influenced by changes in atmospheric patterns caused by the accumulation of greenhouse gases driving climate change. These changes intensify precipitation events, leading to heavier and more frequent rainfall, which increases the risk of flooding in vulnerable areas.

In summer, we can expect rain to fall less frequently in the UK, but with greater intensity, heightening the risk of surface water flooding[90]. Winters are likely to be warmer and wetter, with 5% more rainfall and an increase in both the number of rainy days, and in the intensity of rainfall events[91]. We can expect more autumn downpours too – climate projections show significant increases in heavy hourly rain intensity[92].

All of this will add up to an increase in flooding events for the UK.

Rising sea levels will also increase the risk of flooding due to high tides, as well as from storm surges[93]. Globally, sea level has risen by 6.5cm since 1981-2000, and it is estimated to continue to rise by 2.5cm each decade[94]. But when corrected for land movement, mean sea level around the UK has increased by much more: 17cm since the start of the century[95]. By the end of this century, sea level around the UK is projected to be between 0.29m and 1.15m higher[96], which will put people living in coastal areas at significant risk.

Although storms and droughts are covered separately, it is important to remember these hazards are interrelated. Storms can act as a multiplier, triggering heavy rainfall that causes flooding or storm surges in ravine or coastal areas. Equally, drought can make flooding more likely because dry, baked ground cannot absorb water so easily, leading to greater run-off and potentially flash flooding[97].

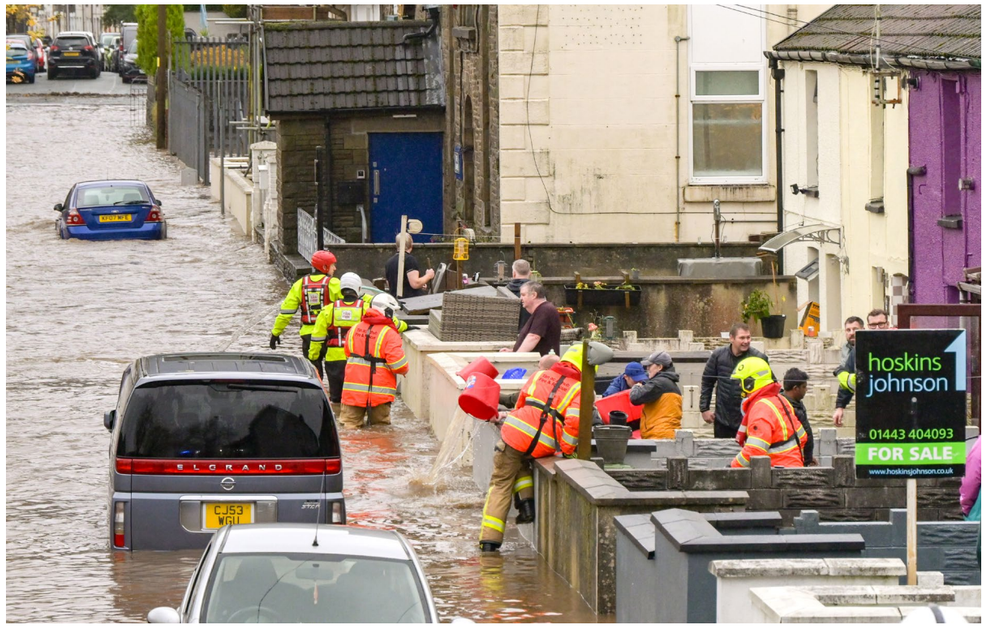
FURTHER IMPACTS OF FLOODING

According to the 2008 National Flood Risk Assessment for England, 21% of railways, 14% of electricity infrastructure sites and 10% of main roads were at risk of flooding[98]. The Environment Agency estimates that for every household directly affected during a large flood, about 16 people suffer knock-on effects from losses of utility services[99]. The latest national assessment of flood and coastal erosion risk for England was published in December 2024, using new data and including future climate scenarios[100].

The damage to building assets from floods results in heavy financial losses: in 2023, weather-related insurance claims were the highest on record, up 36% in 2022. Of the £573 million paid out to homeowners for weather-related damage, half of this was due to flooding[101]. Poor-quality buildings, and those below ground or situated near watercourses are especially vulnerable.

Flood risk is also increasing as construction continues in floodplains. Analysis by the insurer Aviva found that over the last decade in England, almost 110,000 homes (8% of the total) were built in national flood zone three, representing the highest risk[102]. A survey of owners found that three out of five believe their home is at risk of flooding, and one in five that its location is unsuitable for this reason[103]. Overall, 2,696,000 homes, or just over 1 in 10, are estimated to be at risk of flooding in the UK.

This highlights that flooding is not a foregone conclusion, and that it is essential that we plan, design and adapt our communities in response to the changing climate. This will mean opting for resilience rather than resistance, and relearning to live with the natural variability of water. We already have the understanding and the tools to manage the risks and now they just need to be applied.



OVERHEATING

We can already see the danger that overheating presents: during summer 2022, when temperatures exceeded 40°C for the first time in the UK since records began, there were an estimated 3,271 excess deaths in England and Wales, mainly among the over 65s[105]. Climate change has made heatwaves like this 30 times more likely, and by 2050, the unprecedented conditions we experienced in 2022 are predicted to occur every other year[106].

The risk of overheating is expected to increase if left unaddressed, but while some warming of the climate is now inevitable, overheating within buildings is not. Higher external temperatures are just one contributing cause, and social factors and changes in the way we construct also play a significant role. Annual data submissions from NHS trusts in England highlight a worrying trend: in 2016/17, when records began, trusts reported 2,980 occurrences of overheating at NHS sites. Since then, this has risen steadily, and by 2022/23, more than doubled to 6,822[107],[108].

This means that it is within our power to design buildings and cities that are safer, more comfortable and resilient to the impacts of the changing climate, and that it is vitally important that we act now to do so.

WHAT CAUSES OVERHEATING?

Climate change is a significant contributing factor to overheating. Higher external temperatures, especially over prolonged periods, cause indoor temperatures to rise and prevent buildings from cooling down.

Long-term climate trends have, and will continue to, make overheating more likely: between 2009 and 2018, the average temperature was 0.9°C warmer than the 1961-1990 average, and the UK's ten warmest days since 1884 have all occurred since 2002[109].

However, the likelihood of overheating, and the severity of its impacts, are also exacerbated by many other factors.

For example, cities are much more prone to overheating than the surrounding countryside, due to the urban heat island effect. Dense street layouts and hard surfaces absorb and radiate more heat than natural landscapes, and human activities like air-conditioning and car exhausts add to the intensity. Temperatures climb higher during the day, and peaks last longer into the night, so there is less opportunity for buildings to cool down[110]. Mapping for the years 2003-2020 found that the centre of London could be up to 10°C warmer than surrounding rural areas[111]. Meanwhile, modelling by Arup found a 7°C difference between the most and least vegetated areas of the capital on the hottest day of the 2022 heatwave[112].

Our own efforts on climate mitigation have inadvertently contributed too: newer homes are designed to retain as much heat as possible, with much higher standards of airtightness and insulation. While this can dramatically reduce demand for heating during winter, without sufficient levels of ventilation it could increase the risk of overheating during warmer summers, especially when combined with large areas of unshaded glazing. A survey by insurer Aviva found 61% of residents in new homes were concerned about the impacts of heat, compared with 46% living in homes built before 2018[113].

Other features of modern cities add to the likelihood of overheating and increase the danger it poses. Since 2010, more than a quarter of completed new homes have been apartments[114], which are at greater risk of overheating because they are typically smaller and often constructed with windows on only one side, which prevents more effective cross-ventilation[115].

When internal spaces become hotter than outdoor temperatures, people living in urban areas may also be reluctant to open windows due to noise levels, air pollution or security concerns, potentially causing internal temperatures to rise further. People living alone are more prone to social isolation, and less likely to seek the help they need when conditions become unbearable.

FURTHER IMPACTS OF OVERHEATING

Overheating is dangerous to human health, and it has negative impacts on the economy and on the built environment too.

According to the World Health Organisation, heat stress is the leading cause of weather-related deaths – though it also emphasises that negative impacts are "predictable and largely preventable" if we take appropriate public health measures and adapt buildings and cities to cope with temperature extremes[116].

This is particularly important to protect those who are most vulnerable, older people, children, and those with underlying illnesses such as heart disease, diabetes, asthma and dementia. As the UK's population ages – with the proportion of over 65s projected to increase from 19% to 27% by the 2070s[117] the impacts associated with overheating will increase too.

Therefore action to address overheating is not only essential to protect people and the economy, but also to reduce carbon emissions to safe levels, and prevent further, catastrophic levels of warming.

STORMS

The Met Office began naming storms in 2015, borrowing a tactic from the US to raise public awareness of extreme weather, and therefore preparedness. Storms with the potential to cause "medium" or "high" impact, primarily from high winds but also from rain or snow, are given a name from a pre-chosen list, in alphabetical order. This list resets every September, marking the start of the storm season.

Since then, there have been an average of seven named storms each year, and a record-breaking 12 in the 2023/24 storm season – with Storm Lilian in August 2024 the first to begin with an "L".

Recent years have also seen a number of other notable events: Storm Ciarán in 2023 was the most "intense" with the lowest pressure ever measured by modern instruments[118]. During Storm Eunice in 2022, gusts of 122mph (196 km/h) were recorded at Needles Old Battery on the Isle of Wight, one of the highest wind speeds the UK has ever experienced[119].

Although it is difficult to predict how the pattern of storm events may change, we can already see how the severity of impacts will worsen when combined with other climate hazards. For example, they are often accompanied by heavy rainfall, which can lead to flooding. We should consider today's extreme events as a warning sign, and a wake-up call to make our communities and our built environment resilient to what is likely to come.

WHAT CAUSES STORMS?

Wind is the movement of air in the atmosphere, from areas of higher to lower pressure: the greater the difference in pressure, the stronger the wind[120].

The UK is renowned for being stormy because it is at the eastern edge of the North Atlantic Ocean, at the latitude where cold polar air and warm tropical air meet[121]. At this boundary, a stream of strong wind is formed, known as the jet stream. This blows from west to east, directing weather systems across the Atlantic to the UK[122].

Storms form mainly in the winter months, when the temperature difference between the poles and the tropics is greatest, and winds are strongest. This temperature difference also causes heavy precipitation, as the warm and cold air masses clash[123].

When looked at in the context of climate change, no clear trends in wind or windstorms have been projected for storms in the future, and different climate models vary in their estimations. There is high daily and yearly variability in wind speed, which makes identifying or forecasting patterns difficult. By the late 21st century, UK climate projections show an increase in mean winter wind speed, and potentially windstorm number and intensity, but this is small compared to natural year-to-year variability[124].

Moreover, storms do not occur in isolation from other climate hazards, and these are likely to amplify their impact. For example, rainfall events in winter are expected to be both heavier and more frequent, and autumn and summer downpours will become more intense[125].

One study identified a trend for average precipitation levels having increased on stormy days, possibly by up to 30%, compared to a pre-industrial climate[126]. Another found that the number of jointly occurring storm and extreme rainfall events could triple by 2061-2080, under a high emissions scenario, highlighting the need to take a holistic view of the risks of different hazards[127].

FURTHER IMPACTS OF STORMS

In February 2022, a trio of storms hitting in a single week caused £497 million worth of destruction[128], with Storm Eunice killing three people, leaving 1.4 million homes without power[129], and tearing sections of roof and cladding from houses, tower blocks and other buildings[130]. Storm Babet in 2023 bought heavy rainfall and strong winds. This lead to widespread flooding, with 1000 homes flooded in England, 30,000 homes losing power in Northern Scotland, rail services across England being cancelled, and seven people dying[131].

As extreme events pose a growing threat to people, nature, and the built environment, raising awareness of the dangers is just the first step. It is vital that the built environment sector takes action to improve resilience, and to provide communities with safe places that protect them from the elements, but which also recover quickly so that they can continue to live, work, and thrive in a changing world.

DROUGHT

Drought is not simply caused by a lack of rainfall, but by a range of factors linked to how we manage water and how much we consume, in buildings, agriculture and industry. These factors accumulate in slow-motion, providing plenty of time to monitor their build-up and take measures to mitigate their impacts[132].

Climate change will also make winters wetter, and rainfall in summer more intense. This means we have an opportunity to reduce the risks of more frequent droughts by collecting and storing rainwater, and adapting built and natural environments to cope with greater extremes of wet and dry, to make communities, food supplies, and infrastructure more resilient[133].

Rather than rare events, and a fading memory in the much wetter weather of subsequent summers, recent parched summers should be regarded as a stress-test and a chance to prepare for a more extreme world.

WHAT IS DROUGHT?

The Intergovernmental Panel on Climate Change (IPCC) identifies four main types of drought:

- A meteorological drought is when rainfall is below average for a region over a prolonged period. In the UK, a drought is defined as an extended period, typically three weeks, that receives less than a third of usual precipitation. An "absolute drought" is 15 consecutive days with less than 0.2mm of rain on any one day. In the longer term, it can also be defined as a 50% deficit over three months, or a 15% shortfall over two years[134].
- An agricultural drought is when there is not enough rainfall or moisture in the soil to support normal crop growth. This can occur at both high temperatures, when plants transpire more quickly than they can take up water through their roots, or in harsh winters when the water in the soil is frozen.
- An ecological drought is similar but has a detrimental impact on the local environment. The Environment Agency calls this an "environmental drought", describing a situation where river flows are reduced, groundwater levels are exceptionally low, and there is insufficient moisture within soils, placing stress on wildlife, fish, and habitats[135].
- A hydrological drought is when the water available in sources such as aquifers, lakes, streams and reservoirs is lower than average. This can occur after a relatively dry winter when the water table has not been recharged sufficiently, and it can continue for several years as rainfall percolates only slowly through rocks into groundwater supplies. It can also happen in times of normal or above average precipitation when water use increases, which diminishes reserves.

