March 2023

Progress in adapting to climate change

2023 Report to Parliament

Climate Change Committee

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Executive summary

This report provides the Committee's biennial report of progress in preparing for climate change as required under the Climate Change Act. It provides an assessment of progress at the end of two National Adaptation Programmes, the statutory programme required from Government to help prepare the country for climate change. The second National Adaptation Programme covered the period of 2018 – 2023 and the third is due to be published in summer 2023.

The key findings of this assessment are:

- **The second National Adaptation Programme has not adequately prepared the UK for climate change.** Our assessment has found very limited evidence of the implementation of adaptation at the scale needed to fully prepare for climate risks facing the UK across cities, communities, infrastructure, economy and ecosystems. While the recognition of a changing climate within planning and policy is increasing, with some policy in most areas, it is clear that the current approach to adaptation policy is not leading to delivery on the ground and significant policy gaps remain. This limited progress is a direct consequence of the second National Adaptation Programme (NAP2). NAP2 did not address all the risks from climate change identified in the previous Climate Change Risk Assessment, it suffered from a lack of ambition and did not embed a focus on adaptation delivery across Government to drive an effective overall response to the challenges of climate change.

- **The impacts from extreme weather in the UK over the last year highlight the urgency of adapting to climate change.** The record-breaking temperatures seen in summer 2022 brought unprecedented numbers of heat-related deaths, wildfire incidents and significant infrastructure disruption. These, and impacts from other events, highlight the UK's critical exposure and vulnerability to extreme weather even today. Climate change means many weather extremes driving these impacts will continue to get worse for several decades at least. The events of the last year reinforce the urgency of making better preparations for climate change now. Action cannot be delayed further. To do so will lock in more damaging impacts and threaten the delivery of other key Government objectives, such as Net Zero.

- **The next National Adaptation Programme must make a step change.** The next National Adaptation Programme (NAP3) must be much more ambitious than its predecessors and lead to a long overdue shift in focus towards the delivery of effective adaptation. It must permanently and fully embed adaptation across Government and within all relevant major policies and strategies. It must also put in place the enabling conditions needed to drive adaptation by businesses and financial institutions. If the next National Adaptation Programme falls short, it risks another lost five years of ineffectual adaptation action – which the UK's people, ecosystems and infrastructure cannot afford.

This executive summary is set out in three sections:

1. Measuring the UK's preparedness for climate change
2. The urgency of adapting to climate change in the UK
3. The next National Adaptation Programme

1. Measuring the UK's preparedness for climate change

There are a large range of risks from climate change to the UK, and a small number of opportunities.

Climate change leads to a wide range of risks and a small number of opportunities to the UK. The most recent Climate Change Risk Assessment identified 61 separate risks and opportunities to the UK's natural environment, infrastructure, economy and society from climate change. This report assesses progress in preparing for these risks.

(a) Our assessment framework

In this report we have updated our monitoring framework for adaptation progress to increase the focus on tangible outcomes needed for climate resilience.

This report represents an evolution of our monitoring framework for climate change adaptation. We have increased our focus on tangible changes in the economy and across society and the environment by identifying a set of outcomes needed to deliver climate resilience within each sector. We also provide a more granular model of the enabling conditions necessary to achieve these outcomes, and the role of public policy to bring them about, which we use to track policy progress in each sector.

This evolution is required to stimulate a shift in adaptation from being focused mainly on planning and risk assessment towards action that will reduce exposure and vulnerability to climate risks. We will continue to refine further our monitoring framework over the coming years to ensure it can track progress effectively against the aims of the new National Adaptation Programme when it is published.

As in previous progress reports, we assess all relevant policy development from across the period of the second National Adaptation Programme (2018-2023), whether it is formally included within the NAP2 document or not. This allows our assessment to remain up to date and to provide comprehensive coverage of all relevant aspects of policy and planning.

(b) Assessment findings

Adaptation planning is increasingly prevalent but there is limited evidence of it being effective in reducing climate risks.

Consistent with our previous assessments of the NAP2 period, this report finds that no sectors are yet well adapted to the risks of climate change (Figure 1). While some – often quite basic – consideration of climate change within relevant plans is becoming more prevalent, evidence of tangible progress in reducing exposure and vulnerability to climate change is lacking across the board.

- **Delivery and implementation.** For no outcome have we been able to conclude that there is sufficient evidence that reductions in climate exposure and vulnerability are happening at rates needed to appropriately manage risk. For around one-quarter of outcomes available indicators show insufficient evidence of progress.

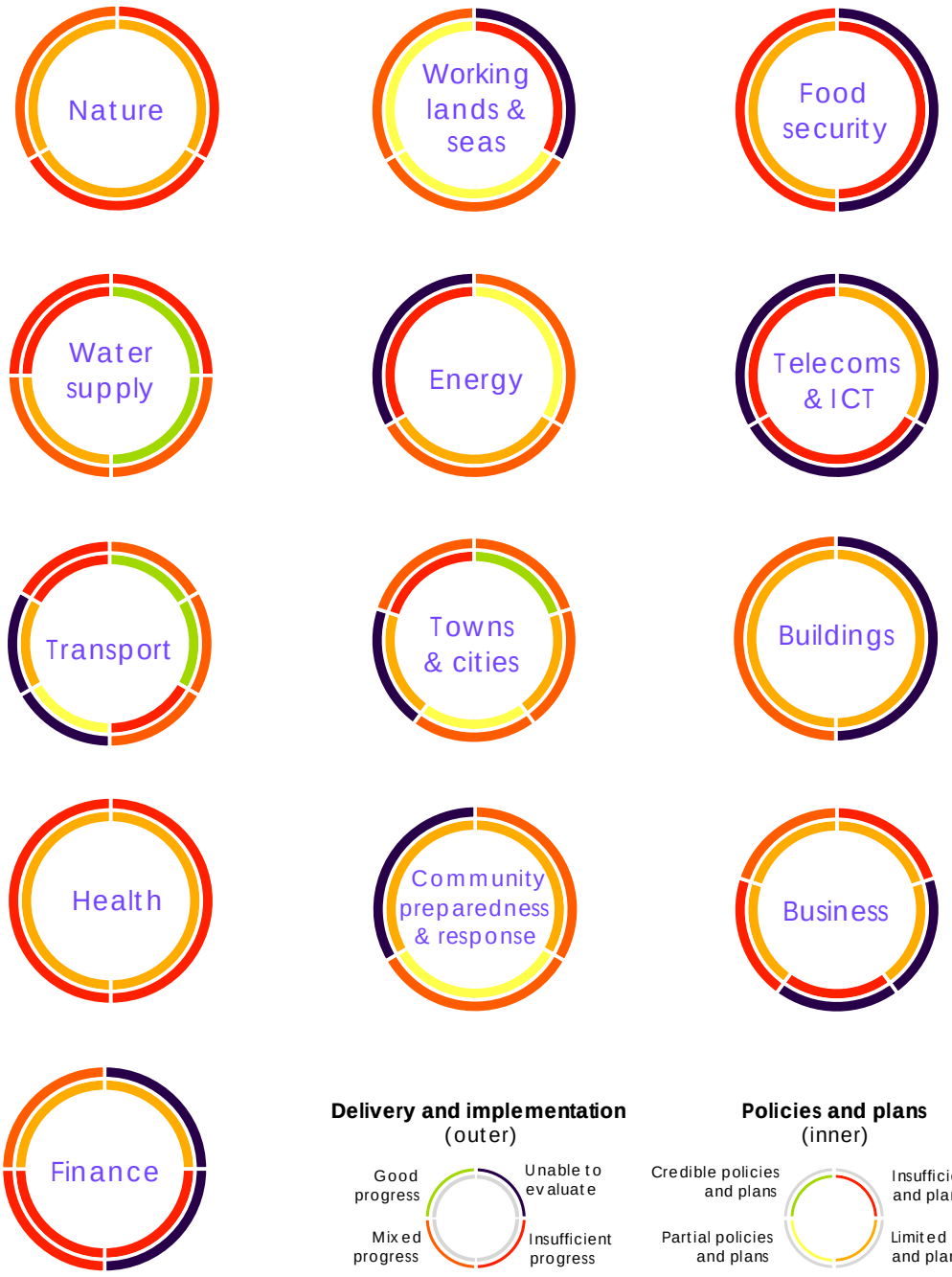
- **Policies and plans.** The provision of key policy milestones and integration of adaptation within relevant sector plans is slowly increasing over time. Most areas now have at least some consideration of adaptation within relevant strategies and plans. However, fully credible planning for climate change – with nearly all required policy milestones in place – is only found for five adaptation outcomes out of the 45 examined in this report.

Effective data monitoring for adaptation remains a key barrier in many sectors.

The absence of relevant robust data remains a key barrier to assessing all aspects relevant to delivery and implementation of adaptation policy.

For nearly 40% of adaptation outcomes, the lack of relevant and up-to-date indicator datasets prevents us making an overall judgement on progress in adaptation delivery and implementation. Datasets to evaluate elements of resilience either do not exist, or where they do exist, are not up to date, are not sufficiently comprehensive in scope or only provide a point-in-time snapshot preventing trends being identified in aspects of climate vulnerability and exposure. An effective climate change adaptation monitoring and evaluation programme, with sufficient long-term funding, is a prerequisite to address this and must be introduced with urgency.

Figure 1 Overview of assessed adaptation outcomes



Source: CCC analysis.
Notes: Each segment of the charts corresponds to an identified climate resilience outcome within our framework. The outer ring assesses delivery and implementation, while the inner ring assesses policies and plans. 'Unable to evaluate' for the delivery and implementation score is used when sufficient relevant indicator datasets are not available, up to date, or do not allow a trend to be robustly estimated.

For each sector the main conclusions from our assessment are:

- **Nature.** Available indicators for the overall ecological health of terrestrial and freshwater habitats, including the state of their biodiversity which underpins resilience to climate change, are mostly either stagnant or declining. There is a more mixed picture for marine and coastal habitats. Newly unveiled environmental policy, including statutory targets, a new plan for environmental improvement and further details of the public money for public goods approach to agricultural management is welcome. While this has significant potential to enhance adaptation, detailed information, for example about implementation and funding, is lacking.

Agriculture stands out as a key sector without an adaptation strategy.

- **Working land and seas.** The UK still lacks a targeted strategy and associated targets for ensuring agriculture remains productive as the climate changes. Indicators to track the exposure and vulnerability of the sector to climate change remain limited. New agricultural policies have been announced, but it remains to be seen how these will impact the climate resilience of agriculture. Climate adaptation planning by the forestry and fisheries sectors is more credible, with a range of new and emerging policies to build resilience, although vulnerability indicators suggest a mixed picture of their effectiveness to date.

- **Food security.** Reporting by large private food companies on their supply chain risks is not currently mandated, preventing evaluation of progress on adaptation delivery and the overall levels of systemic risk in the UK food system. Recent shortages of imported vegetables have highlighted the exposure and vulnerability of food supply chains to weather-related impacts, and recent increases in household food insecurity will likely magnify the impact of food price spikes – including those driven by climate change.

The water sector has credible adaptation planning, but indicators of climate resilience outcomes are not all going in the right direction.

- **Water supply.** The water sector has, as in our past reports, credible planning for climate change. Climate change regulatory mandates are in place and there are statutory targets for water demand and leakage reduction. However, delivery and implementation of these adaptation outcomes in practice is falling short with insufficient progress on reducing demand and reducing leakage over recent years.

- **Energy.** The energy system has some consideration of climate change at an asset level, but lacks key milestones such as resilience standards, and data on exposure for hazards beyond flooding are limited. The Government has an ambition to deliver a fully decarbonised electricity system by 2035 – this will require fundamental integration of system-level weather hazards, such as wind droughts, within planning and governance, including climate resilience remits for Ofgem and the new Future System Operator.

- **Telecoms and ICT.** There is a lack of available data to evaluate progress on reducing exposure and vulnerability to climate change in this sector. There remains no visible plan or process, by the industry or Government, to manage long-term climate risks.

Road and rail continue to have strong adaptation planning.

- **Transport.** The strategic road network and the rail network both have credible planning for adaptation. Gaps remain in adaptation planning for local road networks. However, indicators show increased weather impacts on rail infrastructure, especially from heat and wind. Data for ports and

airports are incomplete, preventing a full picture of adaptation and climate risk for these transport modes.

- **Towns and cities.** Plans for flood defences and improved flood risk mapping are typically credible but maintaining defences and managing surface water flood risk will require further funding commitments. Evidence suggests flood risks are rising across the country and developments are still being built in areas at future risk. Most plans for new developments do not thoroughly regulate or track adaptation for future climate resilience and there are no clear mechanisms to monitor and mitigate the effects of urban heat islands. Plans to ensure developments at the coastline are protected remain non-statutory, and there is insufficient funding to enable affected communities to adapt.

The incorporation of overheating within the Building Regulations for new homes is welcome, but policy gaps remain for existing buildings and other hazards.

- **Buildings.** The update to the Building Regulations is a significant step forward to address overheating in new homes, putting in place good standards. There remains a lack of policy to address overheating in existing homes and buildings and a lack of understanding of the scale of efforts needed to mitigate the risk today. There is a lack of data tracking the overall scale of property flood resilience (PFR) implementation across the country. Recently implemented plans to improve access to and awareness of PFR are a positive step, as are Flood Re's (publicly backed flood reinsurance) Build Back Better scheme, kitemarked standards for PFR products, and industry codes of practice.