WHAT CAUSES DROUGHT?

Drought results from a combination of multiple factors. While a lack of precipitation is a key factor, other elements such as wind, evapotranspiration, temperature, and hydrological conditions also play a role, making it difficult to predict.

In the UK, winters are projected to become wetter, and summers hotter and drier, particularly in southern areas. The risk of drought will depend on how rainfall patterns evolve and how we adapt the built and natural environments. For example, models suggest that there will be longer stretches of dry summer days, with heavier rainfall in between. This could challenge current methods of collecting and storing water, but make it even more important for mitigating the impacts on households and agriculture[136].

Warmer temperatures also increase evaporation from the ground. As soil becomes drier, the air above heats up further, worsening the drought[137].

Under a 3-degree scenario, severe droughts are predicted to occur 129% more often due to less frequent rainfall[138]. Under a high-emissions scenario that results in about 4°C of warming, another study projected that extreme soil moisture droughts lasting longer than 90 days will occur as often as every three years by the 2060s and 2070s, compared to once every 16 years in the recent past[139].

FURTHER IMPACTS OF DROUGHT

During summer 2022, water restrictions were in place across much of the UK, and six water companies issued a hosepipe ban, affecting around 20 million people[140]. By the end of August in England, 17 out of 18 water companies activated drought plans, with five introducing temporary use bans[141]. A lack of water can make it harder for people to take appropriate cooling measures during extreme heat, putting vulnerable groups further at risk.

As water levels fell, wildlife suffered and freshwater ecosystems were damaged. Birds were trapped in exposed mud, and rapid algae growth choked oxygen supplies to fish[142].

There are also knock-on effects for agriculture and industry, whose supplies are affected sooner because households take precedence, hitting food production and the economy. In 2022, both crop and milk yields were low and farmers were forced to use their winter food stores as grass died in grazing fields[143].

In 2022, insurers paid out £219 million in subsidence claims, the highest since 2006[144]. Of the 23,000 claims, 18,000 were made in the second half of the year, after record-breaking summer temperatures, equivalent to one every 15 minutes[145].

In areas with clay soils, we may need to build differently in order to accommodate a greater degree of shrink-swell in future years.

WILDFIRES

When we see images of old-growth forests burning across the vast landscapes of North America, Australia or southern Europe, it may seem like a distant problem for the UK, which has very few true wildlands left. But wildfires are still cause for growing concern, not only for the danger they pose to people, the built environment and nature, but as a serious setback to our climate mitigation efforts.

WHAT CAUSES WILDFIRES?

For a fire to start and spread, it needs an ignition source, fuel, and oxygen. This is known as the "fire triangle". At a landscape scale, we talk about the "fire behaviour triangle", and the three key elements are weather, fuel, and topography[146].

A wildfire is influenced by many factors. The Met Office's Fire Severity Index provides a running assessment of how severe a fire could become if one were to start, based on weather data such as temperature, relative humidity, wind speed, and rainfall, as well as ground conditions and time of year[147]. The index doesn't predict the likelihood of a fire occurring, but the times when it is likely to build up, spread very quickly, and be extremely difficult to control. For example, at times of prolonged drought, and when warm temperatures, high winds, and low humidity occur in combination.

Climate change increases the likelihood and severity of wildfires in several ways. Warmer, wetter winters extend the growing season and increase the amount and density of vegetation like grasses, shrubs, and heathland, which increases biomass and fuel for fires. Hotter summers with prolonged droughts dry that vegetation out, and increase the number of days when weather conditions are conducive to fire[148]. In the UK, the risk of a fire starting is projected to double with 2°C of global warming and to quadruple with 4°C[149].

Climate change may indirectly increase the risk through societal factors too: most wildfires are started by people accidentally, for example as BBQs or campfires that escape control. Warmer weather potentially means more people participating in outdoor activities, which can be a major source of ignitions.

FURTHER IMPACTS OF WILDFIRES

Until relatively recently, wildfires were not classed as a significant concern in the UK: "severe wildfire" was only added to the government's National Risk Register in 2013[150].

However, over a series of record-breaking summers, evidence has amassed of how easily a vegetation fire can start and spread in hot, dry conditions, and how rapidly it can escalate if not brought under control[151].

During the summer 2022 heatwave, fire services in England recorded four times as many wildfires from June to August as during the same period the previous year[152].

This was most acute on the 19th and 20th July 2022, when the UK recorded its highest ever temperature of 40.3°C. The most serious incident occurred in the village of Wennington on the eastern edge of London, when a compost heap spontaneously combusted and fire spread over 40 hectares of grassland, destroying farm buildings, homes and garages[153]. On 20 July 2022, the London Fire Brigade experienced its busiest day since the Second World War, receiving more than 2,600 calls, compared to an average of 350[154].

One of the largest wildfires in recent UK history burned for three weeks in summer 2018 on Saddleworth Moor near Manchester, creating a haze over the city. Pollution rose to double the permitted levels according to DEFRA's Daily Air Quality Index[155].

Subsequent modelling found that concentrations of fine particulate matter would have increased by more than 300% in the immediate area, and increased by up to 50% even over 60 miles away in areas as far as Liverpool and Wigan[156].

As wildfires threaten to become more frequent in periods of hot and dry weather, it's essential that we deepen our understanding of how these events occur and the impacts on our buildings, natural environment and communities. By using this learning to inform the way we design, construct, and operate our built environment, we can improve resilience, reduce the risks of wildfire, and protect ourselves against the dangers of a warmer world.

APPENDIX B

METRICS AND INDICATORS

Metrics and indicators can be used to provide a clear and measurable way to monitor hazards and identify needs, track progress, assess performance or evaluate the effectiveness of strategies and actions over time. In the context of climate resilience, they can help stakeholders monitor key aspects of exposure, sensitivity, adaptive capacity and overall resilience to support and inform decision-making. The table below provides some key examples of metrics that can be used by a variety of stakeholders in the built environment when looking at specific hazards or cross-cutting action.

What is a metric?

Metrics are quantifiable measurements used to assess performance against a standard. Effective climate-related metrics are those that are relevant to decisions, clear and understandable, reliable, verifiable and objective, and consistent over time.

What is an indicator?

Indicators are used to monitor trends, identify patterns or evaluate the success of specific actions.

CROSS CUTTING METRICS AND INDICATORS

Table 10: Metrics and indicators for cross-cutting climate resilience action.

	Metric or indicator	Who should measure	Scale at which this is useful	Existing data sources or frameworks
Exposure	Number of households (#) likely to be displaced per extreme weather event, and rate of displacement e.g., per 1,000 people at risk per year (metrics)	Local authorities, national agencies, asset owners	National assessment, local authority areas, existing assets	ONS Population Statistics
Sensitivity	Proportion (%) of buildings built pre-1960's (metric)	Local authorities, heritage organisations, asset owners	National assessment, local authority areas, existing assets	National Heritage List for England (NHLE) Local council building records
Adaptive capacity	Quality of life in the local area e.g. Life Satisfaction Index (LSI) (indicator)	National agencies, local authorities, NGOs	National assessment, local authority areas, both existing assets and new developments	UK Measures of National Well-being Dashboard (life satisfaction)
Resilience	Health impact e.g. public health systems may assign severity levels based on event impact, at local or national levels (indicator)	National agencies, local authorities, NGOs	National assessment, local authority areas, both existing assets and new developments	Local health authority statistics

METRICS AND INDICATORS FOR FLOODING

Table 11: Metrics and indicators for flooding.

	Metric or indicator	Who should measure	Scale at which this is useful	Existing data sources or frameworks
Exposure	Proportion or number (%, #) of properties close to water sources (m or km) (metric)	National agencies, local authorities, developers, asset owners	National assessment, local authority areas, both existing assets and new developments	Environment Agency Flood Map for Planning
Exposure	Location of assets within flood zones (metric)	Local authorities, developers, asset owners, project teams	Local authority areas, both existing assets and new developments	Flood Map for Planning Long term flood risk service
Sensitivity	Number (#) of sustainable urban drainage systems (SuDS) in local area (metric)	Local authorities, developers, asset owners, project teams	Local authority areas, both existing assets and new developments	Local authority planning data, DEFRA SuDS initiatives
Sensitivity	"Sponginess" of local area e.g. proportion (%) of green and blue infrastructure, hydrogeological properties of soil (metric & indicator)	Local authority areas, both existing assets and new developments	Local authority areas, both existing assets and new developments	UKCEH Land Cover maps
Adaptive capacity	Number (#) of assets with Property Flood Resilience (PFR) measures in place (indicator & metric)	Local authorities, developers, asset owners	Local authority areas, existing assets	N/A – count of assets in area or portfolio
Adaptive capacity	Number (#) of flood defences in local area (metric)	Local authority areas, both existing assets and new developments	Local authority areas, both existing assets and new developments	Environment Agency Asset Management map
Resilience	Number (#) of assets damaged, or value (£) of damage (metric & indicator)	Asset owners, developers	Existing assets	Asset or portfolio level count
Resilience	Average insurance claim (£) for flood events (indicator)	National agencies, developers, asset owners	National assessment, existing assets	Insurance data from organisations such as the ABI

METRICS AND INDICATORS FOR OVERHEATING

Table 12: Metrics and indicators for overheating.

	Metric or indicator	Who should measure	Scale at which this is useful	Existing data sources or frameworks
Exposure	Proportion (%) of buildings located in areas where urban heat island (UHI) intensity (°C) exceeds comfort thresholds (metric)	National agencies, local authorities, developers, asset owners	National assessment, local authority areas, existing assets	English Housing Survey Urban Heat Island – During a Warm Summer (London only)
Exposure	Building density (number of buildings per hectare, or floor area ratio) (indicator)	National agencies, local authorities, developers, project teams, asset owners	National assessment, local authority areas, both existing assets and new developments	Local planning records
Sensitivity	Urban Greening Factor – the proportion (%) of green space relative to total urban area (metric)	National agencies, local authorities, developers, project teams, asset owners, environmental NGOs	National assessment, local authority areas, both existing assets and new developments	Natural England Urban Greening Standards Urban Greening Factor
Sensitivity	Proportion of assets complying with CIBSE TM52 / 59 methodology (indicator & metric)	Developers, asset owners	Existing assets	CIBSE TM59: Design methodology for the assessment of overheating risk in homes
Adaptive capacity	Number (#) of publicly accessible cooled locations in the local area (metric)	National agencies, local authorities, developers, project teams, asset owners	National assessment, local authority areas, both existing assets and new developments	Local authority data on community places of safety City maps such as London Cool Spaces
Resilience	Long-term tracking of apparent temperature (indoor, °C) (indicator)	Asset owners	Existing assets	N/A – internal temperature measurements

METRICS AND INDICATORS FOR STORMS

Table 13: Metrics and indicators for storms.

	Metric or indicator	Who should measure	Scale at which this is useful	Existing data sources or frameworks
Exposure	Proportion (%) of properties located in areas that have historically experienced high wind speeds (above an acceptable threshold) (indicator)	Local authorities, developers, asset owners, project teams	Local authority areas, both existing assets and new developments	Met Office CEDA Archive data on wind speed and direction
Sensitivity	Number (#) of assets undertaking roof and facade survey for loose elements (indicator)	Asset owners, developers,	Existing assets	Count of assets in area or portfolio
Adaptive capacity	Proportion (%) of buildings with access to designated safe zones during storms (metric)	Local authorities, developers, asset owners, project teams	Local authority areas, both existing assets and new developments	Local authority data on community places of safety
Adaptive capacity	Response time for post-storm building inspections (average number of hours from storm event to initial damage inspection for all properties) (metric)	Developers, asset owners, occupiers	Existing assets	Insurance company reporting systems. Emergency response data from local councils.
Resilience	Number (#) of insurance claims due to wind damage (metric)	National agencies, developers, asset owners	National assessment, existing assets	Insurance data from organisation such as the ABI
Resilience	Number (#/year) of workdays lost due to storm disruptions (metric)	Organisations, contractors, building occupiers	Existing assets, during construction	Business continuity frameworks e.g., ISO 22301

METRICS AND INDICATORS FOR DROUGHT

Table 14: Metrics and indicators for drought.

	Metric or indicator	Who should measure	Scale at which this is useful	Existing data sources or frameworks
Exposure	Proportion (%) of properties located in areas with an annual precipitation deficit (mm) above an acceptable threshold (metric)	National agencies, local authorities, developers, asset owners	National assessment, local authority areas, existing assets	UK Hydrological Outlook current conditions
Exposure	Proportion (#) of properties in areas where local groundwater levels (meters below ground level) fall below an acceptable threshold (indicator)	National agencies, local authorities, developers, asset owners	National assessment, local authority areas, existing assets	UK Hydrological Outlook current conditions
Sensitivity	Water storage capacity in soil (m^3/ha) (metric)	National agencies, local authorities, developers, project teams, asset owners	National assessment, local authority areas, both existing assets and new developments	UK Hydrological Outlook current conditions
Adaptive capacity	Proportion (%) of assets with drought resilience measures in place informed by detailed studies (indicator)	National agencies, local authorities, developers, asset owners	National assessment, local authority areas, existing assets	Count of assets in area or portfolio
Adaptive capacity	Uptake of water efficiency and harvesting measures (# or %) in new and existing buildings (metric)	National agencies, local authorities, developers, asset owners	National assessment, local authority areas, existing assets	Count of assets in area or portfolio
Resilience	Frequency of asset repairs (repairs/year or season) due to ground movement (indicator)	Asset owners	Existing assets	Asset specific measurement
Resilience	Value (£) of insurance claims due to subsidence (metric)	National agencies, developers, asset owners	National assessment, existing assets	Insurance data from organisation such as the ABI

METRICS AND INDICATORS FOR WILDFIRE

Table 15: Metrics and indicators for wildfire.