- **Community preparedness and response.** The overall level of planning for adaptation is still limited within local councils. Mandatory reporting, public information, public engagement and targeted adaptation support for vulnerable groups are not yet widely available. Most policy for emergency response within communities is focused on flooding, but often does not extend to other climate hazards. The recent commitment by Government to fund Local Resilience Forums and pilot Chief Resilience Officers across England is a positive policy development that could help improve local level community preparedness and response to climate impacts.

Record heat-related mortality in 2022 highlight the vulnerability to extreme heat in the UK.

- **Health.** Heat-related mortality was estimated to be at an all-time high in 2022, driven by the record-breaking heatwave experienced in the UK. Incidences of overheating are monitored within hospitals but there is no regular recording of temperatures in other healthcare settings such as care homes, domiciliary care or GP surgeries. There is a lack of policy and funding to address climate risks in existing health and social care buildings. Adaptation planning across NHS Trusts, Integrated Care Systems and social care providers is needed. A new Centre for Climate and Health Security within the UK's Health and Security Agency (UKHSA) has been created to lead efforts to protect health in the context of a changing climate. UKHSA has also recently introduced enhanced testing and surveillance of invasive mosquitos and ticks, important climate-sensitive vectors for infectious disease.

Climate-related disclosure is more prevalent, but effective adaptation reporting remains a gap.

- **Business.** More businesses are now reporting their climate risks, but disclosures on physical risk management and adaptation action remain a key gap. The lack of aligned and consistent adaptation standards and targets for business hampers planning, along with only limited financial instruments to support business adaptation action. Several key data gaps remain, such as the exposure and vulnerability of business assets, as well as the tracking of business access to credit and insurance. There is some evidence that businesses are experiencing worker productivity losses, but it

is largely unquantified. Risks are rising for domestic and international supply chains, but business capacity to manage these remains limited due to a lack of standards and information.

- **Finance.** Adaptation projects are failing due to lack of finance – with numerous barriers identified through case study evidence. While there is some good progress to embed adaptation in financial regulators' activities, it is still nascent. Key data on financial exposure to climate risks are limited, with a heavy reliance on uncertain scenario analyses and no way of measuring the positive or negative contribution an investment portfolio is making to adaptation outcomes. The UK Sustainability Disclosure Requirements may increase uptake of climate-related financial disclosures and work to establish adaptation as part of the UK's green finance taxonomy is underway. Overall, the inclusion of adaptation in financial reporting, regulation and institutions is not yet sufficient to drive investment.

Considering linkages between sectors when assessing climate risks remains a critical gap.

Climate impacts can also cascade across sectors due to infrastructure, nature and socio-economic interdependencies between them. Despite the potential for damaging cascading impacts, consideration of these interdependencies in adaptation planning is lacking. Currently, there are not clear responsibilities and mechanisms for cross-Government collaboration, which is needed to enable a more systematic assessment of interdependency risks. Consistent minimum resilience standards across sectors, enforced through remits for climate resilience in key sector regulators, are also largely absent.

(c) Addressing the gaps

We provide a detailed set of recommendations on how gaps in adaptation policy and planning can be closed for each sector.

In each chapter of this report, we provide a set of specific recommendations for policy actions that can help put into place additional pieces of the policy landscape necessary to deliver adaptation outcomes, with a clear owner in Government identified. Table 1 summarises our highest priority recommendation for each sector of our assessment, all of which need to be addressed before our next progress report in two years' time.

Table 1
Highest priority recommendations for Government to address over the next two years

Primary responsibility	Recommendation	Sector
Defra	Set interim adaptation targets to drive early action to improve climate resilience of nature, enable progress assessments, and secure adequate resources (including for green jobs and skills) to facilitate delivery of the targets.	Nature
Defra	The Land Use Framework should address the trade-offs and co-benefits of multifunctional landscapes to benefit climate mitigation, adaptation, food security, nature recovery, forestry, fisheries, recreation and rural livelihoods.	Working land and seas
Defra	Extend the scope of the fourth round of the Adaptation Reporting Power (ARP4) to include food supply chains.	Food security
Defra, Environment Agency, Ofwat	Ensure sufficient investment, resources and progress monitoring to support delivery against demand reduction and leakage targets, given the significant gap between targets and progress.	Water supply

DESNZ, Ofgem, Future System Operator	Designate Ofgem and parties responsible now and in the future (including the new Future System Operator) for the maintenance of energy sector codes and standards, with a clear mandate to ensure climate and weather resilience.	Energy
Defra	Develop a set of indicators to enable monitoring of the impacts of weather and climate on telecoms and ICT services and the actions being taken to manage them, and designate Ofcom with a statutory remit for climate resilience.	Telecoms and ICT
Defra	Extend the scope of the next round of the Adaptation Reporting Power (ARP4) to cover local authority functions related to road infrastructure, ports, airports, and key supply chain organisations.	Transport
DLUHC	Planning policy reform should ensure that climate resilience is a priority, with mandatory adaptation interventions on all built environment project applications.	Towns and cities
DLUHC	Expand the Part O Building Regulation requirement to cover refurbishments of existing buildings, conversions of non-domestic buildings to residential, and prisons.	Buildings
Defra	Include community engagement activities (such as citizens assemblies) under NAP3 to put fairness at the centre of efforts to implement a vision for a well-adapted UK. This engagement programme should focus on exploring issues of fairness in some of the most challenging aspects of adaptation (e.g. coastal retreat) and in the provision of public funding for adaptation.	Community preparedness and response
DHSC, DLUHC	Work across Government and with local authorities to develop a long-term cross-sector approach to address risks in the social care sector, including using appropriate levers to accelerate adaptation action, and ensuring that monitoring of overheating occurrences and air quality in care homes is undertaken frequently.	Health
HMT, DESNZ	Strengthen adaptation reporting requirements across the Sustainability Disclosure regime and build on the work of the Transition Pathways Taskforce (on Net Zero-related corporate transition plans) to define common standards for what a high-quality adaptation transition plan should look like. This should include how relevant physical climate risks are measured and managed and how plans would contribute to wider societal adaptation to climate change.	Business
HMT, Defra	The refresh of the Green Finance Strategy in 2023, together with NAP3, should clarify where the Government expects adaptation actions to be funded through public sources and where private investment is expected. NAP3 should contain clear new funding commitments for investment in adaptation over the coming five-year period and the breakdown across department budgets.	Finance
Defra	Set out, in NAP3, a national plan for managing interdependency risks, including clear and consistent responsibilities for climate resilience across sectors and mechanisms for cross-Government collaboration.	Interdependencies

These actions cover the full range of roles for Government in climate adaptation, including information provision, public sector delivery of improved resilience, and putting in place standards or financial incentives for private sector adaptation. The recommendations extend right across Government and its implementing agencies, emphasising the need for a cross-Government approach to deliver effective adaptation.

2. The urgency of adapting to climate change in the UK

Recent opportunities to integrate climate change adaptation within key policy areas have largely been missed.

Our assessment of progress clearly shows that only incremental steps forward on preparing the UK for climate change have been made over the period of the second National Adaptation Programme. Even since the most recent Climate Change Risk Assessment (in mid-2021) highlighted the increased level of climate change risk facing the UK, significant opportunities to embed climate change adaptation within critical broader policy areas have largely been missed, or key policies delayed (Box 1).

Box 1
Progress on the priority risks for urgent further action from the Independent Assessment of UK Climate Risk

In the 2021 Independent Assessment of UK Climate Risk we identified eight highest priority risk areas to address prior to the next National Adaptation Programme.

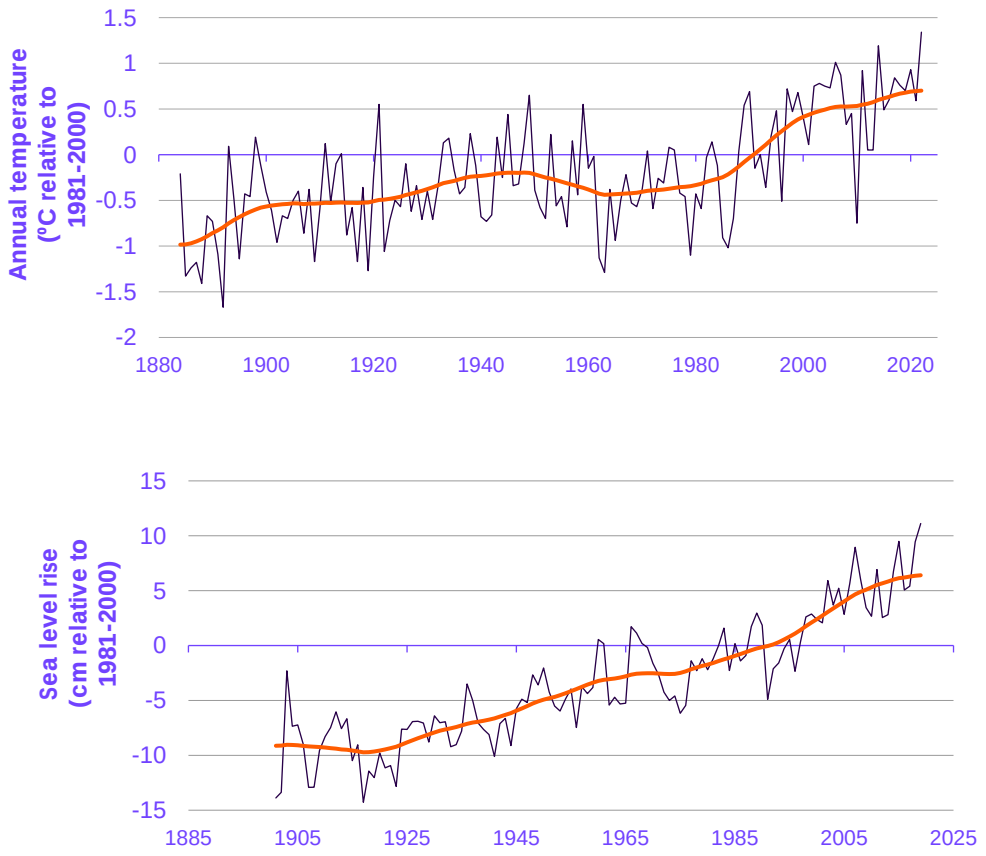
- **Risks to the viability and diversity of terrestrial and freshwater habitats and species; Risks to soil health from increased flooding and drought; Risks to natural carbon stores and sequestration from multiple hazards, leading to increased emissions; Risks to crops, livestock and commercial trees from multiple climate hazards.** A significant opportunity to address these four risks was the planned shift in agricultural and land management subsidies towards a new system of public money for public goods, and statutory targets on environmental improvement. More of this policy has recently been unveiled. It has significant potential to deliver for climate resilience – but details, implementation plans, and crucially funding levels are still unclear. Other key policy vehicles, such as the Soil Health Action Plan, have continued to be delayed.
- **Risks to supply of food, goods, and vital services due to climate-related collapse of supply chains and distribution networks.** Climate change adaptation has largely been absent from discussions on supply chain resilience over recent years, despite examples of supply chain stresses since the COVID-19 pandemic. For example, the Department for International Trade developed a resilience framework that highlights five areas for building resilience in supply chains, but climate change is not explicitly considered within it. Initiatives aiming to improve corporate reporting on climate change have thus far had a predominantly mitigation-focused remit – for example, the Transition Plan Taskforce launched in 2022 and the implementation of the Taskforce on Climate-related Financial Disclosures (TCFD).
- **Risks to people and the economy from climate-related failure of the power system.** Government has committed to full decarbonisation of electricity generation by 2035. While the Net Zero Strategy acknowledged the need for adaptation, key Government outputs since, such as the Energy Security Strategy in 2022, are silent on climate resilience.
- **Risks to human health, wellbeing, and productivity from increased exposure to heat in homes and other buildings.** The need to tackle both the decarbonisation of buildings and overheating risks together is acknowledged within the Net Zero Strategy and the Heat and Buildings Strategy. The update to buildings regulations to consider overheating in new homes represents genuine and significant progress, but there remains a lack of policy to address overheating in existing homes (which will be largest part of the mid-century housing stock) and non-residential buildings.
- **Multiple risks to the UK from climate change impacts overseas.** International climate impacts pose significant risks to the UK; tackling those requires policy efforts and investments across borders and sectors. Adaptation was integrated within the set of initiatives championed through the UK's presidency of COP26 in 2021, but the 2030 Strategic Framework – which will set out the Government's vision on the role in the world tackling climate change and biodiversity loss – has yet to published.

Source: CCC analysis; CCC (2021) *Independent Assessment of UK Climate Risk*.

Evidence of a changing climate in the UK has now become very clear.

The lack of urgency with which Government has approached this task over recent years stands in sharp contrast to the experience of the damaging impacts on people, ecosystems and infrastructure over the same period. In the UK, 2022 was the warmest year on record, while the warmest ten years have all occurred since 2003 (Figure 2). The scale of the impacts on people, ecosystems and infrastructure in the UK from weather extremes even in today's climate has yet again been made clear (Box 2).

Figure 2 Observed climate change in the UK



Source: Met Office (2022) *State of UK Climate 2021*.
Notes: The orange line is a moving 30-year triangular averaging window (reflecting at ends of timeseries) in all panels.

Our vulnerability to climate change has been exposed by the extreme weather events seen recently.

Box 2
Impacts of extreme weather events in the UK since mid-2021

- **Record-breaking heatwaves.** In 2022, a heatwave in July set new records – maximum temperatures reached unprecedented levels across large parts of the country (Figure 3), with temperatures exceeding 40ºC in some places – the first time this has ever occurred in the UK. This heatwave caused power cuts due to conductors sagging and transformers overheating, and increased electricity demand risked triggering blackouts acros the network. This July heatwave, and the subsequent heatwaves in August, led to a record number of heat-related deaths. UK heatwaves will continue to become more intense over coming decades.
- **Widespread drought.** Much of 2022 was very dry for large parts of the country. England's summer was the sixth driest on record, with even more extreme drought conditions seen in East Anglia – a key food production region (where summer 2022 was the fourth driest on record). River flows were very low across the country and particularly in southern and eastern England.

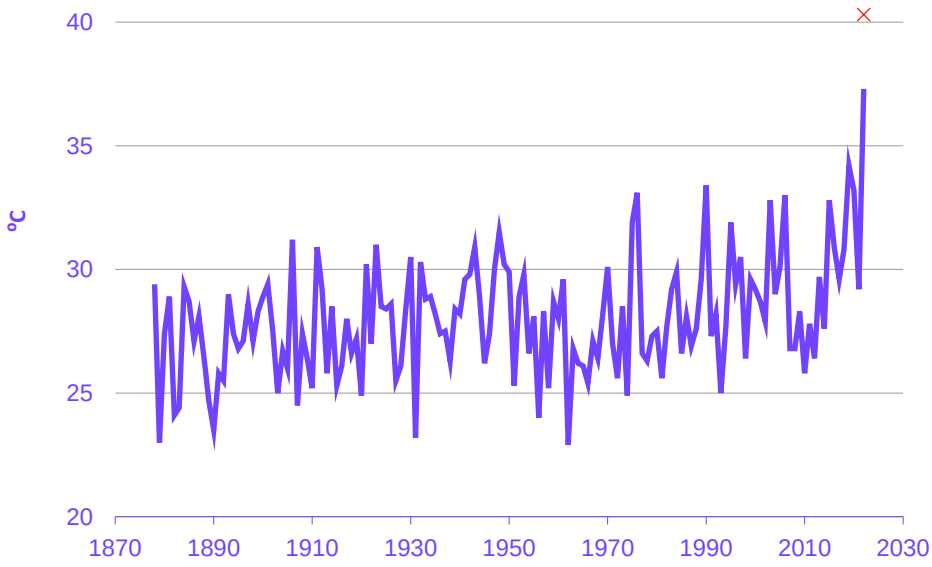
The combination of the lack of rainfall with the summer heat meant soils were very dry, stressing ecosystems and agriculture. At the end of August, reservoir levels across England and Wales as a whole fell to the second lowest level since data was tracked from 1990. This led to temporary water use restrictions by eight water companies across England and Wales. Summers are projected to become increasingly hot and dry over future decades.

- **Record numbers of wildfires.** The very hot and dry summer conditions created high wildfire risk. 2022 saw the highest annual number of wildfires (greater than 30 hectares) ever recorded in the UK, with several fire services coming under major pressure in mid-July. Wildfire conducive weather is expected to increase significantly in future decades, particulary during the middle of summer where the number of days of 'high risk' weather could more than double.
- **Damaging winter storms.** Storm Arwen, in 2021, and three named storms within a week in February 2022 (Dudley, Eunice, Franklin) caused extensive damage to local electricity grids and flooding across the country. Storm Arwen left over one million customers without power and the north-east of Scotland experienced the equivalent of almost two years' worth of overhead line faults in a twelve hour period. Storm Eunice was the most damaging storm to impact England and Wales since 2014, causing widespread damage and disruption. There is currently no strong evidence that climate change is shifting UK storminess patterns but shifts to more frequent stormy winter weather patterns is a possible consequence of climate change simulated by some climate models, and should be considered within a set of plausible outcomes as part of credible adaptation planning.

Lessons from recent extreme weather impacts must be urgently learned to prepare for the future.

The last year of weather impacts has shown that the past is no longer a good guide to the range of unprecedented extremes that will increasingly be seen in the future. The experience of these impacts across the country may be a pivotal moment in raising the urgency of climate change adaptation in the public consciousness. It is now vital that lessons are learned from the impacts of these weather extremes, to help urgently to improve our resilience to extreme weather.

Figure 3 Highest annual maximum temperature in the Central England Temperature record



Source: Parker, D.E., T.P. Legg, and C.K. Folland. (1992). *A new daily Central England Temperature Series,* 1772-1991. Int. J. Clim., Vol 12, pp 317-342.
Notes: The red cross marks the record maximum temperature of 40.3ºC recorded in the Coningsby, Lincolnshire on 19th July 2022.

3. The next National Adaptation Programme

The second National Adaptation Programme did not deliver what is required. This now needs to change for the next programme.

This year marks the end of the second National Adaptation Programme, with its successor (NAP3) expected in summer 2023. It is now clear that NAP2, like its predecessor, has not delivered the implementation of climate change adaptation at anywhere near the levels needed to address climate risks effectively, and lessons from NAP2 must be learnt (Box 3). It is vital that this now begins to change.

Box 3
Reflections on the second National Adaptation Programme

The second national adaptation programme (NAP2) covered the period of 2018 – 2023. It was produced by the Government in response to the second Climate Change Risk Assessment. This programme has now come to an end and its effect on preparing the UK for climate change can be assessed in full.

Over the lifetime of NAP2, our progress reports in 2019, 2021 and 2023 have found an overall persistent lack of progress in demonstrable reductions in exposure and vulnerability to the UK's climate change risks and in the delivery of key adaptation actions. While the overall consideration of climate change within policy and planning has slowly increased, there is no clear evidence that this has led to associated improvements in climate resilience.

Key reasons that limited its impact include:

- **Missing risks.** From the outset NAP2 did not address all the risks from climate change identified in CCRA2. Twenty-one of the risks from CCRA2 have no formal NAP actions, including thirteen in the 'more urgent' categories. These omissions include the risks facing the UK from climate change overseas; opportunities from new species colonisations; changes in suitability of land for agriculture or forestry; and risks to health from changes in air quality driven by climate change.
- **Lack of ambition.** Many of the actions in NAP2 reflected work that was already underway, rather than new or strengthened ambition to address the urgent risks and opportunities set out in the CCRA.
- **No overarching framework.** NAP2 failed to provide a framework for how the actions that it contained together delivered a coherent overall response to the challenges of climate change. Furthermore, no clear objectives, targets or performance indicators were identified to allow Government or others to track progress in implementing the programme or its effects on exposure and vulnerability to climate change. No effective monitoring and evaluation system has been maintained throughout the programme – even within Government itself.

Adaptation is increasingly lagging efforts on climate change mitigation.

Over the duration of NAP2 climate change adaptation in the UK has fallen far behind climate change mitigation, both in terms of policy attention and delivery. It must urgently catch up. It is now essential that the next National Adaptation Programme breaks this cycle of underwhelming policy response and treats adaptation to climate change with the necessary importance and urgency that the impacts of the weather extremes in 2022 and the preceding two decades show that it deserves.

(a) Requirements for the next National Adaptation Programme

We identify six key requirements for the next National Adaptation Programme.

Alongside the detailed sectoral recommendations throughout this report, we have identified six high-level requirements for the next National Adaptation Programme to provide the step-change in adaptation action for the UK that is now needed.

The Committee will provide an independent assessment on the extent to which NAP3 delivers this following the publication of the programme.

- **Vision.** Throughout this report we have identified many outcomes needed to build climate resilience across sectors. Clear and specific outcomes such as these are needed to make adaptation tangible both inside and outside of Government. NAP3 needs to set out a clear vision for adaptation. Making the vision operational requires a delivery programme with measurable goals for specific underlying outcomes, and a theory of change to demonstrate how the outcomes link to the activities in the programme.

- **Ambition.** It is clear that adaptation is an urgent issue that must be tackled now. NAP3 must not just be a compilation of existing policy and initiatives; additional high-ambition commitments are needed to improve the UK's vulnerability to climate change. These should involve increased public funding for adaptation – a cornerstone of an effective adaptation response – as well as helping to remove barriers to private investment. Without sufficient ambition another five years risk being lost.

- **Delivery.** For NAP3 to be effective it must have a clear focus on delivery. This report identifies a range of recommendations across Government departments to put in place the necessary policy milestones for climate adaptation. These include delivering improved resilience directly through the public sector as well as putting in place the enabling conditions needed for others to deliver adaptation. NAP3 must have effective cross-Government governance structures in place to ensure that all relevant departments are engaged and collectively own and deliver on interlinked adaptation challenges across multiple sectors. This is particularly vital to ensure that climate adaptation is integrated within other top-level policy objectives, and does not compromise efforts to reduce greenhouse gases to Net Zero and protect biodiversity. Without this the changing climate will increasingly become a risk to the delivery of the UK's Net Zero and nature recovery statutory goals with severe consequences to our society, environment and economy.

- **Scope.** Unlike NAP2, NAP3 must aim to provide a comprehensive response across all of the risks identified in the most recent CCRA. Risks from climate change outside of the UK is one of the most important routes through which climate change can impact our economy and must be included within the programme.

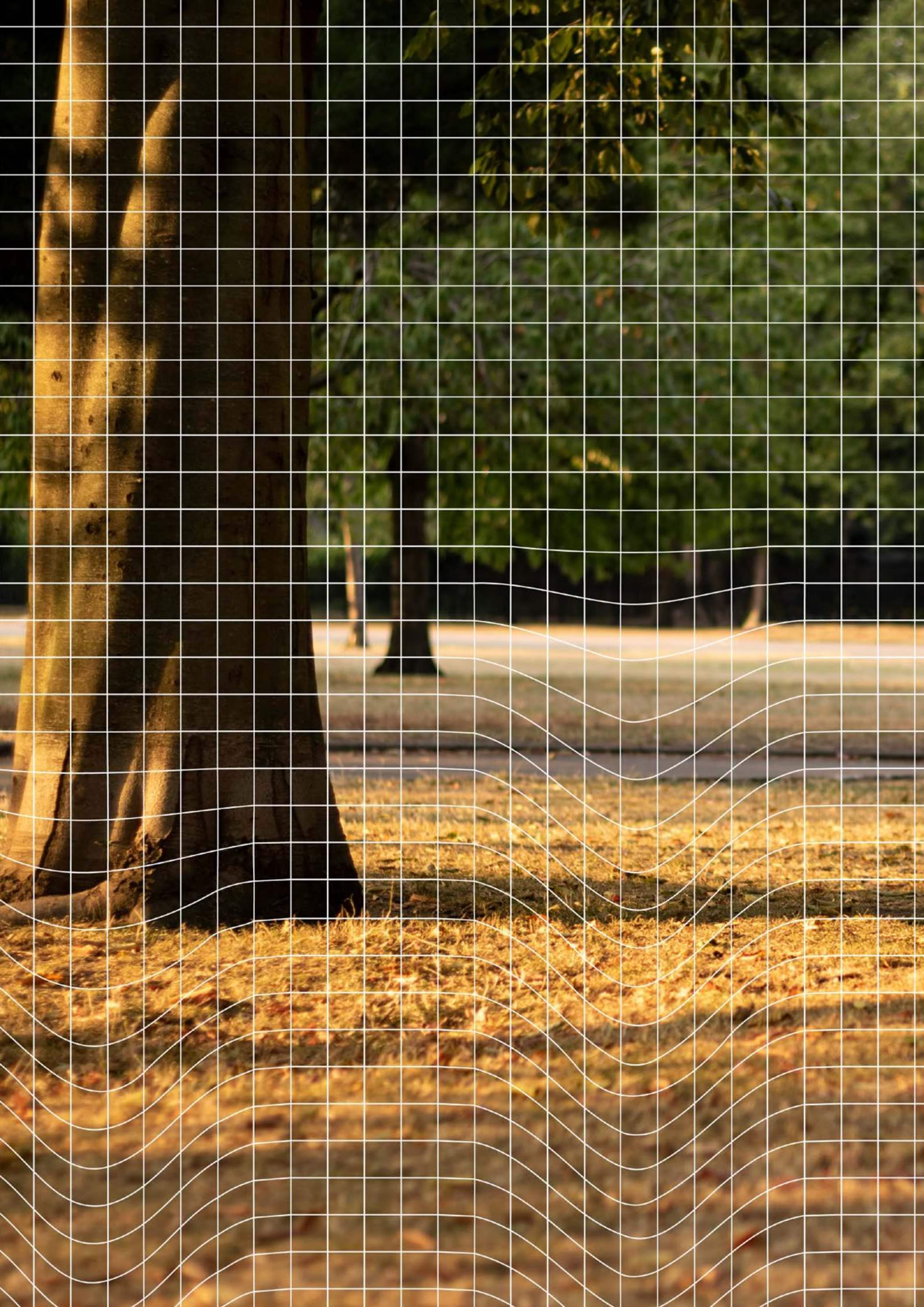
- **Monitoring.** NAP2 did not include an effective way to track progress on adaptation. A functioning monitoring and evaluation system is vital for NAP3 to drive delivery effectively. This monitoring and evaluation framework must be built around a vision for the NAP to enable appropriate key performance indicators underpinned by greater investment in cutting edge research to be identified, monitored, and improved over time. These indicators must be maintained and updated annually (at a minimum). New indicators need to be developed and reported in sectors where progress in delivering adaptation outcomes cannot currently be evaluated. Alongside the NAP a strong plan for the next round of the adaptation reporting power must be provided, extending the requirement to report on climate risk and adaptation to other organisations that have key societal functions (such as local authorities, health and social care organisations, canals, reservoirs and food supply chains).

- **Development.** The next NAP must continue to be implemented and improved across the entire five-year period, with a mechanism to strengthen areas and close gaps as they are identifed. A long-term and stable resource within Government is required to support this.

It is vital that the next National Adaptation Programme now delivers on this challenge.