	Metric or indicator	Who should measure	Scale at which this is useful	Existing data sources or frameworks
Exposure	Proportion (%) of assets within close proximity of wildfire-prone areas (m or km) (metric)	National agencies, local authorities, developers, project teams, asset owners	National assessment, local authority areas, both existing assets and new developments	Met Office Fire Severity Index
Sensitivity	Management of vegetation within Asset Protection Zone (indicator)	Asset owners	Existing assets	Presence of vegetation management plan
Sensitivity	Proportion (%) of building surface area made from fire-resistant materials (metric)	Asset owners, developers, project teams	Both existing assets and new developments	Asset level BIM data
Adaptive capacity	Availability of water for firefighting (litres or gallons per minute) (metric)	Local authorities, developers, project teams, asset owners	Local authority areas, both existing assets and new developments	Infrastructure records from local water company (e.g., fire hydrant locations and information)
Resilience	Quantification of damage (m^2 burned)	National agencies, local authorities, developers, project teams, asset owners	National assessment, local authority areas, both existing assets and new developments	Wildfire damage reports
Resilience	Number (#) of assets damaged or value (£) of damage (metric)	Asset owners, developers	Existing assets	Asset or portfolio level count

APPENDIX C

CASE STUDY CITIES IN THE UK

The following five cities, London, Manchester, Bristol, Glasgow, and Birmingham were investigated in more detail due to their high vulnerability to climate hazards. These cities represent a diverse range of scenarios or “archetypes” and offer valuable insights into how different areas within the UK are affected by key climate hazards and corresponding resilience challenges. These case studies aim to highlight the varying impacts of climate risks and provide examples of built environment sector action within each context.

CASE STUDY ONE

LONDON

HOW DOES LONDON EXPERIENCE KEY CLIMATE HAZARDS?

Overheating risk is more acute in London due to its warm southern location, urban heat island effect, and the prevalence of small, single-aspect homes with limited access to green space[157]. During the record-breaking 2022 heatwave, there were an estimated 387 excess deaths in London[158], and a further 307 in 2023[159]. The 2022 heatwave also saw major transport disruptions and cooling system failures in key hospitals[160]. Furthermore, modelling points to severe overheating impacts London and the South East, even in a future 'low warming' 2°C scenario. Asset types modelled, included schools, homes (houses and flats), healthcare buildings (doctors surgeries, healthcare centres and hospitals) and care homes. Results showed many of these asset types will experience internal temperatures of 28°C for multiple weeks a year[161].

Hot, dry conditions have also increased wildfire risk, with 20th July 2022 marking the London Fire Brigade's busiest day since the Second World War, handling over 2,600 calls, compared to an average of 350[162]. In Wennington, wildfires consumed 40 hectares of grassland, destroying farm buildings, homes and garages[163].

London's dense, impermeable landscape also leaves it highly vulnerable to surface water flooding. In July 2021, two extreme rainstorms overwhelmed drainage systems, with a month's worth of rain falling in just one hour. Over 2,000 properties were inundated with stormwater and sewage, resulting in £281 million in insurance losses[164]. 42% of London's 301,000 commercial buildings are at risk of surface water flooding[165].

HOW IS LONDON ADAPTING TO CLIMATE IMPACTS?

London's approach to climate resilience is based on dual-level governance, with the Greater London Authority operating on a city-wide level, while borough councils/local administrative districts operate more locally. London has also been the focus of some of the best research in the country on climate risks and resilience, including the pioneering London Climate Resilience Review[166] which was commissioned by the Mayor of London and released in July 2024, and the London Climate Risk Maps[167] built by the Greater London Authority in collaboration with Bloomberg Associates. The London Climate Resilience Review includes a comprehensive set of recommendations to increase London's climate resilience at a national, city-wide, and local level. In response to the report, London will be using its participation in the EU-funded Pathways2Resilience programme to create a vision for a climate resilient London and an action plan[168]. Prior to the release the London Climate Resilience Review the Greater London Authority already had in place strategies such as the London Environment Strategy (2018)[169], with a chapter dedicated to "Adapting to climate change", and the London Resilience Strategy (2020)[170]. These documents outline a multi-pronged approach to addressing climate risks, and actions include a £3.1 million new tree planting package[171], launched in 2022, which is intended to cool the city, provide shade, and protect London from flooding.

On a more local level, the London Climate Resilience Review found that all London borough climate action plans contain adaptation related actions. An example of these plans is the City of London Corporation's Climate Action Strategy 2020 - 2027[172]. In terms of climate resilience it focuses on building upgrades, creating flood-resistant public spaces, and strengthening urban greening. Similarly, Hackney has consulted with its local community to develop its Climate Action Plan 2023-2030[173], which is aimed at reducing overheating, mitigating flood risks with sustainable urban drainage systems (SuDS), and urban greening. An example of a local authority working to increase the climate resilience of its built environment is Southwark Council. A key action from its Climate Resilience and Adaptation Action Points (2024)[174] is reviewing the Southwark Plan policies to ensure new development takes further steps to minimise and mitigate the risk of overheating, and provide planning guidance on climate adaptation design for buildings and places through new and updated Supplementary Planning Documents (SPDs).

INSIGHTS FROM LONDON BUILT ENVIRONMENT STAKEHOLDERS

UKGBC gathered over 30 industry professionals together in spring 2024 to discuss climate resilience in the built environment. While these insights were gathered from a small subset of all stakeholders in London, it indicates general trends for this region.

Key insights taken from this event include:

- The risk of inaction on climate resilience is significant, particularly due to its potential financial, reputational, and policy impacts on markets. This concern far outweighed physical, social, and environmental risks for practitioners in London, one of the UK's most prosperous cities and a global hub for finance and law.
- Members emphasised the need for further regulation, legislation and policy while also highlighting the value of voluntary, market-driven drivers such as guidance, standards, frameworks, methods and metrics. This stood in contrast to other locations where policy was typically seen as the dominant driver.

Resources for built environment stakeholders in London

Managing Risks and Increasing Resilience: Framework outlining strategies for managing climate risks and enhancing resilience in the built environment[175].

London Climate Resilience Review: independent report taking stock of London's preparations for climate impacts and recommendations[176].

London Climate Pack**:** high-level information regarding climate change projects for the London area[177].

London Climate Risk Maps: Maps to explore climate exposure and vulnerability across Greater London[178].

CASE STUDY TWO

MANCHESTER

HOW DOES MANCHESTER EXPERIENCE KEY CLIMATE HAZARDS?

Manchester is highly vulnerable to climate change impacts, particularly flooding, storms, and extreme heat. The North West region is predicted to see the UK's highest increase in rainfall, with Manchester expected to receive 59% more rainfall by 2050[179], even if carbon targets are met. The city already faces significant flood risks, with 63,478 properties at risk of fluvial flooding and 162,979 at risk of pluvial flooding[180]. Past events, such as the July 2019 flash floods and Storm Eva in 2015, have caused widespread damage, displacing thousands and costing millions in infrastructure repairs. Storms like Gerrit (2023) and the Beast from the East (2018) have also brought extreme weather events, disrupting transport and damaging homes.

While winters are getting wetter, Manchester's summers are becoming hotter and drier, increasing risks of heatwaves, drought, and wildfires. Summer maximum temperatures have already risen by 1.5°C, and by 2050, they are expected to increase by up to 2.4°C, with heatwaves becoming two to three times more frequent[181]. The July 2022 heatwave saw temperatures reach 37.2°C[182], contributing to 386 excess deaths in the North West[183]. Rising temperatures, coupled with urban density, heighten heat stress risks, while drier summers could strain water supplies. The surrounding moorlands are also increasingly prone to wildfires, as seen in the 2018 Saddleworth Moor fire, which burned 18km², displaced residents, and severely impacted air quality[184].

HOW IS MANCHESTER ADAPTING TO CLIMATE IMPACTS?

Manchester's local government operates through a two-tier system. The Greater Manchester Combined Authority(GMCA) operates at the city-region level, and encompasses 10 local authorities which have their own councils. This governance structure allows for local decision-making within individual councils, while also enabling coordinated efforts on region-wide initiatives through the GMCA. Manchester has already made progress on a number of goals that will increase its climate resilience. Appendix 01 of the Greater Manchester Five-Year Environment Plan 2025-2030[185] lays out the progress the city has made on its environmental goals. It includes planting over 90,000 trees and allocating £3 million to 103 community-led projects that increase the amount and quality of accessible, nature rich green space particularly in the areas most in need. In terms of progress on climate resilience specifically, it lists the joint bid from Greater Manchester Combined Authority and Manchester City Council, which secured funding from the Horizon Europe: Pathways2Resilience (P2R) Programme for the development of a Climate Adaptation Investment Plan. Manchester has also developed, in collaboration with the Met Office, a set of very advanced impact identification and assessments to address heat risk: the Urban heat risks[186], the Manchester Heat Pack[187] and the Climate City Pack[188]. This has led to a focus on nature-based solutions to combat heatwaves with organisations and citizens.

Manchester was among the four European cities selected in 2021 as Resilience Hubs by the United Nations Office for Disaster Risk Reduction Making Cities Resilient 2030 initiative[189]. These cities were selected for their policy and advocacy work in addressing growing climate and disaster risks. Of particular note was Manchester's involvement with the Moors for the Future Partnership[190], which aims to prevent flooding in the city by addressing it at source in the upper catchment. The Partnership restores blanket bogs above the city in the Peak District and South Pennine Moors. Another important initiative was the IGNITION project, created by the GMCA, Urban Innovative Actions and the EU. It is aimed at developing innovative financing solutions to invest in Greater Manchester's natural environment and brought together 12 partners from local government, universities, NGOs, and businesses to collaboratively strengthen the region's climate resilience. It focused on implementing nature-based solutions such as rain gardens, street trees, green roofs, and green walls[191].

INSIGHTS FROM MANCHESTER BUILT ENVIRONMENT STAKEHOLDERS

In autumn 2023, industry stakeholders from the Manchester region came together to discuss risks and needs for resilience in the built environment.

Key insights taken from this event include:

- Financial risks emerged as the top concern, reflecting the focus of consultants on market stability, while social, health, and wellbeing risks were also prominently highlighted, likely influenced by the participation of charities and NGOs.
- Manchester practitioners strongly called for regulation, legislation, and policy as essential tools for progressing climate resilience action, coupled with an emphasis on behavioural change, including leadership and collaboration. These priorities align with the consultancy-driven nature of many attendees' roles, which often rely on structured frameworks to guide client strategies.

Resources for built environment stakeholders in Greater Manchester

Climate Change Framework 2020–2025: Strategic priorities and actions for tackling climate change across Manchester.

Manchester Climate Risk Framework 2021: Comprehensive guidance on assessing and addressing climate risks in the city.

Core Strategy 2012 (Updated 2024): Long-term planning framework for sustainable growth and resilience.

Greater Manchester Resilience Strategy 2020–2030: A decade-long strategy to enhance urban resilience in Greater Manchester.

Manchester Integrated Water Management Plan: Focuses on sustainably managing water resources and flood risks.

Urban Heat Risk in Manchester (ArcGIS): a detailed analysis and mapping of urban heat risk in the region.

Manchester Heat Pack for practical guidance on mitigating overheating risks.

Manchester Climate Pack: A resource for stakeholders addressing climate adaptation and resilience across the city.

Places for Everyone Joint Development Plan: A collaborative framework for sustainable development across Greater Manchester.

CASE STUDY THREE

BRISTOL

HOW DOES BRISTOL EXPERIENCE KEY CLIMATE HAZARDS?

Bristol's location on the River Avon, influenced by the Bristol Channel and Severn Estuary, makes it highly vulnerable to flooding and sea level rise[192]. Over the past decade, tidal events have repeatedly flooded roads and properties, with a major incident in March 2020 when high tides, storm surges, and strong winds caused widespread inundation[193]. By 2050, rainfall levels in Bristol are projected to increase by 9-28%, and by 2080, sea levels could rise by as much as by 42-72cm along the Bristol coastline[194], putting thousands more properties at risk, including key commercial areas like Broadmead and Redcliffe[195].

Beyond flooding, Bristol faces increasing risks from extreme weather events. Storms and high winds cause significant disruption, as seen during the "Beast from the East" in 2018, which led to the temporary closure of the Severn Bridge and temporarily Bristol Airport. Rising temperatures will also pose challenges, with summer heatwaves becoming longer and more frequent. By the 2080s, one in five days could exceed 25°C and heatwaves could double in frequency compared to the 2030s[196]. The wards most vulnerable to overheating are all located in the central and eastern parts of the city, with Lawrence Hill at greatest risk. This is determined based on a combination of factors including levels of deprivation, age-related vulnerability, and environmental and home-related factors that influence exposure to high temperatures[197]. Additionally, drought risk is growing, as seen in 2022 when the region faced its driest conditions in nearly 90 years[198], straining water supplies and increasing wildfire risks.

HOW IS BRISTOL ADAPTING TO CLIMATE IMPACTS?