NAP3 must now deliver on this challenge to demonstrate that the UK's approach to adaptation policy is fit for purpose and able to drive real reductions in exposure and vulnerability to climate risks. The National Adaptation Programme is of critical value to driving adaptation actions across society – without a strong NAP the effects of climate change will be significantly more deadly and costly to the UK's population. If the next National Adaptation Programme falls short, it risks another lost five years of adaptation action which the UK's people, ecosystems and infrastructure cannot now afford.

The next National Adaptation Programme is a critical moment for Government to announce a step-change in adaptation, to avoid another lost five years and meet the urgent needs of the UK's people, ecosystems and infrastructure. A strong programme is also a key element of the UK's contribution to the global effort to tackle climate change and is an essential part of maintaining the UK's international leadership on climate change over the years ahead.



Chapter 1

Framing and methodology

Introduction

This report assesses preparation for the effects of climate change as required under the Climate Change Act (2008), and specifically the efforts to adapt to climate change within the National Adaptation Programme. This chapter summarises the evidence of past and expected future climate change, the assessment framework used across this report and considers the success of measures to improve key cross-cutting adaptation actions.

The key messages of this chapter are:

- **Impacts from the changing climate are being felt today.** The record-breaking temperatures seen in summer 2022 brought unprecedented numbers of heat-related deaths and wildfire incidents. These impacts highlight the UK's exposure and vulnerability to extreme weather today. The weather extremes driving these impacts will continue to get worse for several decades at least. These events reinforce the urgency in preparing for climate change.

- **We have evolved our progress assessment framework for this report.** In this report we consider what is needed to be well adapted to climate change across thirteen different areas, which together span the range of risks identified in the latest Climate Change Risk Assessment. In each sector, we identify a set of key outcomes needed to build climate resilience, the enabling conditions necessary to achieve these outcomes and the role of policy action in bringing them about. This is needed to help track adaptation action more effectively as it moves from being focused mainly on planning and risk assessment towards an increased focus on delivery.

- **Cascading climate risks are critical but challenging.** Dependencies between different areas and systems that mean that climate impacts in one system can cascade and interact with others. Planning for these interdependencies is generally weak across sectors. There is some evidence of cross-sector engagement to address infrastructure interdependencies, but coordination is needed to better identify, measure and manage these risks.

- **Contributing to the global effort to tackle climate change is a vital part of well-rounded adaptation policy.** The UK is embedded within increasingly global systems. This means that the UK is exposed to climate change hazards both nationally and internationally. The UK needs to set out a strategic vision for its international climate policy, seek to support global ambition both to reduce emissions and to adapt to climate risks, provide multi-lateral finance and leverage private finance flows, and ensure that our domestic emissions reduction and adaptation programmes are ambitious and delivering.

This chapter is set out in four sections:

1. Observed and projected climate change
2. The assessment framework for this report
3. Addressing interdependencies
4. Preparing for climate change by helping the global effort

1. Observed and projected climate change

This section covers the latest evidence regarding observed global climate change and observed and projected changes in the UK's weather and climate. It highlights the current evidence regarding which recent trends in weather and climate can be linked to human-induced climate change, and what further changes are expected in the coming decades.

It is set out in three sub-sections:

(a) Global climate change

(b) Observed climate change in the UK

(c) Projected changes in UK climate and weather

(a) Global climate change

The evidence of climate change around the globe continues to accumulate.

Global observations over recent years are fully consistent with those expected from continuing long-term global warming resulting from human activity:

- **Observed global temperatures.** Annual global mean surface temperature in 2022 was estimated to be the fifth or sixth warmest year on record across all prominent global temperature datasets (Figure 1.1).[1] A rare triple-dip La Niña in 2022 (part of a prominent natural climate cycle) meant the global temperatures were lower than in recent years but are expected to return to, or exceed, the long-term trend when a shift to an expected El Niño state occurs over the coming year.

- **Atmospheric carbon dioxide.** Carbon dioxide (CO_2) concentrations continue to increase with a global average concentration of 417.2 ppm in 2022. This is an increase of 2.5 ppm from 2021 levels.[2]

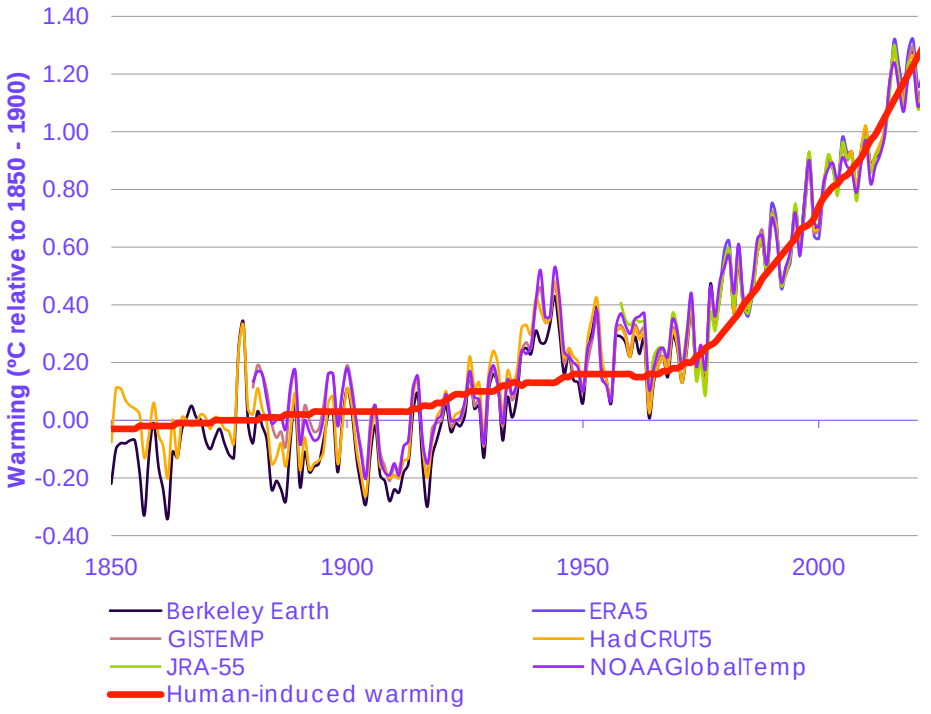
Human-induced warming is rapidly approaching 1.5 ºC above preindustrial levels.

- **Human-induced warming.** Estimated human-induced warming has now reached nearly 1.3ºC above 1850-1900 temperatures (an approximation for preindustrial levels) using methods aligned to the most recent assessment cycle of the Intergovernmental Panel on Climate Change (IPCC).[3] Human-induced warming is estimated to explain 100% (± 20% uncertainty) of the observed warming since 1850-1900. Human-induced warming is increasing at around 0.25ºC per decade, leading to further increases in global and UK climate hazards. At this present rate of increase, human-induced warming would exceed 1.5ºC above preindustrial levels (the lowest level referred to in the Paris Agreement long-term temperature goal) by the early 2030s.

- **Global sea level.** Global sea level continues to rise with an increase in average sea level of 20 cm between 1901 and 2018. The rate of sea level rise is accelerating and has more than doubled from the early 20th century rate of 1.3 mm per year to 3.7 mm per year over 2006-2018.[4]

The past year has also seen significant extreme weather events across the globe – many of which can now be linked with climate change, which drives changes in their frequency or intensity (Box 1.1).

Figure 1.1 Global average surface air temperature change



Source: Met Office (2023) *Climate Dashboard – Tracking the Changing Climate with Earth Observations.*; IPCC (2021) *Climate Change 2021: The Physical Science Basis*; CCC analysis.
Notes: Each thin line represents a different global temperature dataset. All datasets are expressed relative to 1850-1900. The human-induced warming line uses the best estimate for total anthropogenetic forced warming from the IPCC Sixth Assessment Report up until 2019 with data for 2020-2022 derived using linear extrapolation.

Climate and weather extremes caused numerous global impacts in 2022.

Box 1.1
Global extreme weather and climate events in 2022

In 2022, the world experienced a range of extreme climate and weather-related events. Climate change can influence these extremes events by making them more frequent, more intense, or larger in area impacted. Impacts and damages caused by these disasters reflect both the increasing probability of these events and the exposure and vulnerability of populations and ecosystems affected. Below is a summary of the most noteworthy events from 2022:

- **Record breaking heat in India.** Extreme heat broke all-time temperature records in India for March (records go back 122 years). March was extremely dry, and the compound nature of heat and drought led to favourable conditions for a prolonged extreme heatwave. The heatwave continued to intensify through April and peaked toward the end of the month with 70% of the country experiencing heatwave conditions. Estimates suggest that climate change made the heatwave 30 times more likely.
- **Summer drought, heat and wildfires in Europe.** Summer 2022 was one of the hottest and driest on record for Europe. The extreme heat and drought lead to water shortages, crop losses, wildfires, forced power plant curtailment and an estimated 20,000 heat-related deaths.
- **Flooding in Australia and Pakistan.** Australia experienced a series of extreme flooding events in 2022. Severe flooding events were recorded in eastern Australia in February and April, New South Wales in July and south-eastern Australia in October. Pakistan experienced record-breaking floods in July to October caused by heavier than normal monsoon rainfall and rapidly melting glaciers, following an extreme spring heatwave. The floods affected 33 million people, caused mass evacuations,

approximately 1,730 deaths and estimated economic damages and losses of $30 billion.

- **Hurricane Ian in United States and Cuba.** Hurricane Ian was the fifth strongest hurricane on record to make landfall in the contiguous United States and the third costliest weather-related disaster on record. It caused157 deaths, including five in Cuba, and an estimated $113 billion in damages and losses.

Source: Zachariah, M. et al. (2022) *Climate Change made devastating early heat in India and Pakistan 30 times more likely*; The Guardian (2022) *Over 20,000 died in western Europe's summer heatwaves, figures show*; World Bank (2022) *Pakistan: Flood Damages and Economic Losses Over USD 30 billion and Reconstruction Needs Over USD 16 billion - New Assessment*; NOAA National Centers for Environmental Information (NCEI) (2023), *U.S. Billion-Dollar Weather and Climate Disasters.*

(b) Observed climate change in the UK

The last year was the hottest ever recorded in the UK, with temperatures in mid-July exceeding 40°C for the first time.

2022 was the warmest year on record for the UK.[5] It was the first year to exceed an average temperature of 10°C. The mid-July heatwave broke the previous UK maximum temperature by 1.6°C with a temperature of 40.3°C recorded at Coningsby in Lincolnshire on 19 July. This exceeded the previous record temperature of 38.7°C set at Cambridge University Botanic Gardens in 2019, only three years ago.[6] These record-breaking extremes are consistent with continued global warming and are likely to occur more frequently in the coming decades.

Recent trends are largely consistent with overall trends of long-term UK climate change.

The latest weather and climate observations continue to document several clear recent trends in aspects of UK climate (Figure 1.2):

- **Warmer average temperature.** The UK's annual average temperature over the last decade (2013-2022) has risen by around 0.75°C above the average of the 1981-2000 period, consistent with a long-term warming trend since the 1980s.

- **Warming is occurring fastest in winter and slowest in spring.** Seasons are warming at slightly different rates. Over the last decade winter average temperatures have been rising fastest and have increased by around 0.84°C, compared with the 1981-2000 average, while spring average temperatures have risen by 0.5°C. Average temperatures for summer and autumn have risen 0.81°C and 0.87°C respectively.

- **Higher average sea levels**. Since 1900, sea level has risen around the UK by about 16.5 cm. They are currently estimated to be rising at around 3.6 cm per decade.[7]

There is strong evidence that climate change is altering the UK's temperature extremes.

- **Changed temperature extremes**. The shifting UK climate is having a clear effect on observed temperature extremes.[8]

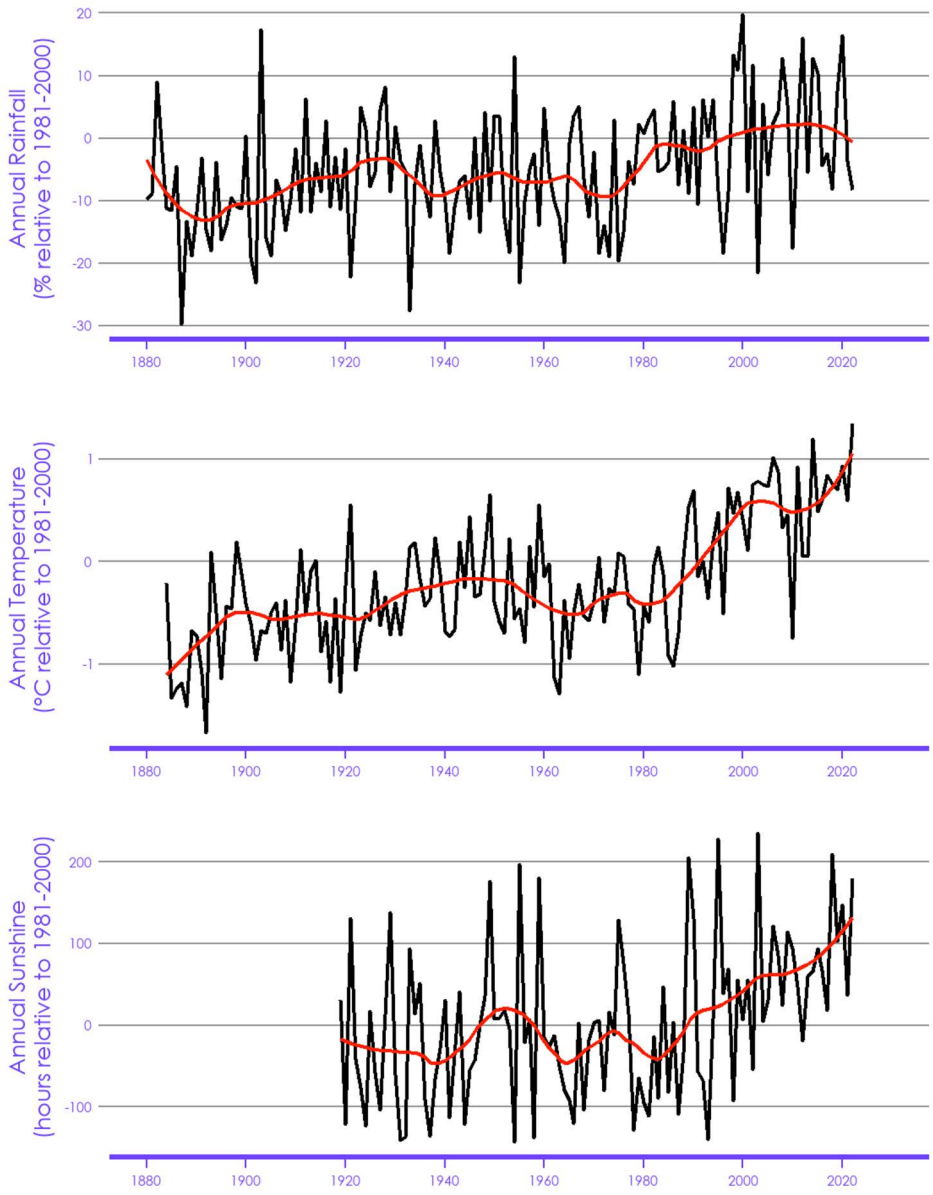
  – The warmest temperature recorded each year has increased over time. Averaged across the UK, the warmest temperature of the year has increased to around 27ºC from around 25ºC in the 1960s, with much more rapid rates of increase in South East England. The average duration of heatwaves (periods in which there are more than three days in excess of 25ºC) has increased over time. For the UK as a whole, summers as hot as in 2018 (the joint warmest summer on record) are expected to occur in up to 25% of years, compared to less than 10% of years a few decades ago.

  – The coldest temperature of the year has also increased over time. Averaged across the UK, the coldest temperature of the year is now around -7.5ºC. In the 1960s it was around -9ºC.

– The number of icing days (days in which the maximum temperature remains below 0ºC) across the UK was around six per year in the 1960s, but has fallen to around three per year today. Individual years with a significantly greater number of icing days remain possible.

- **Sunshine**. The most recent decade has been the sunniest on record in the UK (around 7% sunnier than over 1981-2000, with increases in spring, summer and winter), however the causal link between this trend and human-induced climate change currently remains under investigation, with possible links to changes in aerosol emissions.[9,10]

Figure 1.2 Observed changes in aspects of the UK's climate



Source: Met Office; Hollis, D. et al. (2018): *HadUK-Grid gridded and regional average climate observations for the UK*. Centre for Environmental Data Analysis, (accessed March 2023); CCC analysis.
Notes: Annual data is shown in all panels. The red line is a 30-year loess smooth.

Other expected changes in the UK's climate have not yet emerged from the noise of year-to-year weather variation – but are expected to do so in future.

Signals of climate change may be emerging in other climate variables, but the strong annual and decadal variability in the UK's weather and climate still prevents their clear detection, despite this being possible in other regions of the world:

- **Annual and seasonal precipitation**. Since the 1980s, there has been an overall increase in the annual average amount of rainfall in the UK (the most recent decade was around 1% wetter than 1981–2000), but with both significantly wetter and drier years being observed. Winters were, on average, 12% wetter and springs 10% drier over the last decade. Recent wet summers (not including 2022) means that summers over the last decade have been around 9% wetter than over 1981-2000, despite central projections for drier summers on average in the future.[11]

- **Precipitation extremes**. Heavy rainfall metrics generally show an increase in very wet days across the UK, but the expected signal from climate change remains hard to distinguish from the large interannual variability in the observational record. Extreme event attribution studies have found robust signals that human-induced climate change has increased the likelihood of some observed UK precipitation extremes.[12,13]

- **Storminess**. Storms can bring heavy rainfall and strong winds to the UK (particularly in winter), with increased risks of flooding and wind damage. There are no clear trends in UK storminess over the observed record.[14,*] As UK storminess is strongly linked to the Jetstream, improving understanding of how Jetstream variability may change in the future is an important area of research to develop a better understanding of future UK climate hazards.[†]

The absence of clearly distinguishable observed trends in these aspects of UK weather and climate does not mean that there is no effect of climate change. Detectable changes in other aspects of UK climate are expected to emerge from natural climate variability as human-induced global warming continues to increase.

(i) Extreme weather and impacts in 2022

The extreme weather events in 2022 have highlighted the exposure and vulnerability to climate change.

In 2022, there were several significant extreme weather events in the UK which caused impacts to people, infrastructure and ecosystems (Box 1.2) – most particularly from the record-breaking heatwave in mid-July. These impacts highlight the extent of exposure and vulnerability to weather and climate extremes even in today's climate.

* Storminess is here defined in terms of maximum wind gust speed.

† Evidence from the latest generation of climate models produced by the UK Met Office, which have improved representation of Jetstream variability, suggests a possible shift to more stormy winters on average in the future.

Box 1.2
Extreme weather events in the UK in 2022

There were several notable weather and climate related extremes in the UK in 2022. These events highlighted the compound nature of extreme weather with a succession of storms in January and February and an unusual dry period in spring that acted as pre-conditioning for the extraordinary heatwave in July.

- **Unprecedented July Heatwave.** The UK experienced a short but unparalleled extreme heatwave from 16 to 19July, with temperatures peaking on 18 and 19 July. A maximum temperature of 40.3°C was recorded at Coningsby, Lincolnshire on 19 July exceeding the previous UK temperature record by 1.6°C. The heatwave was remarkable in both intensity and extent, with temperatures of more than 39°C experienced by a large area of eastern England and extending as far north as Yorkshire. Impacts were extensive, with disruption to rail and road networks, flights suspended, school closures, spikes in 999 calls and fire services declaring major incidents due to multiple wildfires – with record wildfire instances (greater than 30 hectares) recorded in 2022. This heatwave, and the subsequent heatwaves in August, led to record-levels of heat-related deaths.
- **Drought.** The July heatwave coincided with a period of dry conditions in England that started in early spring and continued into autumn. England's summer was the sixth driest on record, with even more extreme drought conditions seen in East Anglia – a key food production region (where summer 2022 was the fourth driest on record). River flows were very low across the country, particularly in southern and eastern England. The combination of the lack of rainfall with the summer heat meant soils were very dry, stressing ecosystems and agriculture. At the end of August, reservoir levels across England and Wales fell to the second lowest level since data was tracked from 1990. This led to temporary water use restrictions by eight water companies.
- **Storms Dudley, Eunice and Franklin.** Three named storms affected the UK in a week between 16 and 22 February. Storm Eunice caused widespread impact including four deaths, power outages to over a million homes and businesses, school closures, temporary closure of the Port of Dover and rail and flight cancelations. Storms Dudley and Franklin also caused significant impacts including power cuts to Cumbria, Lancashire and Yorkshire and rail disruption on mainlines to Glasgow and Edinburgh. Cumulative rainfall from successive storms caused significant flooding to parts of England, Wales and Northern Ireland. Storm Eunice was the most damaging storm to impact England and Wales since 2014, causing widespread damage and disruption.

Concurrent drought and heatwaves, like those experienced in summer 2022, can significantly increase the individual hazard and overall risk. Unusually dry soils can cause localised increases in maximum temperatures during a heatwave due to reduced surface cooling from evapotranspiration. This can lead to an increase in the likelihood of wildfires, like those experienced in the summer. Likewise, water demand can increase significantly during periods of hot weather, if this occurs during drought conditions it can put addition pressure on water supply infrastructure.

Source: Met Office (2022) *Unprecedented extreme heatwave, July 2022.*; Met Office (2022) *Storms Dudley, Eunice and Franklin, February 2022.*; European Fire Information Service; ONS (2022) *Excess mortality during heat-periods: 1 June to 31 August 2022*; Centre for Ecology and Hydrology (2022) *Why we are still in drought despite recent rain.*

(c) Projected changes in UK climate and weather

Warmer and wetter winter, drier and hotter summer and continued sea level rise is expected in the UK over coming decades.

The Committee recently published its advice on the Third UK Climate Change Risk Assessment (CCRA3).[15] This advice, supported by an extensive Technical Report, provides a detailed assessment of the changes in UK weather and climate that might be expected in the future.

- **Warmer and wetter winters.** By 2050, the UK's average winter could be around 1ºC warmer (0.5ºC cooler – 2.5ºC warmer uncertainty range) than it was on average over 1981-2000 and around 5% wetter (10% drier – 20% wetter uncertainty range). An increase in both the intensity of winter rainfall and the number of wet days is expected.

- **Drier and hotter summers.** By 2050, the UK's average summer could be around 1.5ºC warmer (0ºC – 3ºC uncertainty range) than it was on average over 1981-2000 and around 10% drier (30% drier – 5% wetter uncertainty range). A summer as hot as in 2018 (the joint hottest summer on record) for the UK could be normal summer conditions by 2050. The temperature of the hottest days each year are expected to increase more than the average summer temperature increase. The intensity of summer rainfall (when it occurs) is expected to increase.

- **Continued sea-level rise**. The seas around the UK will continue to rise over the three decades to 2050. By 2050, sea levels could be around 10-30 cm higher than over 1981-2000, depending on the specific location in the UK.*

Climate change out to mid-century is largely inevitable. Global ambition for greenhouse gas emission reductions will determine the levels of climate change seen in the second half of the century.

These additional changes in the UK's climate to 2050 are largely insensitive to the pathway of global greenhouse gas (GHG) emissions over coming decades. Beyond mid-century, the different possible future trajectories in global GHG emissions become the main source of uncertainty in global and UK climate changes. If global emissions continue at a high level through to mid-century and beyond, global temperatures will continue to rise beyond 2050 and associated climate changes in the UK and elsewhere will continue in the second half of the century. If, however, global emissions have been significantly reduced by mid-century and are brought to Net Zero soon after, then many aspects of global and UK climate in the second half of the century can be kept close to that experienced at mid-century.†

Long-term UK climate risks therefore depend on both the ambition and implementation of global emissions reductions:

- Current ambition for global emissions reduction is expected to be consistent with a central estimate of 2 - 3ºC of warming above preindustrial levels by 2100.[16] Warming reaching 4ºC above preindustrial levels by 2100 remains at the upper end of possible outcomes.

- Current global commitments to reduce emissions by 2030 and long-term Net Zero commitments around mid-century would, if delivered, move the central estimate for warming under 2ºC above preindustrial levels, but more ambition is needed to keep warming well-below 2ºC or to below 1.5ºC.

* Range (in 50th percentile) outcomes across UK capital cities is given here. Climate uncertainties means that changes could range from 30 – 40 cm above 1981 – 2000 levels across capital cities under a high climate response (95th percentile).

† Some aspects of the climate (e.g. sea level) will continue to change in the second half of the century regardless of global emissions trajectories continuing to increase hazards such as coastal flooding.

2. The asssessment framework for this report

This report is our third statutory progress report during the period of the second National Adaptation Programme.

Under the Climate Change Act (2008) the Committee is required to provide a formal progress assessment on preparation for climate change every other year. This is required to include an assessment of the progress made towards implementing the objectives, proposals and policies set out the current National Adaptation Plan. This report is the Committee's third assessment of progress in delivering the current (second) National Adaptation Programme (NAP) which runs from 2018-2023 (Box 1.3). Our most recent assessment under this NAP was published in 2021 (Box 1.4).

Box 1.3
The Second National Adaptation Programme

The second National Adaptation Programme (NAP2) was published in 2018 and covered a five-year period (2018-2023). The NAP is required to be produced by the Government to respond to the risks identified in the most recent Climate Change Risk Assessment (CCRA) under the Climate Change Act. The NAP programme was primarily for England (as most policy areas relevant to climate change adaptation are devolved) as well as covering adaptation for the whole UK in policy areas that are reserved for the UK Government. The NAP is coordinated and published by Defra but contains actions from a wide range of Government departments.

NAP2 included the following chapters, each identifying actions from across the UK Government intended to support adapting to climate change risks in each area:

- Natural environment
- Infrastructure
- People and the built environment
- Business and industry
- Local government

Of the 56 risks and opportunities identified in the second CCRA, 21 did not have any related actions in NAP2, including 13 in the 'more urgent' categories. NAP2 also did not include any consideration of international risks to the UK, a key sub-set of the risks identified in the CCRA.

Alongside the actions related to the risks, NAP2 set out the objectives and principles for the third round of the Adaptation Reporting Power (ARP). The ARP was created under the Climate Change Act to help understand and improve the resilience of key infrastructure systems to climate change. It enables Government to ask certain organisations to produce reports on:

- The current and future predicted effects of climate change on their organisation.
- Their actions taken and their future proposals for adapting to climate.

The Committee provided a detailed assessment of this third round of the ARP in a report published in 2022, analysing the extent to which the ARP is delivering on its stated objectives.

Source: Defra (2018); CCC (2022) *Understanding climate risks to UK infrastructure: Evaluation of the third round of the Adaptation Reporting Power.*

Box 1.4
2021 assessment of progress under the second National Adaptation Programme

The Committee's most recent progress report was published in 2021. It concluded that:

- UK adaptation policy has not, to-date, produced the necessary resilience to fully address the risks that a changing climate poses to the UK across the economy.
- The gap between future levels of risk and planned adaptation has widened in the last 5 years.
- Planning for a global warming level of 2ºC and considering a 4ºC warmer world is not happening.
- No adaptation priority area achieved the highest risk management score, although some were scored as having good consideration of adaptation in planning.