Bristol is part of the Mayoral Combined Authority of the West of England, while Bristol City Council administers the city itself. Bristol's key climate document is its One City Climate Strategy[199]. This comprehensive plan outlines the city's objectives to become carbon neutral and climate resilient by 2030. The strategy provides a timeline until 2050 with goals every year. The development of the One City Climate Strategy included the Preliminary Climate Resilience Assessment[200] in 2020, which analyses Bristol's exposure to climate hazards and made recommendations including retrofitting existing buildings in a way that considers resilience against climate events.

Bristol has produced high quality data on overheating and flood risk. In 2022 Bristol City Council launched the Keep Bristol Cool mapping tool[201], funded by the UK Climate Resilience Programme, which highlights heat vulnerabilities across the city. It layers threats to the built environment with factors that make people more vulnerable to overheating such as being elderly, living alone, and living in a south-facing home. Bristol City Council also produced the Bristol Local Flood Risk Management Strategy in 2023[202]. As part of this it lists the duties and powers of the Bristol City Council to address flood risk. This includes a duty as a statutory consultee on planning applications in relation to surface water drainage; and a duty to establish and maintain a register of structures that have a significant effect on flood risk in its area.

The West of England Combined Authority and Bristol City Council (via the Bristol City Leap partnership) are both part of the Bristol Climate & Nature Partnership. This project has facilitated the development of community-specific climate action plans, through engaging diverse neighborhoods and groups. For example Easton & Lawrence Hill's Community Action Plan lays out detailed, specific goals for achieving greater local climate resilience[203]. This includes giving residents access to safe spaces in extreme heat and cold, and strictly enforced requirements for new housing developments to contribute to additional tree cover amongst other measures to increase resilience.

INSIGHTS FROM BRISTOL BUILT ENVIRONMENT STAKEHOLDERS

In summer 2023, industry stakeholders from Bristol came together to discuss risks and needs for resilience in the built environment. Key insights taken from this event include:

- The discussions highlighted three key risks: social impacts, threats to property, and financial vulnerabilities. These reflect a well-rounded awareness of the challenges posed by climate change.
- Industry members in Bristol emphasised the need for behavioural change as a crucial driver of resilience, particularly collaboration, stakeholder alignment, and fostering a culture that supports adaptation. Regulatory needs were also cited as essential enablers.
- While not fully representative of the industry, the insights collected reinforce the urgency of creating systemic and collaborative approaches to ensure climate resilience in Bristol's built environment.

Resources for built environment stakeholders in Bristol

One City Plan: A strategic framework outlining Bristol's vision for a sustainable, resilient, and inclusive future.

Bristol Development Framework (BDF): (June 2011) Key planning policies to guide sustainable development in the city, with an emphasis on climate resilience.

Bristol City Pack: A compilation of resources and insights to inform sustainable urban development in Bristol.

Preliminary Climate resilience assessment: An initial review of climate risks affecting the city, providing a foundation for resilience strategies.

Avon Flood Strategy: Outlines measures to manage flood risk along the River Avon, aiming to protect property and infrastructure.

Keep Bristol Cool Mapping Tool: A tool to map areas at risk from urban heat and to inform resilience planning for overheating.

Keep Bristol cool Framework: A strategy to tackle urban heat through green infrastructure, building retrofits, and urban design.

West of England Sustainable Drainage Developer Guide: Guidance on implementing sustainable drainage solutions to manage stormwater and reduce flooding risks.

UKCR Heat Pack Bristol: A resource focusing on addressing the risks of urban heat in Bristol through climate adaptation measures.

CASE STUDY FOUR

GLASGOW

HOW DOES GLASGOW EXPERIENCE KEY CLIMATE HAZARDS?

Glasgow is geographically vulnerable to storms, with strong Atlantic winds and frequent depressions affecting the west of Scotland[204]. Storm Ciara and Storm Dennis in February 2020, caused widespread coastal, fluvial and pluvial flooding[205], while Storm Agnes in September 2023 brought gusts of up to 80 mph[206]. The city also has a long history of river and surface water flooding, with coastal flooding emerging as a growing risk due to rising sea levels and storm surges. In October 2023, a month's worth of rain fell in 24 hours, triggering severe flooding and an amber weather warning[207]. Currently, an estimated 170,000 people and 98,000 homes and businesses are at risk, a figure that could rise to 220,000 people and 130,000 properties by the 2080s due to climate change[208].

While overheating and water scarcity are less familiar issues, they have increasingly affected Glasgow. Heatwaves in 2018 and 2021 saw temperatures in built-up areas rise 4–6°C higher due to the urban heat island effect[209], and summer 2022 brought both high temperatures and drought concerns, which led Scottish Water and SEPA to ask households and businesses to reduce their consumption[210]. Surrounding uplands also heighten climate risks, making the city vulnerable to wildfires during hot, dry conditions. In June 2023, wildfires on the Campsie Fells burned for two days, with smoke visible from Glasgow[211].

HOW IS GLASGOW ADAPTING TO CLIMATE IMPACTS?

Glasgow's approach to climate resilience is structured through both city-level and regional initiatives. The city is governed by the Glasgow City Council, and regional adaptation efforts are driven by Climate Ready Clyde[212]. This initiative covers the Glasgow City Region and is made up of 12 member organisations comprising several local universities, councils in the Glasgow region, and the Scottish Environmental Protection Agency (SEPA). In June 2021, ahead of hosting COP26, Climate Ready Clyde launched the region's first Climate Adaptation Strategy and Action Plan[213].

Glasgow City Council published its Climate Adaptation Plan 2022-2030 in 2022[214]. The plan focuses on mitigating climate risks while enhancing the city's ability to adapt to long-term climate changes, and highlights the role of urban greening in enhancing resilience. These initiatives align with the city's broader aim to integrate nature-based solutions into urban planning. It is on track to achieve some of its climate adaptation goals including adopting Green Belt and Green Network supplementary guidance in September 2024[215]. This offers guidance on the circumstances under which Glasgow City Council will expect a roof on a new development to provide green network functionality for biodiversity and SuDs. However other actions are behind schedule, such as undertaking strategic analysis of flood risk to move greenspace to areas of high risk and built development to areas of low risk.

Glasgow's planning regulations are underpinned by its City Development Plan[216] which includes policies requiring climate resilience measures in new developments. For example, Policy CDP8 (Water Environment) mandates that developments reduce flood risks and protect the city's water environment. Similarly, CDP6 (Green Belt and Green Network) supports the expansion of green infrastructure to mitigate heat and flooding impacts.

INSIGHTS FROM GLASGOW BUILT ENVIRONMENT STAKEHOLDERS

UKGBC convened an in-depth discussion with industry members from Glasgow in Winter 2024, which revealed the following insights:

- Stakeholders demonstrated a balanced understanding of both transitional (reputation, policy and sustainability) and physical risks (energy and environmental concerns), with market-related risks being most prominent. The event saw strong input from Sustainability Consultants (20%) and Engineers (10%), which influenced the discussions towards a technical and environmental focus.
- Glasgow's industry members emphasised a balanced approach to climate resilience, highlighting the importance of both behavioural change (including collaboration and cultural shifts) and regulatory/financial needs. These insights reflect Glasgow's unique challenges and opportunities in advancing climate adaptation within its built environment sector.

Resources for built environment stakeholders in Glasgow

Climate adaptation plan 2022-2030: Strategic planning document outlining Glasgow's climate adaptation goals for the 2022–2030 period.

Clydeplan:Regional planning framework for the Glasgow City Region, addressing climate resilience and sustainability.

Glasgow City Development Plan (CDP) 2017 & Supplementary Guidance (SG): Strategic planning documents that guide development in Glasgow, incorporating climate resilience measures.

Glasgow City Region, Climate adaptation strategy and action plan. Climate Ready Clyde June 2021: A comprehensive plan for climate resilience in the Glasgow City Region.

Met Office – Glasgow Climate Pack: A climate assessment tool providing data and projections specific to Glasgow's climate risks.

The Govan/Patrick Strategic Development Framework: A framework outlining development strategies for Govan and Patrick areas in Glasgow with an emphasis on sustainability.

This River Clyde Strategic Development Framework (SDF): A framework detailing development strategies for the River Clyde area, focusing on urban regeneration and climate resilience.

The City Centre Strategic Development Framework (SDF): A plan for the strategic development of Glasgow's city centre, incorporating climate resilience.

Climate vulnerability map, Glasgow, Clyde: A tool for mapping climate vulnerabilities across the Glasgow and Clyde areas.

Flood management plan – Clyde and loch lomond
Plan for managing flood risks in the Clyde and Loch Lomond areas.

Climate Ready Climate – Technical Report
Technical report covering climate risk impacts, with a focus on infrastructure and built environment vulnerabilities.

CASE STUDY FIVE

BIRMINGHAM

HOW DOES BIRMINGHAM EXPERIENCE KEY CLIMATE HAZARDS?

Birmingham, the UK's most inland major city, faces significant flooding risks from watercourses, surface water, and groundwater due to its topography, geological characteristics and water features including 160 miles of canals. Many buildings sit on floodplains, making them vulnerable to extreme rainfall events and storms[217], particularly in the city's northern areas where groundwater flooding is exacerbated by a geological fault crossing the city from north west to south east. Flash floods in September 2024 brought the south of the city to a standstill, as standing water led to the closure of roads and the cancellation of train and bus services, as well as several school closures[218]. As climate change is predicted to increase both levels of precipitation and the frequency of storms, it will be important to consider the adaptive capacity of the local population and support those living in more deprived areas to become resilient to extreme weather.

Birmingham has more neighbourhoods at high-risk of exposure to heat and in need of priority adaptation than any other local authority area in England[219] and the average temperature is projected to rise a further 2.3°C to 6.5°C[220]. The city's urban heat island effect makes the city centre particularly vulnerable, as seen in the 2003 heatwave, which accounted for over half of the heat-related mortality in the West Midlands[221]. Those living in the centre of Birmingham are likely to be more intensely affected by extremes of heat and also have less adaptive capacity due to deprivation levels. Extreme heat will also increase the risks of drought and wildfires, as evidenced by the summer 2022 wildfires across Lickey Hills County Park, which spread over 50,000m2 and forced 15 people to leave their homes[222]. Local residents were asked to keep windows and doors closed to protect against high levels of air pollution and local habitats were destroyed[223],[224].

HOW IS BIRMINGHAM ADAPTING TO CLIMATE IMPACTS?

Birmingham is governed by Birmingham City Council and is part of the West Midlands Combined Authority (WMCA). The main focus of Birmingham's climate resilience work is nature-based solutions. Through data-mapping projects, the council has pinpointed priority areas for tree planting, aiming to improve air quality, reduce urban heat islands, and manage stormwater runoff. In 2023 Birmingham City Council, Treeconomics, the Natured Based Solutions Institute and Birmingham Tree People released An Urban Forest Master Plan for Birmingham 2021-2051[225]. The plan aims to help build a greener, healthier urban forest and is action-focused and based around key performance indicators with specific targets and milestones. The Food and Agriculture Organisation of the United Nations and the Arbor Day Foundation has given Birmingham its "Tree City of the World"[226] award 5 times, reflecting its dedication to urban forestry. The Environment Agency also launched the Bourn Flood Risk Management Scheme[227], which is working with local communities in Birmingham to explore options to better protect communities in the Bournville and Stirchley areas from flooding. It aims to minimise flood risk by creating flood storage areas in local parks that can hold excess water during high rainfall, which reduces flood risk to approximately 200 residential properties and 100 businesses.

Birmingham City Council collaborated with the University of Birmingham to develop a Climate Risk and Vulnerability Assessment[228]. This map identifies areas and communities most susceptible to climate impacts, which helps the city prioritise interventions to protect its residents and infrastructure. In January 2025 the West Midlands Combined Authority (WMCA) and the University of Birmingham launched the WM-Adapt project, a £2 million initiative aimed at enhancing the region's capacity to adapt to climate change[229]. This project focuses on integrating community perspectives, modelling surface water flooding and urban heat islands, and developing a framework that can be replicated across the UK.

INSIGHTS FROM BIRMINGHAM BUILT ENVIRONMENT STAKEHOLDERS

Birmingham's Collaboration Café in spring 2024 brought together a diverse range of participants. Key insights from this event included:

- The discussions focused on the city's climate resilience, with responses from Product Manufacturers (21% of responses) and Architects/Designers (21% of responses). Topics included the importance of reputation management, market stability, and how civic engagement encourages businesses to prioritise sustainability.
- There was widespread agreement on the need for robust financial support and regulatory systems. Contributions from Local Authorities, Developers, and Engineers (each representing 5% of responses), all acknowledge the critical role that governance and funding mechanisms play in driving climate adaptation in Birmingham's built environment.

Resources for built environment stakeholders in Birmingham

Birmingham Climate Change Action Plan 2010: Birmingham's action plan for addressing climate change, outlining strategies and goals to mitigate and adapt to environmental impacts.

Aston, Newtown, and Lozells Area Action Plan (2012):
A specific action plan for the Aston, Newtown, and Lozells areas in Birmingham, addressing development and sustainability measures.

Longbridge Area Action Plan (2009): Planning document for the regeneration of the Longbridge area, focusing on sustainability and climate adaptation.

City of Nature Plan (February 2022): A plan focusing on enhancing green infrastructure and biodiversity in Birmingham, integrating nature-based solutions to climate risks.

West Midlands Climate Pack: A strategic document detailing the climate risks and resilience strategies for the West Midlands.

Environmental Justice Map:
A tool for identifying areas in the West Midlands that are most vulnerable to climate impacts, with a focus on environmental justice.

Climate Impacts – West Midlands Combined Authority: Report assessing the climate impacts and resilience across the West Midlands, focusing on regional adaptation strategies.

West Midlands Climate Change Risk Assessment and Adaptation Plan 2021-2026:
An updated risk assessment and action plan for adapting to climate change in the West Midlands, focusing on infrastructure and community resilience.

Birmingham Flood Risk Plans: Birmingham's plans to address and manage flood risks, including mitigation and adaptation strategies.

REFERENCES

1 Climate Change Committee, "Independent Assessment of UK Climate Risk," June 2021. [Online]. Available: https://www.theccc.org.uk/publication/independent-assessment-of-uk-climate-risk/.

2 Construction Industry Council, "APPG for Excellence in the Built Environment," CIC, [Online]. Available: https://www.cic.org.uk/policy-and-public-affairs/appg-for-excellence-in-the-built-environment. [Accessed 14 3 2025].

3 UK Government, "Climate Change Act 2008," 2008. [Online]. Available: https://www.legislation.gov.uk/ukpga/2008/27/contents. [Accessed 15 3 2025].

4 Arup, "Addressing overheating risk in UK homes," October 2022. [Online]. Available: https://www.theccc.org.uk/publication/addressing-overheating-risk-in-existing-uk-homes-arup/.

5 Office for National Statistics (ONS), "Excess mortality during heat-periods: 1 June to 31 August 2022," 7 October 2022. [Online]. Available: https://www.ons.gov.uk/peoplepopulationandcommunity/birthsdeathsandmarriages/deaths/articles/excessmortalityduringheatperiods/englandandwales1juneto31august2022.

6 Climate Change Committee, "Independent Assessment of UK Climate Risk," June 2021. [Online]. Available: https://www.theccc.org.uk/publication/independent-assessment-of-uk-climate-risk/.

7 S. Kovats and D. Osborn, "UK Climate Change Risk Assessment Evidence Report: Chapter 5, People and the Built Environment," 2016. [Online]. Available: https://www.theccc.org.uk/uk-climate-change-risk-assessment-2017/ccra-chapters/people-and-the-built-environment/.

8 R. Black, "How will flood risk to the UK change in future - and are we prepared," Energy & Climate Intelligence Unit, 11 February 2022. [Online]. Available: https://eciu.net/analysis/briefings/climate-impacts/flood-risk-and-the-uk. [Accessed 6 3 2025].

9 The Joint Committee on the National Security Strategy, "Readiness for storms ahead? Critical national infrastructure in an age of climate change," 21 October 2022. [Online]. Available: https://publications.parliament.uk/pa/jt5803/jtselect/jtnatsec/132/summary.html. [Accessed 6 3 2025].

10 British Geological Survey , "Understanding landslides," [Online]. Available: https://www.bgs.ac.uk/discovering-geology/earth-hazards/landslides/. [Accessed 14 3 2025].

11 British Geological Survey, "Understanding sinkholes and karst," [Online]. Available: https://www.bgs.ac.uk/discovering-geology/earth-hazards/sinkholes/. [Accessed 18 03 2025].

12 British Geological Survey, "Regional geological summaries," [Online]. Available: https://www.bgs.ac.uk/geology-projects/regional-geological-summaries/. [Accessed 18 03 2025].

13 Met Office, "UK regional climates," [Online]. Available: https://www.metoffice.gov.uk/research/climate/maps-and-data/regional-climates/index. [Accessed 14 3 2025].

14 Hilson, C., & Arnall, A. (2024). Sea level rise, claims-making and managed retreat in Fairbourne, North Wales. Climate Policy, 1–14. https://doi.org/10.1080/14693062.2024.2420739

15 Environment Agency, 2021. "Future Fens flood risk management". Online. Available at: https://www.gov.uk/government/news/future-fens-flood-risk-management

16 United Nations Office for Disaster Risk Reduction, "Definition: Resilience," [Online]. Available: https://www.undrr.org/terminology/resilience. [Accessed 6 3 2025].

17 United Nations Framework Convention on Climate Change, "Introduction," UNFCCC, [Online]. Available: https://unfccc.int/topics/adaptation-and-resilience/the-big-picture/introduction. [Accessed 6 3 2025].

18 IPCC, "Glossary (Special report: Gloabl warming of 1.5 degree C)," IPCC, 2018. [Online]. Available: https://www.ipcc.ch/sr15/chapter/glossary/. [Accessed 6 3 2025].

19 IPCC, "Glossary (Special report: Gloabl warming of 1.5 degree C)," IPCC, 2018. [Online]. Available: https://www.ipcc.ch/sr15/chapter/glossary/. [Accessed 6 3 2025].

20 United Nations Office for Disaster Risk Reduction , "Definition: Vulnerability," [Online]. Available: https://www.undrr.org/terminology/vulnerability. [Accessed 6 3 2025].

21 IPCC, "Glossary (Special report: Gloabl warming of 1.5 degree C)," IPCC, 2018. [Online]. Available: https://www.ipcc.ch/sr15/chapter/glossary/. [Accessed 6 3 2025].

22 UK Climate Risk , "Technical report (CCRA3-IA)," 16 June 2021. [Online]. Available: https://www.ukclimaterisk.org/publications/technical-report-ccra3-ia/. [Accessed 7 3 2025].

23 European Commission, "Sustainable finance taxonomy: Appendix A," 2023. [Online]. Available: https://ec.europa.eu/sustainable-finance-taxonomy/assets/documents/CCA%20Appendix%20A.pdf. [Accessed 7 3 2025].

24 Met Office, "Extreme weather," [Online]. Available: https://weather.metoffice.gov.uk/learn-about/met-office-for-schools/other-content/other-resources/extreme-weather. [Accessed 6 3 2025].

25 Chartered Institute of Building Service Engineers, "TM52 The limits of thermal comfort: avoiding overheating (2013)," October 2013. [Online]. Available: https://www.cibse.org/knowledge-research/knowledge-portal/tm52-the-limits-of-thermal-comfort-avoiding-overheating-in-european-buildings. [Accessed 18 03 2025].

26 UKGBC, "Health and wellbeing in homes," July 2016. [Online]. Available: https://ukgbc.org/wp-content/uploads/2017/12/Healthy-Homes-Full-Report.pdf.

27 CIBSE, "Overheating Position Statement," March 2020. [Online]. Available: https://www.cibse.org/policy-insight/position-statements-and-briefings/overheating-position-statement/. [Accessed 6 3 2025].

28 Met Office , "Storms," Met Office , [Online]. Available: https://www.metoffice.gov.uk/weather/learn-about/weather/types-of-weather/storms. [Accessed 7 3 2025].

29 ABI, "Storms," [Online]. Available: https://www.abi.org.uk/products-and-issues/topics-and-issues/flooding/storms/. [Accessed 7 3 2025].

30 BBC, "Storm names 2024-25: How do storms like Éowyn get their names?," 29 August 2024. [Online]. Available: https://www.bbc.co.uk/weather/articles/c1w7zl30dq5o. [Accessed 7 3 2025].

31 Met Office , "UK and Global extreme events – Wind storms," Met Office, [Online]. Available: https://www.metoffice.gov.uk/research/climate/understanding-climate/uk-and-global-extreme-events-wind-storms. [Accessed 6 3 2025].

32 World Meteorological Organisation , "Drought," [Online]. Available: https://wmo.int/topics/drought. [Accessed 7 3 2025].

33 UKGBC, "What does the dry weather mean for the built environment?," 17 August 2022. [Online]. Available: https://ukgbc.org/news/what-does-the-dry-weather-mean-for-the-built-environment/. [Accessed 7 3 2025].

34 British Geological Survey, "Swelling and shrinking soils," BGS, [Online]. Available: https://www.bgs.ac.uk/geology-projects/shallow-geohazards/clay-shrink-swell/. [Accessed 7 3 2025].

35 British Geological Survey, "Maps show the real threat of climate-related subsidence to British homes and properties," 19 5 2021. [Online]. Available: https://www.bgs.ac.uk/news/maps-show-the-real-threat-of-climate-related-subsidence-to-british-homes-and-properties/. [Accessed 7 3 2025].

36 UK Centre for Ecology & Hydrology, "Summer 2022 drought provides warning for future years," 28 3 2024. [Online]. Available: https://www.ceh.ac.uk/press/summer-2022-drought-provides-warning-future-years. [Accessed 7 3 2025].

37 C. M. Belcher, I. Brown, G. D. Clay, S. H. Doerr, A. Elliott, R. Gazzard, N. Kettridge, J. Moison, M. Perry, C. Santin and T. E. Smith, "UK Wildfires and their Climate Challenges," Expert Led Report Prepared for the third Climate Change Risk Assessment, 2021.

38 Woodland Trust , "Peatland struggles to recover six years on from devastating wildfires," 20 September 2024. [Online]. Available: https://www.woodlandtrust.org.uk/press-centre/2024/09/peatland-struggles-to-recover-from-devastating-wildfires/#:~:text=Smithills%20site%20manager%20Oliver%20Stainthorpe,peat%20to%20how%20it%20was. [Accessed 14 3 2025].

39 Lancashire Wildlife Trust , "Wildfires on peatlands," Lancashire Wildlife Trust , 12 June 2023. [Online]. Available: https://www.lancswt.org.uk/blog/jenny-bennion/wildfires-peatlands. [Accessed 14 3 2025].

40 The Ignition Project , "Nature-based solutions to the climate emergency," August 2020. [Online]. Available: https://www.ukgbc.org/wp-content/uploads/2020/08/Nature-based-solutions-to-the-climate-emergency.pdf. [Accessed 14 3 2025].

41 IUCN , "Peatland Damage," [Online]. Available: https://www.iucn-uk-peatlandprogramme.org/about-peatlands/peatland-damage#:~:text=Described%20as%20the%20'Cinderella%20habitat,of%20past%20and%20present%20management. [Accessed 14 3 2025].

42 M. W. Jones, S. Varaverbeke, N. Andela, S. H. Doerr, G. Mataveli, M. L. Pettinari, C. Le Quere, T. M. Rosan, G. R. Van der Werf, D. Van Wees and J. T. Abatzoglou, "Global rise in forest fire emissions linked to climate change in the extratropics," *Science*, vol. 386, no. 6719, 2024.

43 Met Office , "Climate change increases global burnt area," 20 October 2024. [Online]. Available: https://www.metoffice.gov.uk/about-us/news-and-media/media-centre/weather-and-climate-news/2024/climate-change-increases-global-burnt-area. [Accessed 7 3 2025].

44 Department for Communities and Local Government, "Improving the flood performance of new buildings," May 2007. [Online]. Available: https://assets.publishing.service.gov.uk/media/5a797ab2ed915d07d35b5da4/flood_performance.pdf. [Accessed 3 5 2025].

45 Department for Communities and Local Government, "Improving the flood performance of new buildings," May 2007. [Online]. Available: https://assets.publishing.service.gov.uk/media/5a797ab2ed915d07d35b5da4/flood_performance.pdf. [Accessed 3 5 2025].

46 Department for Communities and Local Government, "Improving the flood performance of new buildings," May 2007. [Online]. Available: https://assets.publishing.service.gov.uk/media/5a797ab2ed915d07d35b5da4/flood_performance.pdf. [Accessed 3 5 2025].

47 Department for Communities and Local Government, "Improving the flood performance of new buildings," May 2007. [Online]. Available: https://assets.publishing.service.gov.uk/media/5a797ab2ed915d07d35b5da4/flood_performance.pdf. [Accessed 3 5 2025].

48 Department for Communities and Local Government, "Improving the flood performance of new buildings," May 2007. [Online]. Available: https://assets.publishing.service.gov.uk/media/5a797ab2ed915d07d35b5da4/flood_performance.pdf. [Accessed 3 5 2025].

49 The Ignition Project , "Nature-based solutions to the climate emergency," August 2020. [Online]. Available: https://www.ukgbc.org/wp-content/uploads/2020/08/Nature-based-solutions-to-the-climate-emergency.pdf. [Accessed 14 3 2025].

50 Department for Communities and Local Government, "Improving the flood performance of new buildings," May 2007. [Online]. Available: https://assets.publishing.service.gov.uk/media/5a797ab2ed915d07d35b5da4/flood_performance.pdf. [Accessed 3 5 2025].

51 BSI, "BS 85500:2015 Flood resistant and resilient construction. Guide to improving the flood performance of buildings," 30 November 2015. [Online]. Available: https://knowledge.bsigroup.com/products/flood-resistant-and-resilient-construction-guide-to-improving-the-flood-performance-of-buildings. [Accessed 14 3 2025].

52 The Flood Hub, "Property Flood Resilience (PFR) Booklet," May 2024. [Online]. Available: https://thefloodhub.co.uk/wp-content/uploads/2018/09/FT-Q-R38-R2-Property-Flood-Resilience-PFR-booklet.pdf. [Accessed 14 3 2025].

53 The Flood Hub, "Property Flood Resilience (PFR) Booklet," May 2024. [Online]. Available: https://thefloodhub.co.uk/wp-content/uploads/2018/09/FT-Q-R38-R2-Property-Flood-Resilience-PFR-booklet.pdf. [Accessed 14 3 2025].

54 The Flood Hub, “Property Flood Resilience (PFR) Booklet,” May 2024. [Online]. Available: https://thefloodhub.co.uk/wp-content/uploads/2018/09/FT-Q-R38-R2-Property-Flood-Resilience-PFR-booklet.pdf. [Accessed 14 3 2025].

55 Climate Change Committee, “Progress in adapting to climate change,” March 2023. [Online]. Available: https://www.theccc.org.uk/wp-content/uploads/2023/03/WEB-Progress-in-adapting-to-climate-change-2023-Report-to-Parliament.pdf. [Accessed 14 3 2025].