This assessment also provided a detailed set of recommendations for actions within the NAP2 period that would help strengthen preparation for climate change. In the 2022 Progress Report on reducing emissions of greenhouse gases, we provided an updated assessment of how the recommendations from the 2021 Progress Report had been implemented. Of the recommendations related to adaptation for actions over the year from summer 2021 none had been achieved in full, despite some areas of policy progress.

Source: CCC (2021) *Progress in preparing for climate change*; CCC (2021) *Independent Assessment of UK Climate Risk*.

The next National Adaptation Programme will soon be published.

This assessment of efforts to prepare for climate change is published in the final few months of NAP2, and shortly before the publication of NAP3 in mid-2023. NAP3 will run over the period of 2023-2028. This progress report is both a final assessment on the progress that has been achieved on preparing for climate change by the end of the NAP2 cycle, and a snapshot of adaptation progress to date at the start of the NAP3 cycle.

We have evolved our assessment framework for this report to best suit the changing needs of adaptation progress assessment.

For this progress report, the Committee has evolved its framework for assessing adaptation progress from that used in its previous NAP2 progress reports. There are several reasons for this:

- Adaptation action in the UK needs now to extend beyond focusing mainly on risk assessment and planning to include a stronger focus on delivery and implementation of adaptation action in the next NAP period. To achieve this, there is a need for a more granular and specific focus on required adaptation outcomes and the theory of change that will enable policy to unlock the needed action right across the economy.
- The next NAP will respond to the increased evidence on the risks of climate change published in the UK's Third Climate Change Risk Assessment (CCRA3 published in 2021). This updated evidence base increasingly highlights the systemic and interacting nature of climate risks, which can be more difficult to respond to adequately within narrow policy focus areas and requires more of an integrated approach across climate risks.
- The structure of NAP3 is not yet known but is expected to change from the NAP2 structure.

The rest of this section sets out an updated approach to adaptation progress reporting for this report. This framework will form the basis of the structure that the Committee intends to use to assess progress in preparing for climate change over the NAP3 cycle, subject to evolutions needed to enable it to capture the full range of outcomes targeted within NAP3, once established.

(a) Key features of the assessment framework

This assessment largely covers adaptation in England but also covers UK-wide adaptation for reserved policy areas.

The scope of this progress report is adaptation policy for which the UK Government is responsible. For reserved areas of policy, the progress on adaptation across the UK is assessed; for devolved areas of policy, progress on adaptation is assessed only for England. Northern Ireland, Scotland and Wales produce their own national adaptation plans, on which the Committee provides separate advice and assessment of progress when requested.

(i) Adaptation areas

This report assesses progress in preparing for climate change across thirteen chapters. Each focuses on a specific part of the adaptation challenge, for which climate change poses one or many risks and opportunities which require proactive preparation today (Box 1.5).

Box 1.5
Areas of adaptation covered within each chapter of this report

The areas of adaptation covered within each chapter of this report are:

- **Nature** (Chapter 2): This chapter covers protecting the UK's terrestrial (including on farmland), freshwater and marine habitats and biodiversity from climate change.
- **Working land and seas** (Chapter 3): This chapter covers the necessary adaptation needed to ensure that UK agriculture, forestry and fisheries remain economically productive under changing climate conditions.
- **Food security** (Chapter 4): This chapter covers the UK's domestic and imported food supply chains and their climate resilience, as well as the vulnerability of society to climate-related food disruption.
- **Water supply** (Chapter 5): The chapter covers the public water system which supplies households and businesses.
- **Energy** (Chapter 6): This chapter covers adaptation within the key energy systems – the electricity system (transmission, distribution, and generation), gas networks and novel sources of energy supply (such as hydrogen) as they develop.
- **Telecoms & ICT** (Chapter 7): This chapter covers the communications and ICT infrastructure (data centres, networks and other critical national infrastructure) that needs to be climate resilience for the functioning of the UK's economy.
- **Transport** (Chapter 8): This chapter covers the road networks (both the national strategic road network and local roads), railways, ports and airports.
- **Towns and cities** (Chapter 9): This chapter covers adaptation needed within or for the built environment. Only settlement scale adaptation is covered in this chapter. This includes flood defences to protect people and property, urban design to limit the urban heat islands and surface water flooding, coastal protection for settlements on the coast and the planning system. Adaptation responses to heat and flood at the household level are covered in the Buildings chapter, and response and recovery within the Community preparedness and response chapter.
- **Buildings** (Chapter 10): This chapter covers building-level interventions to ensure that they are protected from overheating and flooding.
- **Health** (Chapter 11): This chapter covers actions needed to ensure public health is maintained and improved despite climate change. This includes mortality and morbidity risks from overheating as well as climate-sensitive vector-borne diseases and the delivery of health care during periods of extreme weather.
- **Community preparedness and response** (Chapter 12): This chapter covers the preparedness of communities for climate impacts, including the ability to protect

cultural heritage, and their ability to effectively respond when climate and weather-related disruptions occur.

- **Business** (Chapter 13): This chapter covers the adaptation that is required of business, specific to their function as a commercial entity. This includes adapting their supply chains (both domestic and international), their business sites and assets, access to capital and productivity impacts.
- **Finance** (Chapter 14): This chapter covers adapting the UK's financial system so that systemic risks from climate change are minimised and it can effectively support the economy in investing in necessary adaptation actions.

The chapters of this report focus on adaptation to a range of climate risks for a particular set of assets or system.

These chapters are structured around assets or systems impacted by climate risks. Often key assets and systems are impacted by multiple risks and require joined up policy responses from the same set of actors or institutions to manage them adequately. Together these chapters cover all 61 risks and opportunities identified by CCRA3 (Table 1.1), including risks from climate change outside of the UK where relevant. Each chapter is also subject to a range of different climate hazards. Some risks are relevant to multiple chapters, but the chapters will differ in the manifestation of the risk or the type of assets that are impacted.

Table 1.1
Relevant CCRA3 risks across chapters of this report

Chapter	Relevant CCRA3 risks
2. Nature	Risks to terrestrial habitats and species (N1, N2, N3); Risks to soils (N4); Risks and opportunities for natural carbon stores, carbon sequestration and GHG emissions (N5); Risks to freshwater habitats and species (N11, N12); Opportunities to freshwater habitats and species (N13); Risks to marine habitats and species, and fisheries (N14, N16); Opportunities to marine habitats and species, and fisheries (N15) Risks and opportunities to coastal habitats and species (N17); Risks and opportunities to landscape character (N18).
3. Working land and seas	Risks to soils (N4); Risks and opportunities for natural carbon stores, carbon sequestration and GHG emissions (N5); Risks to agriculture and forestry (N6, N7, N8); Opportunities to agriculture and forestry (N9); Risks to aquifers agricultural land (N10); Risks to marine habitats and species, and fisheries (N14, N16); Opportunities to marine habitats and species, and fisheries (N15).
4. Food security	Risks and opportunities to UK food availability, safety, and quality from climate change overseas (ID1, ID2); Risks and opportunities from climate change on international trade routes (ID6, ID7); Risks to food safety and food security (H9); Risks to business from disruption to supply chains and distribution networks (B6); Risks to soils (N4); Risks to aquifers and agricultural land (N10).
5. Water supply	Risks to infrastructure networks from cascading failures (I1); Risks to infrastructure services from flooding and coastal erosion (I2, I3); Risks to subterranean and surface infrastructure from subsidence (I7); Risks to public water supplies from reduced water availability (I8); Risks to health from poor water quality and household supply interruptions (H10).
6. Energy	Risks to infrastructure networks from cascading failures (I1); Risks to infrastructure services, bridges and pipelines from flooding and coastal erosion (I2, I3, I4); Risks to hydroelectric generation from low or high river flows (I6); Risks to subterranean and surface infrastructure from subsidence (I7); Risks to energy generation from reduced water availability (I9); Risks to energy from high and low temperatures, high winds, lightning (I10); Risks to offshore infrastructure from storms and high waves (I11); Risks and opportunities from summer and winter household energy demand (H6).
7. Telecommunications & ICT	Risks to infrastructure networks from cascading failures (I1); Risks to infrastructure services, bridges and pipelines from flooding and coastal erosion (I2, I3, I4); Risks to subterranean and surface infrastructure from subsidence (I7); Risks to digital from high and low temperatures, high winds and lightning (I13).

8. Transport	Risks to infrastructure networks from cascading failures (I1); Risks to infrastructure services, bridges and pipelines from flooding and coastal erosion (I2, I3, I4); Risks to transport networks from slope and embankment failure (I5); Risks to subterranean and surface infrastructure from subsidence (I7); Risks to transport from high and low temperatures, high winds, lightning (I12).
9. Towns and cities	Risks to health and wellbeing from high temperatures (H1); Risks to people, communities and buildings from flooding (H3); Risks to viability of coastal communities from sea level rise (H4); (aspects of Risks to infrastructure services from river, surface water and groundwater flooding (I2) and Risks to infrastructure services from coastal flooding and erosion (I3) are also covered less explicitly in this system).
10. Buildings	Risks to health and wellbeing from high temperatures (H1); Risks to people, communities and buildings from flooding (H3); Risks to building fabric (H5); Risks and opportunities from summer and winter household energy demand (H6); Risks to health and social care delivery (H12); Risks to education and prison services (H13).
11. Health	Risks and opportunities to health and wellbeing from high temperatures (H1, H2); Risks to people, communities and buildings from flooding (H3); Risks to health and wellbeing from changes in air quality (H7); Risks to health from vector-borne diseases (H8); Risks to health and social care delivery (H12).
12. Community preparedness and response	Risks and opportunities to health and wellbeing from high temperatures (H1, H2); Risks to people, communities and buildings from flooding (H3); Risks to viability of coastal communities from sea level rise (H4); Risks to cultural heritage (H11); Risks and opportunities from climate change to landscape character (N18).
13. Business	Risks to business from flooding (B1); Risks to businesses and infrastructure from coastal change (B2); Risks to businesses from water scarcity (B3); Risks to business from reduced employee productivity (B5); Risks to business from disruption to supply chains and distribution networks (B6); Opportunities for business from changes in demand for goods and services (B7).
14. Finance	Risks to finance, investment and insurance including access to capital for businesses (B4); Risks to the UK financial sector from climate change risks overseas (ID8).

(ii) Assessment methodology

Within each chapter our updated assessment framework has the following components:

We set out a monitoring map for each chapter to structure our assessment around and to evaluate progress against.

- **A monitoring map**, which lays out an indicative high-level goal or vision for what being resilient to climate change in this area might mean and identifies tangible key outcomes that the Committee believes will need to be in place to help deliver this. We also identify a set of enabling factors (which are important to the realisation of the outcomes), policy and planning milestones which need to be in place and contextual factors (things which are largely independent of policy action but will nonetheless affect the ability for the identified adaptation outcomes to be delivered).

- **Evaluation of relevant delivery and implementation indicators** that we identify for each top-level adaptation outcome identified within the monitoring map. This helps track progress towards the delivery of the identified outcomes and the extent to which key enabling factors are in place. Typically, available indicators only tell a partial story and multiple indicators often need to be considered together to provide an overall picture. We evaluate relevant indicators and assess the extent to which these are moving in the right direction. In many instances there are important data gaps or indicators are not sufficiently up to date to provide a current understanding of trends.

- **An assessment of progress against policy and planning requirements** described in the monitoring map. We document recent developments in relevant policies and plans and assess to what extent the relevant policy milestones identified on the monitoring maps are in place, to what extent they are appropriately ambitious, and whether there is appropriate monitoring and evaluation to allow them to function effectively.

Full details of our assessment methodology is provided in a supporting publication.

A separate publication, **CCC Adaptation Monitoring Framework** explains in detail the approach of the updated assessment framework applied within each chapter of this report.

(iii) Scoring

For each identified adaptation outcome, we score 'delivery and implementation' and 'policies and plans' separately.

Within this report we score progress in preparing for climate change at the level of the identified key outcomes within each chapter. For each outcome we identify two summary scores, one for 'Delivery and implementation' (Table 1.2) and one for 'Policies and plans' (Table 1.3). This allows us to distinguish important policy developments that help put in place or strengthen the key identified policy milestones within the monitoring map, and evidence that adaptation outcomes are being delivered on the ground.* While the criteria below are followed to determine scores, inevitably some judgement is required to synthesise all the available evidence into one score, which the Committee makes as necessary and describes our reasoning where possible.

Table 1.2
Scoring criteria for delivery and implementation

Score	Criteria
Good progress	Indicators are moving in the right direction or being maintained at a high level
Mixed progress	Some indicators are moving in the right direction, others are stagnant at a low level or moving in the wrong direction
Insufficient progress	Indicators are stagnant at a low level or are moving in the wrong direction
Unable to evaluate	Limited or no available data

* For our policy and plans assessment we include policy published up until early March 2023.

Table 1.3
Scoring criteria for policies and plans

Score	Criteria
Credible policies and plans	Policy milestones: • are almost entirely achieved or in place • are comprehensive and appropriately ambitious • include monitoring and evaluation
Partial policies and plans	Policy milestones: • are achieved or in place for key milestones but some gaps remain • cover most important elements, could be more ambitious • include some monitoring and evaluation
Limited policies and plans	Policy milestones: • are partially achieved or in place with some key milestones missing • cover some important elements, could be more ambitious • include some monitoring and evaluation
Insufficient policies and plans	Policy milestones: • are mostly not achieved, only minor policies in place • lack important elements, do not cover key areas or lack ambition • have minimal monitoring and evaluation

(iv) Recommendations

We provide a set of recommendations for each chapter to close identified policy gaps.