56 BSI, “BS 85500:2015 Flood resistant and resilient construction. Guide to improving the flood performance of buildings,” 30 November 2015. [Online]. Available: https://knowledge.bsigroup.com/products/flood-resistant-and-resilient-construction-guide-to-improving-the-flood-performance-of-buildings. [Accessed 14 3 2025].

57 BSI, “BS 85500:2015 Flood resistant and resilient construction. Guide to improving the flood performance of buildings,” 30 November 2015. [Online]. Available: https://knowledge.bsigroup.com/products/flood-resistant-and-resilient-construction-guide-to-improving-the-flood-performance-of-buildings. [Accessed 14 3 2025].

58 BSI, “BS 85500:2015 Flood resistant and resilient construction. Guide to improving the flood performance of buildings,” 30 November 2015. [Online]. Available: https://knowledge.bsigroup.com/products/flood-resistant-and-resilient-construction-guide-to-improving-the-flood-performance-of-buildings. [Accessed 14 3 2025].

59 The Flood Hub, “Property Flood Resilience (PFR) Booklet,” May 2024. [Online]. Available: https://thefloodhub.co.uk/wp-content/uploads/2018/09/FT-Q-R38-R2-Property-Flood-Resilience-PFR-booklet.pdf. [Accessed 14 3 2025].

60 Know your flood risk, “Flood guide for resilience,” [Online]. Available: https://www.landmark.co.uk/wp-content/uploads/2021/08/FloodGuide_ForResilience.pdf. [Accessed 14 3 2025].

61 The Flood Hub, “Property Flood Resilience (PFR) Booklet,” May 2024. [Online]. Available: https://thefloodhub.co.uk/wp-content/uploads/2018/09/FT-Q-R38-R2-Property-Flood-Resilience-PFR-booklet.pdf. [Accessed 14 3 2025].

62 BSI, “BS 85500:2015 Flood resistant and resilient construction. Guide to improving the flood performance of buildings,” 30 November 2015. [Online]. Available: https://knowledge.bsigroup.com/products/flood-resistant-and-resilient-construction-guide-to-improving-the-flood-performance-of-buildings. [Accessed 14 3 2025].

63 BSI, “BS 85500:2015 Flood resistant and resilient construction. Guide to improving the flood performance of buildings,” 30 November 2015. [Online]. Available: https://knowledge.bsigroup.com/products/flood-resistant-and-resilient-construction-guide-to-improving-the-flood-performance-of-buildings. [Accessed 14 3 2025].

64 The Flood Hub, “Property Flood Resilience (PFR) Booklet,” May 2024. [Online]. Available: https://thefloodhub.co.uk/wp-content/uploads/2018/09/FT-Q-R38-R2-Property-Flood-Resilience-PFR-booklet.pdf. [Accessed 14 3 2025].

65 BSI, “BS 85500:2015 Flood resistant and resilient construction. Guide to improving the flood performance of buildings,” 30 November 2015. [Online]. Available: https://knowledge.bsigroup.com/products/flood-resistant-and-resilient-construction-guide-to-improving-the-flood-performance-of-buildings. [Accessed 14 3 2025].

66 The Flood Hub, “Property Flood Resilience (PFR) Booklet,” May 2024. [Online]. Available: https://thefloodhub.co.uk/wp-content/uploads/2018/09/FT-Q-R38-R2-Property-Flood-Resilience-PFR-booklet.pdf. [Accessed 14 3 2025].

67 Climate Change Committee, “Progress in adapting to climate change,” March 2023. [Online]. Available: https://www.theccc.org.uk/wp-content/uploads/2023/03/WEB-Progress-in-adapting-to-climate-change-2023-Report-to-Parliament.pdf. [Accessed 14 3 2025].

68 Climate Change Committee, “Progress in adapting to climate change,” March 2023. [Online]. Available: https://www.theccc.org.uk/wp-content/uploads/2023/03/WEB-Progress-in-adapting-to-climate-change-2023-Report-to-Parliament.pdf. [Accessed 14 3 2025].

69 The Flood Hub, “Property Flood Resilience (PFR) Booklet,” May 2024. [Online]. Available: https://thefloodhub.co.uk/wp-content/uploads/2018/09/FT-Q-R38-R2-Property-Flood-Resilience-PFR-booklet.pdf. [Accessed 14 3 2025].

70 BSI, “BS 85500:2015 Flood resistant and resilient construction. Guide to improving the flood performance of buildings,” 30 November 2015. [Online]. Available: https://knowledge.bsigroup.com/products/flood-resistant-and-resilient-construction-guide-to-improving-the-flood-performance-of-buildings. [Accessed 14 3 2025].

71 T. Greenhill, “Heatwave Toolkit - Solutions for a UK Heat Emergency,” [Online]. Available: https://www.heatwavetoolkit.com/. [Accessed 18 03 2025].

72 UK Climate Risk , “Housing briefing: Findings from the third UK Climate Change Risk Assessment (CCRA3) Evidence Report 2021,” 2021. [Online]. Available: https://www.ukclimaterisk.org/wp-content/uploads/2021/06/CCRA3-Briefing-Housing.pdf. [Accessed 17 3 2025].

73 UK Climate Risk , “Housing briefing: Findings from the third UK Climate Change Risk Assessment (CCRA3) Evidence Report 2021,” 2021. [Online]. Available: https://www.ukclimaterisk.org/wp-content/uploads/2021/06/CCRA3-Briefing-Housing.pdf. [Accessed 17 3 2025].

74 UK Climate Risk , “Housing briefing: Findings from the third UK Climate Change Risk Assessment (CCRA3) Evidence Report 2021,” 2021. [Online]. Available: https://www.ukclimaterisk.org/wp-content/uploads/2021/06/CCRA3-Briefing-Housing.pdf. [Accessed 17 3 2025].

75 British Red Cross, “Community Resilience Toolkits,” 2016.

76 Aviva, “Windstorm - Property. Loss Prevention Standards - Asset Classes,” 22 10 2024. [Online]. Available: https://static.aviva.io/content/dam/document-library/risk-solutions/windstorm_property_lps.pdf. [Accessed 17 3 2025].

77 A. A. Ager, C. R. Evers, et al., “Network analysis of wildfire transmition,” *PLOS ONE*, 2017.

78 M. Francos, P. Pereira, and X. Ubeda, “Effect of management practices on plant recovery after wildfire,” *Journal of Forestry Research*, 2019.

79 E. Kuligowski, “Evacuation decision-making and behaviour in wildfires,” *Fire Safety Journal*, 2021.

80 P. D. Howe, M. Brunson, et al., “Risk perceptions and community response,” *Landscape and Urban Planning*, 2021.

81 S. C. P. Coogan, F. N. Robinne, and P. Jain, “Scientists’ warning on wildfire - a Canadian perspective,” *Canadian Jounral of Forest Research*, 2019.

82 H. A. Kramer, V. Butsic, et al., “Post-wildfire rebuilding and fire risk adaptation,” *Land Use Policy*, 2021.

83 J. W. Long, C. Skinner, S. Charnley, and K. Hubbert, “Post-wildfire management,” *Science Synthesis*, 2014.

84 A. A. Ager, C. R. Evers, et al., “Network analysis of wildfire transmition,” *PLOS ONE*, 2017. 84 World Economic Forum, “The ROI of transition: the new driver of corporate sustainability agendas,” World Economic Forum , 16 Janurary 2025. [Online]. Available: https://www.weforum.org/stories/2025/01/how-cfos-are-driving-corporate-sustainability-agendas/?utm_source=chatgpt.com. [Accessed 17 3 2025].

85 National House-Building Council (NHBC), “New home statistics review,” July 2024. [Online]. Available: https://www.nhbc.co.uk/insights-and-media/insights/current-house-building-volumes-must-double-to-meet-labours-1-5m-new-homes-pledge. [Accessed 17 3 2025].

86 Zero Carbon Hub , “Overheating in homes,” 2016. [Online]. Available: https://www.cewales.org.uk/files/9714/4370/9984/Drivers_of_Change_-_Overheating_in_Homes.pdf. [Accessed 6 3 2025].

87 UK Research and Innovation , “Boosting UK infrastructure resilience against climate change,” UK Research and Innovation , 24 August 2023. [Online]. Available: https://www.ukri.org/news/boosting-uk-infrastructure-resilience-against-climate-change/. [Accessed 17 3 2025].

88 Meadows, D. H. (2008). Thinking in Systems: A Primer. Chelsea Green Publishing.

89 Environment Agency, “Flooding in England: A National Assessment of Flood Risk,” 2009. [Online]. Available: https://assets.publishing.service.gov.uk/media/5a7ba398ed915d4147621ad6/geho0609bqds-e-e.pdf. [Accessed 6 3 2025].

90 Met Office, “UK Climate Projections: Headline Findings,” August 2022. [Online]. Available: https://www.metoffice.gov.uk/research/approach/collaboration/ukcp/summaries/headline-findings.

91 Met Office , “Named storms and low pressure systems in the UK,” [Online]. Available: https://www.metoffice.gov.uk/weather/learn-about/weather/types-of-weather/storms/winter-storms. [Accessed 7 3 2025].

92 Met Office, “UK Climate Projections: Headline Findings,” August 2022. [Online]. Available: https://www.metoffice.gov.uk/research/approach/collaboration/ukcp/summaries/headline-findings.

93 Climate Change Committee, “Independent Assessment of UK Climate Risk,” June 2021. [Online]. Available: https://www.theccc.org.uk/publication/independent-assessment-of-uk-climate-risk/.

94 Climate Change Committee, “Independent Assessment of UK Climate Risk,” June 2021. [Online]. Available: https://www.theccc.org.uk/publication/independent-assessment-of-uk-climate-risk/.

95 Met Office, “UK Climate Projections: Headline Findings,” August 2022. [Online]. Available: https://www.metoffice.gov.uk/research/approach/collaboration/ukcp/summaries/headline-findings.

96 UK Climate Risk, “Water Briefing. Findings from the third UK Climate Change Risk Assessment (CCRA3) Evidence Resport 2021,” 2021. [Online]. Available: https://www.ukclimaterisk.org/wp-content/uploads/2021/06/CCRA3-Briefing-Water.pdf. [Accessed 6 3 2025].

97 R. Thompson, “Drought: heavy rain now might be a serious problem for the UK’s parched landscape,” University of Reading, 24 August 2022. [Online]. Available: https://research.reading.ac.uk/research-blog/2022/08/24/drought-heavy-rain-serious-problem-for-uk/. [Accessed 6 3 2025].

98 Environment Agency, “Flooding in England: A National Assessment of Flood Risk,” 2009. [Online]. Available: https://assets.publishing.service.gov.uk/media/5a7ba398ed915d4147621ad6/geho0609bqds-e-e.pdf. [Accessed 6 3 2025].

99 Environment Agency, “National Flood and Coastal Erosion Risk Management Strategy for England,” 2020. [Online]. Available: https://assets.publishing.service.gov.uk/media/5f6b6da6e90e076c182d508d/023_15482_Environment_agency_digitalAW_Strategy.pdf. [Accessed 6 3 2025].

100 Environment Agency, “New national flood and coastal erosion risk information,” 20 February 2024. [Online]. Available: https://www.gov.uk/guidance/updates-to-national-flood-and-coastal-erosion-risk-information. [Accessed 6 3 2025].

101 ABI, “Weather damage insurance claims worst on record,” 15 4 2024. [Online]. Available: https://www.abi.org.uk/news/news-articles/2024/4/weather-damage-insurance-claims-worst-on-record/. [Accessed 6 3 2025].

102 ABI, “Weather damage insurance claims worst on record,” 15 4 2024. [Online]. Available: https://www.abi.org.uk/news/news-articles/2024/4/weather-damage-insurance-claims-worst-on-record/. [Accessed 6 3 2025].

103 ABI, “Weather damage insurance claims worst on record,” 15 4 2024. [Online]. Available: https://www.abi.org.uk/news/news-articles/2024/4/weather-damage-insurance-claims-worst-on-record/. [Accessed 6 3 2025].

104 S. Kovats and D. Osborn, “UK Climate Change Risk Assessment Evidence Report: Chapter 5, People and the Built Environment,” 2016. [Online]. Available: https://www.theccc.org.uk/uk-climate-change-risk-assessment-2017/ccra-chapters/people-and-the-built-environment/.

105 Office for National Statistics (ONS), “Excess mortality during heat-periods: 1 June to 31 August 2022,” 7 October 2022. [Online]. Available: https://www.ons.gov.uk/peoplepopulationandcommunity/birthsdeathsandmarriages/deaths/articles/excessmortalityduringheatperiods/englandandwales1juneto31august2022.

106 Met Office, “Effects of climate change,” Met Office, [Online]. Available: https://www.metoffice.gov.uk/weather/climate-change/effects-of-climate-change. [Accessed 6 3 2025].

107 Estates Returns Information Collection, "Estates Returns Information Collection, Summary page and dataset for ERIC 2022/23," 14 December 2023. [Online]. Available: https://digital.nhs.uk/data-and-information/publications/statistical/estates-returns-information-collection/england-2022-23. [Accessed 6 3 2025].

108 Round our Way , "NHS Overheating. Analysis of the impact of heatwaves on the people who rely on and work in the NHS," June 2023. [Online]. Available: https://roundourway.org/uploads/files/NHSOVERHEATING-RoundOurWayreport-June2023-FINAL.pdf.

109 Met Office, "UK Climate Projections: Headline Findings," August 2022. [Online]. Available: https://www.metoffice.gov.uk/research/approach/collaboration/ukcp/summaries/headline-findings.

110 MIT, "Urban Heat Islands," 16 April 2021. [Online]. Available: https://climate.mit.edu/explainers/urban-heat-islands. [Accessed 6 3 2025].

111 L. Mentaschi, G. Duveiller, G. Zulian, C. Corbane, M. Pesaresi, J. Maes, A. Stocchino and L. Feyen, "Global long-term mapping of surface temperature shows intensified intra-city urban heat island extremes," *Global Environmental Change*, vol. 72, p. January, 2022.

112 Arup, "London's most extreme urban heat island "hot spot" revealed in new survey," Arup, 21 August 2023. [Online]. Available: https://www.arup.com/news/londons-most-extreme-urban-heat-island-hot-spot-compared-to-five-other-global-cities-in-new-survey/. [Accessed 6 3 2025].

113 Aviva, "One in thirteen new homes built in flood zone," 17 January 2024. [Online]. Available: https://www.aviva.com/newsroom/news-releases/2024/01/one-in-thirteen-new-homes-built-in-flood-zone/. [Accessed 6 3 2025].

114 National House-Building Council (NHBC), "New home statistics review," July 2024. [Online]. Available: https://www.nhbc.co.uk/insights-and-media/insights/current-house-building-volumes-must-double-to-meet-labour-s-1-5m-new-homes-pledge. [Accessed 17 3 2025].

115 Zero Carbon Hub , "Overheating in homes," 2016. [Online]. Available: https://www.cewales.org.uk/files/9714/4370/9984/Drivers_of_Change_-_Overheating_in_Homes.pdf. [Accessed 6 3 2025].

116 World Health Organisation, "Heat and health," [Online]. Available: https://www.who.int/news-room/fact-sheets/detail/climate-change-heat-and-health#:~:text=Heat%20stress%20is%20the%20leading,a%20high%2Dcase%20fatality%20rate.. [Accessed 18 03 2025].

117 C. Barton , G. Sturge and R. Harker, "The UK's changing population," UK Parliment, 16 July 2024. [Online]. Available: https://www.metoffice.gov.uk/about-us/news-and-media/media-centre/weather-and-climate-news/2022/continued-impacts-from-storm-eunice-ahead-of-unsettled-weekend. [Accessed 6 3 2025].

118 Met Office, "Storm Ciarán, 1 to 2 November 2023," 18 June 2024. [Online]. Available: https://www.metoffice.gov.uk/binaries/content/assets/metofficegovuk/pdf/weather/learn-about/uk-past-events/interesting/2023/2023_09_storm_ciaran_2.pdf. [Accessed 7 3 2025].

119 Met Office, "Storm Eunice continues ahead of unsettled weekend," 18 February 2022. [Online]. Available: https://www.metoffice.gov.uk/about-us/news-and-media/media-centre/weather-and-climate-news/2022/continued-impacts-from-storm-eunice-ahead-of-unsettled-weekend. [Accessed 7 3 2025].

120 NCAS, "Weather disruptors: What are named storms and how do they affect the UK," National Centre for Atmospheric Science, 5 April 2024. [Online]. Available: https://ncas.ac.uk/weather-disruptors-what-are-named-storms-and-how-do-they-affect-the-uk/. [Accessed 7 3 2025].

121 Met Office , "Named storms and low pressure systems in the UK," [Online]. Available: https://www.metoffice.gov.uk/weather/learn-about/weather/types-of-weather/storms/winter-storms. [Accessed 7 3 2025].

122 Met Office , "Named storms and low pressure systems in the UK," [Online]. Available: https://www.metoffice.gov.uk/weather/learn-about/weather/types-of-weather/storms/winter-storms. [Accessed 7 3 2025].

123 Met Office , "Named storms and low pressure systems in the UK," [Online]. Available: https://www.metoffice.gov.uk/weather/learn-about/weather/types-of-weather/storms/winter-storms. [Accessed 7 3 2025].

124 Met Office, "UKCP18 Factsheet: Storms," 2023. [Online]. Available: https://www.metoffice.gov.uk/binaries/content/assets/metofficegovuk/pdf/research/ukcp/ukcp18-factsheet-storms.pdf. [Accessed 7 3 2025].

125 Met Eireann, "Drought Summary," 9 June 2020. [Online]. Available: https://www.met.ie/drought-summary. [Accessed 7 3 2025].

126 S. F. Kew, M. McCarthy, C. Ryan, J. S. Pirret, E. Murtagh, M. Vahlberg, A. Amankona, J. O. Pope, F. Lott, O. Claydon, B. Coonan, I. Pinto, C. Barnes, S. Philip, F. Otto, E. Wallace, L. Bryant, E. Tranter, R. Singh and A. Mijic, "Autumn and Winter storms over UK and Ireland are becoming wetter due to climate change," 2024.

127 Met Office, "UK and Global extreme events – Drought," [Online]. Available: https://www.metoffice.gov.uk/research/climate/understanding-climate/uk-and-global-extreme-events-drought#:~:text=As%20global%20temperatures%20rise%2C%20there,determine%20future%20UK%20drought%20risk. [Accessed 7 3 2025].

128 ABI, "Weathering the Storm," 14 Decmber 2023. [Online]. Available: https://www.abi.org.uk/news/news-articles/2023/12/weathering-the-storm/. [Accessed 7 3 2025].

129 Barker, L. J., Hannaford, J., Magee, E., Turner, S., Sefton, C., Parry, S., Evans, J., Szczykulska, M., & Haxton, T., "An appraisal of the severity of the 2022 drought and its impacts.," *Weather*, vol. 79, no. 7, pp. 206-224, 2024.

130 Building Design, "Storm Eunice damages O2 Arena, Laban Centre and Cressingham Gardens," 18 February 2022. [Online]. Available: https://www.bdonline.co.uk/news/storm-eunice-damages-o2-arena-laban-centre-and-cressingham-gardens/5116140.article. [Accessed 7 3 2025].

131 Met Office , "Storm Babet, 18 to 21 October 2023," 2023. [Online]. Available: https://www.metoffice.gov.uk/binaries/content/assets/metofficegovuk/pdf/weather/learn-about/uk-past-events/interesting/2023/2023_08_storm_babet.pdf. [Accessed 7 3 2025].

132 World Meteorological Organisation , "Drought," [Online]. Available: https://wmo.int/topics/drought. [Accessed 7 3 2025].

133 UK Centre for Ecology & Hydrology, "Summer 2022 drought provides warning for future years," 28 3 2024. [Online]. Available: https://www.ceh.ac.uk/press/summer-2022-drought-provides-warning-future-years. [Accessed 7 3 2025].

134 BBC, "Storm names 2024-25: How do storms like Éowyn get their names?," 29 August 2024. [Online]. Available: https://www.bbc.co.uk/weather/articles/c1w7zl30dq5o. [Accessed 7 3 2025].

135 Environment Agency , "Drought response: our framework for England," June 2017. [Online]. Available: https://assets.publishing.service.gov.uk/media/5a820510ed915d74e62355a0/LIT_10104.pdf. [Accessed 7 3 2025].

136 Met Office, "UK and Global extreme events – Drought," [Online]. Available: https://www.metoffice.gov.uk/research/climate/understanding-climate/uk-and-global-extreme-events-drought. [Accessed 7 3 2025].

137 Met Office, "UK and Global extreme events – Drought," [Online]. Available: https://www.metoffice.gov.uk/research/climate/understanding-climate/uk-and-global-extreme-events-drought. [Accessed 7 3 2025].

138 A. M. Graham, R. J. Pope, K. P. Pringle, M. P. Chipperfield, L. A. Conibear, E. W. Butt, L. Kiely, C. Knote and J. B. McQuaid, "Impact on air quality and health due to the Saddleworth Moor fire in northern England," *Environmental Research Letters*, vol. 15, no. 7, 23 June 2020.

139 UK Centre for Ecology & Hydrology, "Frequency and duration of soil moisture droughts set to increase under climate change," 16 9 2024. [Online]. Available: https://www.ceh.ac.uk/news-and-media/news/frequency-and-duration-soil-moisture-droughts-set-increase-under-climate-change. [Accessed 7 3 2025].

140 UK Centre for Ecology & Hydrology, "Summer 2022 drought provides warning for future years," 28 3 2024. [Online]. Available: https://www.ceh.ac.uk/press/summer-2022-drought-provides-warning-future-years. [Accessed 7 3 2025].

141 Barker, L. J., Hannaford, J., Magee, E., Turner, S., Sefton, C., Parry, S., Evans, J., Szczykulska, M., & Haxton, T., "An appraisal of the severity of the 2022 drought and its impacts.," Weather, vol. 79, no. 7, pp. 206-224, 2024.

142 Barker, L. J., Hannaford, J., Magee, E., Turner, S., Sefton, C., Parry, S., Evans, J., Szczykulska, M., & Haxton, T., "An appraisal of the severity of the 2022 drought and its impacts.," Weather, vol. 79, no. 7, pp. 206-224, 2024.

143 UK Centre for Ecology & Hydrology, "Summer 2022 drought provides warning for future years," 28 3 2024. [Online]. Available: https://www.ceh.ac.uk/press/summer-2022-drought-provides-warning-future-years. [Accessed 7 3 2025].

144 ABI, "Sinking UK – last summer's record-breaking heatwave leads to surge in insurance payouts for subsidence," 21 3 2023. [Online]. Available: https://www.abi.org.uk/news/news-articles/2023/3/sinking-uk--last-summers-record-breaking-heatwave-leads-to-surge-in-insurance-payouts-for-subsidence/. [Accessed 7 3 2025].

145 ABI, "Sinking UK – last summer's record-breaking heatwave leads to surge in insurance payouts for subsidence," 21 3 2023. [Online]. Available: https://www.abi.org.uk/news/news-articles/2023/3/sinking-uk--last-summers-record-breaking-heatwave-leads-to-surge-in-insurance-payouts-for-subsidence/. [Accessed 7 3 2025].

146 National Parks Service, "Wildland Fire Behavior," [Online]. Available: https://www.nps.gov/articles/wildland-fire-behavior.htm. [Accessed 7 3 2025].

147 Met Office , "England and Wales Fire Severity Index," [Online]. Available: https://www.metoffice.gov.uk/public/weather/fire-severity-index/#?tab=map&fcTime=1742212800&zoom=5&lon=-4.00&lat=55.74. [Accessed 17 3 2025].

148 C. M. Belcher, I. Brown, G. D. Clay, S. H. Doerr, A. Elliott, R. Gazzard, N. Kettridge, J. Moison, M. Perry, C. Santin and T. E. Smith, "UK Wildfires and their Climate Challenges," Expert Led Report Prepared for the third Climate Change Risk Assessment, 2021.

149 UK Climate Risk , "Wildfire Briefing: Findings from the third UK Climate Change Risk Assessment (CCRA3) Evidence Report 2021," 2021. [Online]. Available: https://www.ukclimaterisk.org/wp-content/uploads/2021/06/CCRA3-Briefing-Wildfire.pdf. [Accessed 17 3 2025].

150 R. Gazzard, J. McMorrow and J. Aylen, "Wildfire policy and management in England: an evolving response from Fire and Rescue Services, forestry and cross-sector groups," *Philosophical Transactions of the Royal Society B: Biological Sciences*, vol. 371, no. 1696, 2016.

151 Copernicus, "EFFIS Annual Statistics for United Kingdom," [Online]. Available: https://forest-fire.emergency.copernicus.eu/apps/effis.statistics/estimates/GBR. [Accessed 17 3 2025].

152 The Guardian, "Summer wildfires increased fourfold in England in 2022," 30 December 2022. [Online]. Available: https://www.theguardian.com/world/2022/dec/30/summer-wildfires-increased-fourfold-in-england-in-2022. [Accessed 17 3 25].

153 BBC, "London wildfires: Crews say they experienced absolute hell," 20 July 2022. [Online]. Available: https://www.bbc.co.uk/news/uk-england-london-62236018. [Accessed 17 3 2025].

154 BBC, "London wildfires: Crews say they experienced absolute hell," 20 July 2022. [Online]. Available: https://www.bbc.co.uk/news/uk-england-london-62236018. [Accessed 17 3 2025].

155 Hackney Council, "Climate Action Plan 2023 - 2030".

156 A. M. Graham, R. J. Pope, K. P. Pringle, M. P. Chipperfield, L. A. Conibear, E. W. Butt, L. Kiely, C. Knote and J. B. McQuaid, "Impact on air quality and health due to the Saddleworth Moor fire in northern England," *Environmental Research Letters*, vol. 15, no. 7, 23 June 2020.

157 Estates Returns Information Collection, "Estates Returns Information Collection, Summary page and dataset for ERIC 2022/23," 14 December 2023. [Online]. Available: https://digital.nhs.uk/data-and-information/publications/statistical/estates-returns-information-collection/england-2022-23. [Accessed 6 3 2025].

158 UK Health Security Agency, "Heat mortality monitoring report: 2022," UK Government, 22 July 2024. [Online]. Available: https://www.gov.uk/government/publications/heat-mortality-monitoring-reports/heat-mortality-monitoring-report-2022.

159 UK Health Security Agency, "Heat mortality monitoring report: 2022," UK Government, 22 July 2024. [Online]. Available: https://www.gov.uk/government/publications/heat-mortality-monitoring-reports/heat-mortality-monitoring-report-2022.

160 C. Howarth, N. McLoughlin, A. Armstrong, E. Murtagh, S. Mehryar, A. Beswick, B. Ward, S. Ravishankar and A. Stuart-Watt, "Turning up the heat," Grantham Research Institute on Climate Change and the Environment, 2024.