Targeted recommendations on further policy actions that are required within each adaptation area to close gaps are provided in the relevant chapters of this report and in a separate document published alongside. We identify owners for these recommendations within Government and implementing agencies and timelines by which they need to be delivered.

3. Addressing interdependencies

Accounting for the interdependencies between different areas and systems is a key part of effective adaptation planning.

The assessment within this report is conducted separately for each chapter. However, there are a complex set of dependencies between different areas and systems that mean that climate impacts in one system can cascade and interact with others. This has been demonstrated during the record-breaking heatwave conditions experienced in 2022 (Box 1.6). An important part of adaptation planning is identifying and managing these interdependences.

Box 1.6
Cascading impacts across infrastructure and health systems in the summer 2022 heatwaves

Extreme high temperatures in July 2022 resulted in clear instances of interacting and cascading risks, which affected multiple systems.

- On 19 July 2022, London experienced temperatures reaching 40°C. This resulted in failures at two data centres used to host the 371 legacy IT systems of London's largest NHS hospital trust. The two data centres support clinical services, patient records and administration. The centres were designed to act as a back up to each other in the event that one failed.
- The cooling failures took down most of the clinical IT systems at Guy's, St Thomas' and Eveline London hospitals, and community services. The Trust declared a critical site incident and moved to a paper-based operating model and requested wider system support (a Level 3 critical incident, the highest level). Complete restoration of IT systems took several weeks, with the Emergency Department IT system restored after five days, electronic Pathology and Imaging requests restored after ten days, and the incident only formally stood down on 21 September.
- The incident caused widespread disruption to patient care and clinical services, including to hospitals in the wider area where patients were diverted. Only 68% of referrals were received and 68% of diagnostic tests carried out compared to historic averages for July. The Trust incurred £1.4 million out-of-plan spending, including cloud hosting and recovery services
- Recovery from the critical incident was complicated by the unrelated national cyberattack on Adastra and CareNotes systems, which impacted the Trust, particularly its community services, and NHS organisations across the country.[17]

Source: Guy's and St Thomas' Hospital Trust (2023) *Review of the Guy's and St Thomas' IT critical incident final report from the deputy Chief Executive Officer.*

Interdependencies from infrastructure linkage, dependencies on the natural environment and socioeconomic connections are all key sources of cascading and compounding climate change risks.

There are several types of independencies that are important when considering climate change adaptation.

- **Infrastructure interdependencies**. Infrastructure systems depend on each other to function. For example, water systems need a reliable supply of power, and power system operators require reliable transport networks to maintain the energy network and restore power following an outage. Connectedness of infrastructure systems means that climate and weather-related impacts in one system can cause large and cascading failures in connected systems.

- **Nature interdependencies.** Healthy and functioning habitats and ecosystem are critical for the whole economy. They fundamentally underpin the ability of the land and oceans to provide food, feed and fibre, but also have broader contributions such as water purification, control of disease spread, flood control and cultural significance.

Access to nature also provides health and wellbeing services. Research carried out for the Third Climate Change Risk Assessment (CCRA3) also found that the many connections between the natural environment and other sectors indicated that a well-managed natural environment could provide resilience to other sectors across infrastructure and the built environment.

- **Socio-economic interdependencies.** Sectors are related to each other through the commercial relationships across the economy. Climate impacts in one area can cascade through to other areas through these relationships, for example via changes in factors of production (prices, availability of inputs, availability of labour, etc) and changes in the demand for goods and services. Climate change can also pose risks to social structures and norms (both domestic and international) that can cascade into impacts in a wide range of areas. Similarly, current policy goals and initiatives (such as reducing greenhouse gas emissions to Net Zero) often cut across areas of climate change impacts and can influence key aspects of climate change vulnerability and exposure in complex ways.

Addressing interdependencies in adaptation planning is challenging and generally at a low level.

These interdependencies can enable climate risks to interact, cascade and compound spatially, temporally and across sectors. By identifying these pathways of interdependency, climate risks can be assessed and mitigated as much as possible. Despite their importance, analysis and evaluation of interdependencies and climate risks are often the most challenging areas for organisations and policy. Most analysis of interdependencies as part of adaptation planning is currently limited to infrastructure interdependencies in some sectors. Conclusions based on available evidence for these is summarised in the next sub-section, with interdependencies with the need to reduce greenhouse emissions to Net Zero covered in the following subsection.

(a) Infrastructure interdependencies

Infrastructure interdependencies are covered under the adaptation reporting power. We provided an assessment of the third round in 2022.

The Adaptation Reporting Power (ARP) is an important mechanism to increase understanding of how risks to infrastructure are being addressed across a range of organisations. It enables the Government to request reports from critical infrastructure providers (and public bodies more broadly) on the current and predicted effects of climate change on their organisation, their proposals for adapting to climate change and progress made towards their implementation. The ARP is a key element of the adaptation policy cycle and provides a unique source for understanding the UK's infrastructure-related climate risks.

The third round of the ARP (ARP3) concluded in December 2021. The Committee was commissioned to undertake an independent assessment of ARP3 which was published in July 2022 (Box 1.7).

Box 1.7
Overall conclusions of the Committee's assessment of ARP3

The CCC's evaluation of the third round of ARP found that:

- The current timing of the ARP, CCRA and NAP cycles are not well aligned, significantly limiting the utility of the ARP in informing the overall level of climate risk.
- Participation in ARP3 was voluntary, with a sizeable number of invited organisations (20%) not submitting a report. Gaps in coverage exist in many sectors. Non-reporting organisations include one airport, six port authorities, one rail operator, five organisations in the water sector, two government regulators, one financial regulator and two heritage organisations.

- These coverage gaps mean there is only an incomplete picture of climate preparedness of key sectors. Furthermore, these gaps prevent other sectors, organisations and Government from gaining an understanding of the risks to their organisations and the UK population that result from infrastructure interdependencies.
- Sources of interdependency risk (risks that arise from an organisation's reliance on another organisation or sector) have been identified in most ARP3 reports, however these are not being consistently incorporated into risk assessments and adaptation plans.
- No sector scored highly in assigning timescales to actions, and while linking adaptation actions to risks has improved since ARP2, there is still not consistent linking of actions to risks in every sector.
- In addition, some key organisations and sectors are not currently being invited to report under ARP. For example, canals and reservoirs (not covered by water company reports), wider aspects of the health and social care sector, local authorities and food supply chains.

Source: CCC (2022) *Understanding climate risks to UK infrastructure.*

Interdependencies from infrastructure are not generally well integrated into risk assessment or adaptation planning.

The ARP demonstrates that climate risks from interdependencies (risks that arise from an organisation's reliance on another organisation or sector) are currently not being consistently incorporated into risk assessments or adaptation plans. There is some evidence of cross-sector engagement to address interdependencies, but coordination is needed to enable reporting organisations to identify more clearly, and measure and manage these risks better. Gaps in submissions to the ARP (20% of invited organisations did not submit a report to ARP3) in many sectors prevents other sectors, organisations and Government from gaining an understanding of risks to their organisations and the UK population that result from infrastructure interdependencies. This hinders the role of ARP as a driver for more action and collaboration on adaptation.

Our assessment identified a number of barriers to identifying and managing interdependencies across reporting organisations:

- Lack of understanding of climate impacts in sectors they depend on for their own operations and the complexity of interactions.
- Inconsistencies across sectors in measuring and reporting on climate risks e.g. different risk criteria and different climate scenarios.
- Incomplete data, or concerns about sharing data.
- Regulatory barriers or disincentives.
- Lack of funding, misalignment of funding cycles or research priorities.
- Lack of top-down leadership.
- Limited mechanisms or opportunities for cross sector engagement.

Government will need to help support key organisations to assess interdependency risks.

Government needs to do more to support organisations to identify and manage risks from interdependencies. In February 2023, Defra published a consultation paper on changes to the Adaptation Reporting Power.

The consultation broadly aligns with many of the Committee's recommendations in the ARP3 evaluation, by:

- Proposing to improve the alignment of adaptation reporting with other elements of the associated statutory framework for climate change adaptation by shortening the reporting cycle for the next round.
- Exploring options to increase the scope of reporting.
- Seeking input on whether the process should be mandatory.
- Indicating an intention to provide more guidance on interdependencies and review the approach to sectoral overview reporting.

These are positive proposals which, if implemented, should improve the overall usefulness of next ARP round, including on assessing infrastructure interdependencies.

Other policy milestones outside of the adaptation reporting power are also needed to help manage interdependency risks.

Beyond the ARP, there are further cross sectoral policy milestones that need to be put in place to help manage climate risk interdependencies across infrastructure systems:

- **National Resilience Strategy.** This was a key commitment of the Integrated Review over 18 months ago. Government has now signalled a commitment to improve standards for resilience by 2030 under the new UK Resilience Framework, published in late 2022. This presents an opportunity to ensure that infrastructure systems are resilient to the full range of climate conditions under which they will operate and to facilitate better coordination on resilience across infrastructure sectors. Given the scale of work needed to agree and implement standards, in line with regulatory cycles, a pathway to delivery of these standards needs to be set out as a priority.
- **Regulator remits for resilience**. Ofwat has clear statutory responsibilities for climate resilience, implemented through the water sector price review process. Other regulators, including Ofgem and Ofcom, do not have a legislated climate resilience remit. Consistent regulator roles across infrastructure sectors, combined with better co-ordination across regulators, would support greater understanding of and progress in managing interdependency risks. Current barriers include data sharing limitations and misaligned resilience standards.
- **National plan for managing interdependency risks.** There are limited actions for interdependency risks in NAP2. NAP3, including the ARP4 reports produced during the NAP3 cycle, must provide for a more systematic assessment of interdependency risks and improve the evidence base. The NAP should set out clear responsibilities across Government and effective mechanisms for the necessary cross-Government collaboration.

Making significant progress against these policy milestones required to address interdependencies should be a top priority for the next NAP.

(b) Net Zero interdependencies

Without integrating adaptation into efforts to reduce emissions efforts to reach Net Zero greenhouse gas emissions may fall short.

Without proactive and well-planned adaptation, many of the climate risks facing the UK will put efforts to reduce emissions rapidly over the next decade, and to Net Zero by 2050, at risk. In other areas, implementing actions to reduce emissions without considering the future UK climate could act to increase risk in those areas.

- **Increasing long-term carbon storage in UK land.** There are risks and opportunities from climate change for the ability of land to contribute to Net Zero. Peatlands are critical for both carbon storage and other environment services such as water regulation. If peatlands are not in good condition, they are at higher risk of degradation and carbon loss as the UK's climate changes, as well as failing to deliver their other benefits. Peatland restoration therefore benefits both climate resilience and carbon storage. Tree and hedgerow planting and catchment-sensitive farming can have benefits for increasing climate resilience (e.g. flood prevention) and biodiversity, as well as carbon sequestration. However, careful planning about species mix, location and management is necessary to ensure such benefits are maintained over the long-term despite a changing climate. Policy therefore needs to be designed with future climate risks to the natural carbon stores fully incorporated to ensure that carbon sequestered into UK land is maintained permanently.

- **Maintaining a resilient power system.** Access to reliable and plentiful electricity is essential to the functioning of the UK's economy and society. Far-reaching changes in the supply, use and management of electricity are required to reach Net Zero. The growing dependence of other systems on electricity and the move towards an energy system with high levels of variable renewables highlights the importance of considering changing climate hazards as part of diligent planning of this Net Zero electricity system – with the consequences of failure more acutely felt by the more vulnerable in society. Much of the UK's Net Zero electricity system is yet to be built and must be designed to be resilient to the weather and climate conditions expected in the future to maintain security of supply. Continued changes in UK climate over the coming decades are inevitable. These climate changes will create risks across society and need proactive adaptation actions to minimise impacts on people and ecosystems. Without considering adaptation the achievement of Net Zero will be at risk. This large investment into new assets for the electricity system presents an opportunity to simultaneously reduce emissions and ensure that the system is sufficiently resilient to future climate conditions.

- **Decarbonisation of the UK's building stock.** Action to reduce emissions from buildings, in particular improvements to fabric efficiency, can also make them more resilient to future changes in climate (e.g. more frequent and intense heatwaves) if designed and implemented well. Buildings should be warm in the winter and cool in summer. Without consideration of future climate when undertaking retrofit programmes, emissions reduction measures, such as increasing the energy efficiency of homes, may inadvertently increase the risk of overheating in buildings and worsen indoor air quality. The Government's plans for reducing emissions from buildings do not yet adequately include adapting to future overheating to minimise the risk of unintended consequences for adaptation efforts.

We will provide an updated assessment of progress reducing emissions in summer 2023.

Embedding and integrating Net Zero and climate adaptation properly across the policy landscape is vital to the delivery of the Government's Net Zero Strategy. The Committee will provide an updated assessment of progress in reducing greenhouse gas emissions in summer 2023.

Some risks to the UK from climate change overseas require a coordinated global response to address.

CCRA3 identified risks arising from climate change occurring outside of the UK as well as domestically. Where these 'international' risks are relevant to the adaptation areas, they are covered within the chapters of this report. For example, risks to UK food availability, safety, and quality from climate change overseas is integrated within Chapter 4 (Food security). However, there is an additional set of international risks and opportunities identified that don't clearly map to specific chapters of this report (Box 1.8).