161 Hoare Lea, 2025. Overheating risk analysis. UK Climate Resilience Roadmap. UKGBC. Available at: https://hoarelea.com/app/uploads/2025/06/overheating_risk_summary.pdf

162 BBC, “London wildfires: Crews say they experienced absolute hell,” 20 July 2022. [Online]. Available: https://www.bbc.co.uk/news/uk-england-london-62236018. [Accessed 17 3 2025].

163 BBC, “Wennington wildfire probably started in back garden - report,” 13 July 2023. [Online]. Available: https://www.bbc.co.uk/news/uk-england-london-66148110. [Accessed 17 3 2025].

164 PERILS, “Facilitating Risk Transfer,” [Online]. Available: https://www.perils.org/losses. [Accessed 18 03 2025].

165 Zurich, “Two-fifths of London firms at risk of climate-fuelled flash floods,” 7 March 2022. [Online]. Available: https://www.zurich.co.uk/news-and-insight/two-fifths-of-london-firms-at-risk-of-climate-fuelled-flash-floods. [Accessed 17 3 2025].

166 E. Howard Boyd, G. Leigh and J. Sutton, “The London Climate Resilience Review,” London, 2024.

167 Greater London Authority, “London Climate Risk Maps,” [Online]. Available: https://data.london.gov.uk/dataset/climate-risk-mapping. [Accessed 18 03 2025].

168 Mayor of London, “Response to Climate Change Resilience Review,” [Online]. Available: https://www.london.gov.uk/who-we-are/what-london-assembly-does/questions-mayor/find-an-answer/response-climate-change-resilience-review. [Accessed 18 03 2025].

169 Mayor of London, “Environment and Climate Change,” [Online]. Available: https://www.london.gov.uk/programmes-strategies/environment-and-climate-change. [Accessed 18 03 2025].

170 Mayor of London, “London City Resilience Strategy 2020,” London, 2020.

171 Mayor of London, “Trees for London,” [Online]. Available: https://www.london.gov.uk/programmes-strategies/environment-and-climate-change/parks-green-spaces-and-biodiversity/trees-and-woodlands/trees-london. [Accessed 18 03 2025].

172 City of London, “Climate Action Strategy 2020 - 2027,” London.

173 Hackney Council, “Climate Action Plan 2023 - 2030”.

174 Southwark Council, “Climate Resilience and Adaptation Action Points,” London, 2024.

175 Greater London Authority, “Managing risks and increasing resilience,” October 2011. [Online]. Available: https://www.london.gov.uk/sites/default/files/gla_migrate_files_destination/Adaptation-oct11.pdf. [Accessed 17 3 2025].

176 Mayor of London, “The London Climate Resilience Review,” July 2024. [Online]. Available: https://www.london.gov.uk/sites/default/files/2024-07/The_London_Climate_Resillience_Review_July_2024_FA.pdf. [Accessed 17 3 2025].

177 Met Office , “LONDON CLIMATE PACK,” August 2022. [Online]. Available: https://www.metoffice.gov.uk/binaries/content/assets/metofficegovuk/pdf/research/spf/london-city-pack_august-2022.pdf. [Accessed 17 3 2025].

178 Greater London Authority and Bloomberg Associates, “Climate Risk Mapping,” 2021. [Online]. Available: https://data.london.gov.uk/dataset/climate-risk-mapping. [Accessed 17 3 2025].

179 Greater Manchester Combined Authority, “Transforming how we manage water in Greater Manchester,” 3 July 2023. [Online]. Available: https://www.greatermanchester-ca.gov.uk/news/transforming-how-we-manage-water-in-greater-manchester/. [Accessed 17 3 2025].

180 GREATER MANCHESTER COMBINED AUTHORITY, “Response to Flood Risk Management Issues,” 10 September 2021. [Online]. Available: https://democracy.greatermanchester-ca.gov.uk/documents/s16385/22%20Flood%20Risk%20Management%2030%20July%20GMCA.pdf. [Accessed 17 3 2025].

181 Greater Manchester Combined Authority, “Greater Manchester Climate Change Risk Assessment,” October 2024. [Online]. Available: https://www.greatermanchester-ca.gov.uk/media/qtrhgi2y/gm-ccra-report_final.pdf. [Accessed 17 3 2025].

182 Met Office , “Manchester Heat Pack,” [Online]. Available: https://www.metoffice.gov.uk/binaries/content/assets/metofficegovuk/pdf/research/spf/ukcr_heat_pack_manchester.pdf. [Accessed 17 3 2025].

183 UK Health Security Agency, “Heat mortality monitoring report: 2022,” UK Government, 22 July 2024. [Online]. Available: https://www.gov.uk/government/publications/heat-mortality-monitoring-reports/heat-mortality-monitoring-report-2022.

184 P. O’Hare, “MANCHESTER CLIMATE RISK: A FRAMEWORK,” Manchester Climate Change Agency, Manchester, 2021.

185 Greater Manchester Combined Authority, “Greater Manchester Five-Year Environment Plan 2025–2030,” Greater Manchester.

186 G. M. C. Authority, “Greater Manchester Resilience Strategy 2020 - 2030,” Greater Manchester, 2021.

187 Met Office, “Manchester Heat Pack”.

188 Met Office, “Manchester Climate Pack”.

189 United Nations Office for Disaster Risk Reduction, “Four European cities announced as global Making Cities Resilient 2030 Resilience Hubs for climate and disaster risk reduction,” [Online]. Available: https://www.undrr.org/news/four-european-cities-announced-global-making-cities-resilient-2030-resilience-hubs-climate-and. [Accessed 18 03 2025].

190 Moors for the Future Partnership, “Protecting the uplands for the benefit of us all,” [Online]. Available: https://www.moorsforthefuture.org.uk/. [Accessed 18 03 2025].

191 Greater Manchester Combined Authority, “The IGNITION project,” [Online]. Available: https://www.greatermanchester-ca.gov.uk/what-we-do/environment/natural-environment/ignition/. [Accessed 18 03 2025].

192 Arup , “Bristol One City Climate Strategy,” Bristol One city, Bristol, 2020.

193 Bristol City Council, “Flood Investigation: March 2020,” March 2020. [Online]. Available: https://www.bristol.gov.uk/files/documents/787-flood-investigation-report-river-avon-march-2020/file#:~:text=The%2012th%20March%20event%20had,been%20higher%20due%20to%20westerly. [Accessed 17 3 2025].

194 Arup , “Bristol One City Climate Strategy,” Bristol One city, Bristol, 2020.

195 Arup , “Bristol One City Climate Strategy,” Bristol One city, Bristol, 2020.

196 Bristol City Council, “Keep Bristol Cool. A Framework for Urban Heat Resilience,” [Online]. Available: https://www.bristol.gov.uk/files/documents/6697-keep-bristol-cool-framework/file. [Accessed 17 3 2025].

197 Bristol City Council, “Keep Bristol Cool. A Framework for Urban Heat Resilience,” [Online]. Available: https://www.bristol.gov.uk/files/documents/6697-keep-bristol-cool-framework/file. [Accessed 17 3 2025].

198 Environment Agency, “All of England’s South West region now in drought,” 30 August 2022. [Online]. Available: https://www.gov.uk/government/news/all-of-england-s-south-west-region-now-in-drought#:~:text=Bristol%2C%20Somerset%2C%20Dorset%2C%20south,now%20moved%20to%20drought%20status.&text=Public%20and%20businesses%20in%20drought,dry%20summer%20impacts%20the%20env. [Accessed 17 3 2025].

199 Bristol One City, “One City Climate Strategy,” Bristol, 2020.

200 Arup, Bristol One City, “Bristol One City Climate Strategy Preliminary Climate Resilience Assessment,” Bristol, 2020.

201 Bristol City Council, “The Keep Bristol Cool mapping tool,” [Online]. Available: https://www.bristol.gov.uk/council/policies-plans-and-strategies/energy-and-environment/the-keep-bristol-cool-mapping-tool. [Accessed 18 03 2025].

202 Bristol City Council, “Bristol Local Flood Risk Management Strategy,” Bristol, 2023.

203 Eastside Community Trust, “Easton & Lawrence Hi l’s Community Climate Action Plan,” Bristol, 2022.

204 Met Office , “GLASGOW CLIMATE PACK,” 2022. [Online]. Available: https://www.metoffice.gov.uk/binaries/content/assets/metofficegovuk/pdf/research/spf/glasgow-city-pack_august-2022.pdf. [Accessed 17 3 2025].

205 SEPA, “Flood Risk Management Plans,” 2021. [Online]. Available: https://www2.sepa.org.uk/frmplans/. [Accessed 17 3 2025].

206 Glasgow times, “In pictures: Glasgow locals struggle as Storm Agnes sweeps city,” 27 September 2023. [Online]. Available: https://www.glasgowtimes.co.uk/news/scottish-news/23818291.pictures-glasgow-locals-struggle-storm-agnes-sweeps-city/.

207 Glasgow times, “Glasgow City Council received almost 100 calls to floods,” 10 October 2023. [Online]. Available: https://www.glasgowtimes.co.uk/news/scottish-news/23844780.glasgow-city-council-received-almost-100-calls-floods/.

208 SEPA, “Flood Risk Management Plans,” 2021. [Online]. Available: https://www2.sepa.org.uk/frmplans/. [Accessed 17 3 2025].

209 Glasgow City Council, “Glasgow’s climate adaptation plan 2022-2030,” 3 July 2022. [Online]. Available: https://www.glasgow.gov.uk/media/2376/Glasgow-s-Climate-Adaptation-Plan-2022-30/pdf/GlasgowsClimateAdaptationPlan-03July2022_002.pdf?m=1673601867777.

210 BBC, “Why is a wet country like Scotland facing water scarcity?,” 5 August 2022. [Online]. Available: https://www.bbc.co.uk/news/uk-scotland-62424001.

211 The Scottish Sun , “FIRE FEARS Extreme wildfire warning as huge smoke cloud rages on near Glasgow for two days,” 8 June 2023. [Online]. Available: https://www.thescottishsun.co.uk/news/10793595/extreme-wildfire-warning-huge-smoke-cloud-rages-near-glasgow/.

212 Climate Ready Clyde, “Building a more resilient, prosperous,” [Online]. Available: https://climatereadyclyde.org.uk/. [Accessed 18 03 2025].

213 Clyde, Climate Ready, “Glasgow City Region Climate Adaptation Strategy and Action Plan,” Glasgow, 2021.

214 Glasgow City Council, “Glasgow Climate Adaptation Plan 2022-2030,” [Online]. Available: https://www.glasgow.gov.uk/article/9330/Glasgow-Climate-Adaptation-Plan-2022-2030. [Accessed 18 03 2025].

215 Glasgow City Council, “SG6: Green Belt & Green Network,” Glasgow, 2024.

216 Glasgow City Council, “Glasgow City Development Plan,” Glasgow.

217 Birmingham city council, “Local Flood Risk Management Strategy,” October 2017. [Online]. Available: https://www.birmingham.gov.uk/downloads/file/2556/local_flood_risk_management_strategy. [Accessed 17 3 2025].

218 BBC, “Floods shut roads, halt trains and close schools,” 26 September 2024. [Online]. Available: https://www.bbc.co.uk/news/articles/cn4zg0vlprdo. [Accessed 17 3 2025].

219 Friends of the Earth, “Who suffers most from heatwaves in the UK?,” July 2022. [Online]. Available: https://policy.friendsoftheearth.uk/print/pdf/node/275. [Accessed 17 3 2025].

220 “A Summary of Climate Change Impacts in the West Midlands Combined Authority Area,” 2022. [Online]. Available: https://www.wmca.org.uk/media/d2pons0q/summary-of-climate-change-impacts-in-wmca-area.pdf. [Accessed 17 3 2025].

221 C. Heaviside, S. Vardoulakis and X.-M. Cai, “Attribution of mortality to the urban heat island during heatwaves in the West Midlands, UK,” *Environmental Health*, vol. 15, 2016.

222 BBC, “Wildfire concerns raised 12 months after Lickey Hills blaze,” 27 July 2023. [Online]. Available: https://www.bbc.co.uk/news/uk-england-hereford-worcester-66311540. [Accessed 17 3 2025].

223 Metro, “Wildfire breaks out at Country Park as UK heads for hottest day on record,” 18 July 2022. [Online]. Available: https://metro.co.uk/2022/07/18/birmingham-wildfire-breaks-out-at-country-park-17021609/. [Accessed 17 3 2025].

224 Birmingham city council, “What is the council doing about climate change,” [Online]. Available: https://www.birmingham.gov.uk/info/50282/climate_change/2642/what_is_the_council_doing_about_climate_change/5. [Accessed 17 3 2025].

225 Birmingham Tree People, Birmingham City Council, Treeconomics and Nature Based Solutions Institute, “An Urban Forest Master Plan for Birmingham 2021-2051,” Birmingham, 2021.

226 Tree Cities of the World, “Recognised Cities,” [Online]. Available: https://treecitiesoftheworld.org/directory.cfm. [Accessed 18 03 2025].

227 UK Government, “Environment Agency exploring options to reduce Birmingham floods,” [Online]. Available: https://www.gov.uk/government/news/environment-agency-exploring-options-to-reduce-birmingham-floods. [Accessed 18 03 2025].

228 Birmingham City Council, “Climate risk and vulnerability assessment (CRVA) map,” [Online]. Available: https://maps.birmingham.gov.uk/webapps/CRVA/?page=page_28. [Accessed 18 03 2025].

229 University of Birmingham, “University of Birmingham and WMCA join forces to combat impact of climate change in West Midlands,” [Online]. Available: https://www.birmingham.ac.uk/news/2025/university-of-birmingham-and-wmca-join-forces-to-combat-impact-of-climate-change-in-west-midlands. [Accessed 18 03 2025].