Box 1.8
Complex and cross-cutting risks from climate change overseas requiring a global response

While many of the international risks to the UK identified in CCRA3 have been integrated into the report chapters, the following international risks are too closely interconnected with multiple systems and the UK's overall economy and foreign policy positions to be isolated within a single chapter:

- Risks and opportunities to the UK from climate-related international human mobility (ID3).
- Risks to the UK from violent conflict overseas resulting from climate change (ID4).
- Risks to international law and governance from climate change that will impact the UK (ID5).
- Systemic risks arising from the amplification of named risks cascading across sectors and borders (ID10).

Source: CCC (2021) *Independent assessment of UK climate risk.*

An effective international climate policy, alongside domestic efforts, is a key part of how the UK tackles these risks.

These risks arise from the complex interactions of multiple global systems and norms. The UK, by itself, has only limited levers available to reduce its exposure and vulnerability to these risks as they fundamentally require a sustained global effort to address them, which the UK must be part of. It is only by an effective international climate policy to both support global emissions reductions and increased efforts to adapt to climate impacts across the world that the UK can reduce its own exposure to these risks.

In December 2022, the Committee published its updated view on the priorities for the UK's international climate policy following the 27th meeting of the Conference of Parties (COP27) to the United Nations Framework Convention on Climate Change (UNFCCC).[18] COP27 achieved some important steps for supporting efforts to deal with global climate impacts (Box 1.9).

Box 1.9
The COP27 outcome on support for climate impacts

COP27 agreed the following:

- **Funding.** A fund will be established to respond to Loss and Damage, as part of a wider suite of new funding arrangements. Also, a Transitional Committee was set up to make recommendations on operationalisation of the fund for consideration at COP28.
- **Informing funding decisions.** The UNFCCC will publish a synthesis report on existing and innovative sources of funding for Loss and Damage in 2023. The Glasgow Dialogue on Loss and Damage will be extended to 2024.

- **Operationalisation of the Santiago Network.** The Santiago Network will have a hosted secretariat, an Advisory Board and a network of member organisations, bodies and experts that can provide technical assistance relating to Loss and Damage.
- **Framework to be developed for Global Goal on Adaptation.** Negotiators continued to progress discussions around defining and operationalising the global goal on adaptation. This workstream aims to improve understanding on levels of adaptation action, resilience and vulnerability to climate change around the world.
- **Food.** COP27 acknowledged the impacts of climate change on global food security for the first time, highlighting the importance of safeguarding food supply.
- **Health.** The COP27 cover decision acknowledged the human right to a clean, healthy and sustainable environment, as recently recognised by the UN.

Countries also pledged money for Loss and Damage and adaptation, and a number of initiatives made progress:

- **Global Shield against Climate Risks.** Launched by the German G7 Presidency in consultation with the V20 group of vulnerable countries. The initiative has received over €200m in funding from Germany, Denmark, Canada, the US, Ireland and France and aims to provide climate risk finance and disaster preparedness solutions that can be rapidly accessed in emergencies.
- **Other pledges.** Funds were also pledged by Scotland, Belgium, New Zealand, Austria and the UK for general Loss and Damage support, the Santiago Network and early warning systems.
- **Adaptation funding.** The UK announced a tripling of adaptation finance on 2019 levels by 2025 within existing ODA budgets and a £200 million contribution to the African Development Bank's Climate Action Window. The EU and US announced €1 billion and $150 million respectively for African adaptation and resilience programmes. New Adaptation Fund pledges and contributions totalled $230 million, down from $365 million at COP26.
- **UN Race to Resilience.** The UN R2R initiative launched a Data Explorer to boost transparency and accountability for their partner organisations' efforts to improve resilience.

Source: UNFCCC (2022) *Funding arrangements for responding to loss and damage associated with the adverse effects of climate change, including a focus on addressing loss and damage.*

We set out our priorities for the UK's international climate policy in a briefing after COP27.

Our identified priorities for UK actions were:

- **Defining the UK's role.** The delayed 2030 Strategic Framework (the Government's vision for the UK's long-term international role tackling climate change and biodiversity loss) is an opportunity to set out the UK's leadership role in helping the world achieve the goals of the Paris Agreement.
- **Championing international ambition.** At COP27, the UK negotiated as an individual party for the first-time following departure from the EU and holding the COP Presidency for COP26. The UK should continue to champion high climate ambition and the promising initiatives begun in Glasgow (COP26). The UK should also publish a full stocktake of these initiatives and ensure it defines its commitments under the pledges, such as the Global Methane Pledge.
- **Mobilising finance.** As a major finance centre and sponsor of the multilateral development banks, the UK should pay particular attention to its positions on mobilising finance, which are vital to global success on climate change and how it contributes to future Just Energy Transition Partnerships.

- **Delivering the UK's contributions to the Paris Agreement.** The UK must implement its Net Zero Strategy to deliver its legislated domestic targets and international commitments. It must strengthen its response on climate adaptation. This must be matched by maintaining strong support for implementation internationally to cut emissions, to adapt and to deal with climate losses and damages.

The UK provides support through its official development assistance (ODA) to countries which are vulnerable to climate change. For example, the UK's Conflict, Stability and Security Fund (CSSF) aims to build resilience and stability overseas, reducing national security threats to the UK. Under the UK's international climate finance commitments, £1.5 billion has been pledged by 2025 for adaptation.

Cooperation through avenues beyond the international climate policy framework is also critical.

Cooperation through other fora outside of the UNFCCC are also important for helping to tackle these international climate risks. Bilateral and multilateral engagements with organisations such as UNHCR (the UN Refugee Agency) and the International Organisation for Migration (IOM) can support international cooperation efforts to respond to climate-related migration and better protect migrants. Similarly, political engagement with the UN's peacebuilding work can support the peacebuilding agenda to protect UK interests and mitigate the impacts of violence or conflict. Engaging with multi-lateral international efforts to reduce climate (and other) risks will also support overarching international law and governance structures.

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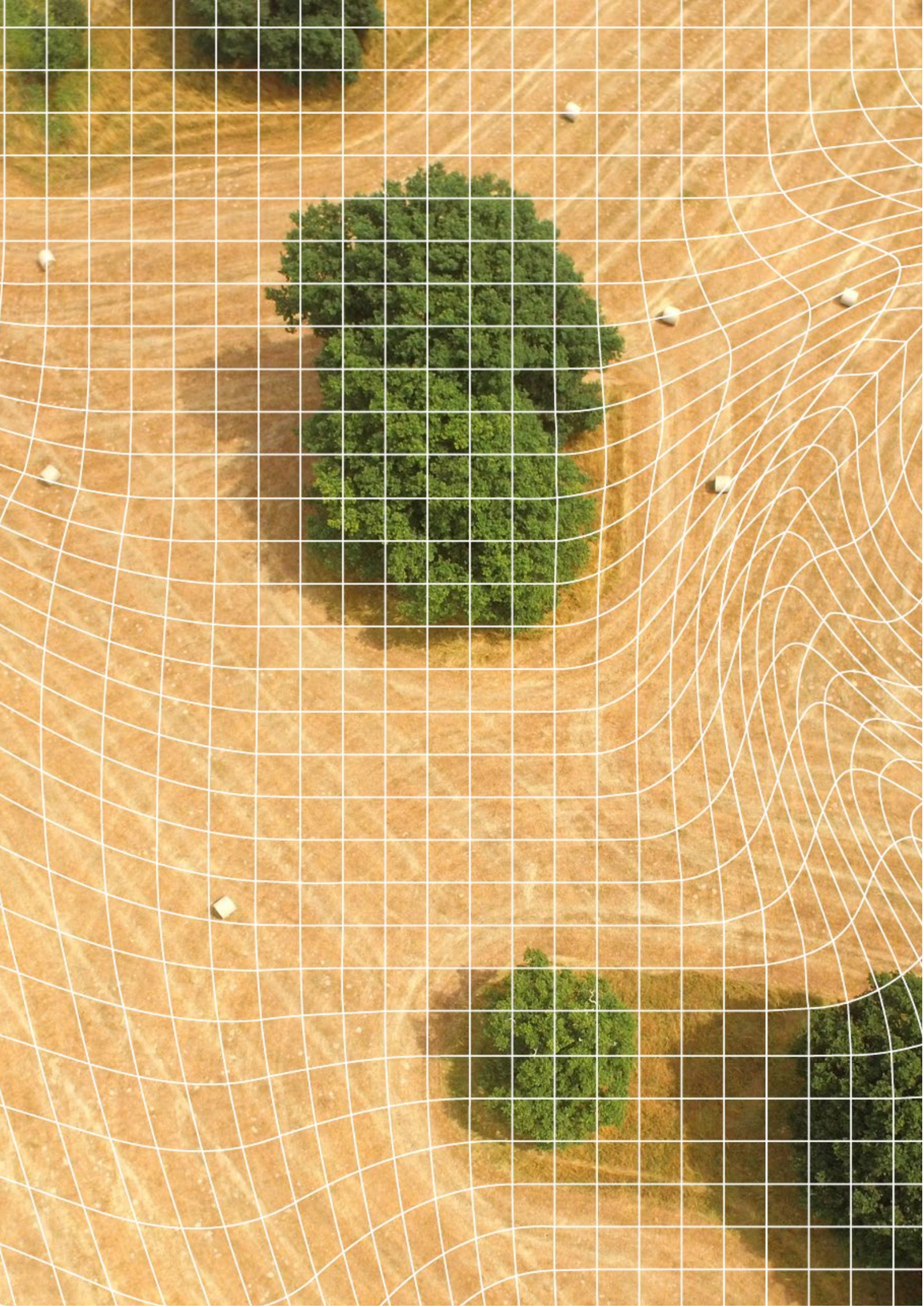


Chapter 2

Nature

Table 2.1
Progress summary – Nature

	Delivery and implementation	Policies and plans	Summary
Outcome 1: Terrestrial habitats are in good ecological health	Insufficient progress	Limited policies and plans	• Most of the available indicators that monitor the vulnerability of terrestrial habitats to climate change show no progress, or a continued decline. • Environment Act commitments (Environmental Improvement Plan update, Environmental Targets), together with further information on the Environmental Land Management Scheme are welcome. However, there remains a concerning lack of detail on the impacts of a changing climate on nature. Several other key policies and implementation plans to support adaptation in the natural environment are also still outstanding. Defra has yet to set out how the numerous polices for the environment, agriculture and planning, will fit together under the Environment Act (2021) targets.
Outcome 2: Freshwater habitats are in good ecological health	Insufficient progress	Limited policies and plans	• The majority of surface water bodies in England are in very poor condition, while abundance data for freshwater species indicate populations remain at low levels over the long-term. • The River Basin Management Plans' update has incorporated climate impacts under 2°C and 4°C scenarios, as well as the effects of other external pressures (e.g. pollutant emissions). Building resilience to higher water temperatures is a key principle under the revised Plans, which include a summary of actions which should reduce vulnerability to this risk although their scale and rate of deployment by both public and private actors is not clear.
Outcome 3: Marine and coastal habitats are in good ecological health	Mixed Progress	Limited policies and plans	• Indicators available suggests some progress towards meeting this outcome. However, there are gaps in the range of datasets required to support a comprehensive assessment. • The Government has met its commitment to complete the full series of England Marine Plans by 2021though delays in responding to several marine-based consultations launched in recent years will hinder progress. The publication of the monitoring programmes under the Marine Strategy: Part Two will provide more evidence to support the 2024 assessment of progress towards achieving Good Ecological Status (GES) within the UK Marine Strategy area.

Relevant risks from CCRA3:
Risks to terrestrial habitats and species (N1, N2, N3; Risks to soils (N4); Risks and opportunities for natural carbon stores, carbon sequestration and GHG emissions (N5:) Risks to freshwater habitats & species (N11, N12); Opportunities to freshwater habitats and species (N13); Risks to marine habitats and species, and fisheries (N14, N16); Opportunities to marine habitats and species, and fisheries (N15) Risks and opportunities to coastal habitats and species (N17); Risks and opportunities to landscape character (N18).

This chapter covers adaptation to climate change for habitats and species native to England's terrestrial, freshwater, marine and coastal environments.*†

* England is a highly modified country with very limited wilderness left; as such, the "nature" here refers to non-human elements of land and seascapes.

† In a change to previous progress reports, farmland habitats are now assessed within the outcome 'Terrestrial habitats are in good ecological condition'.

Thriving natural ecosystems that can prosper despite climate change, are important both for the intrinsic value of nature, but also for the range of benefits that nature provides (often implicitly) to people and the UK economy (e.g. pollination and improved flood mitigation). If natural ecosystems are damaged by climate change, other societal goals (including climate adaptation, nature recovery and net zero) will increasingly be jeopardised.

Across England, nature will be impacted by climate change. Thriving natural ecosystems and species are fundamental to a properly functioning society and economy.

England's nature can be impacted by a wide variety of climate-induced changes, as ecosystems and the species within them are generally adapted for a particular climatic niche. For example, changes to average temperatures, average rainfall, and temperature extremes, as well as increased flood and drought occurrences can affect the viability of ecosystems around England. Degraded and fragmented ecosystems are more vulnerable to climate change as they limit the ability for species to move to their preferred climate niche.

In the UK, nature and farming policy is largely devolved. Defra is responsible for the key levers that relate to terrestrial, freshwater, marine and coastal habitats, and species in England. The current focus of policymaking is dominated by the replacement of the EU's Common Agricultural Policy with an English alternative. This will seek to move away from payments linked solely to the area of land in agricultural production and instead to offer 'public money for public goods', which helps support England's nature and climate commitments.

The fundamental underpinning that nature has on many parts of society and the economy means there are key links with climate adaptation covered in this chapter and elsewhere in the report (Box 2.1). This is particularly the case for climate risks to farming, forestry and fishing, as economic activities dependent on large-scale rural land, water and sea use require healthy and functioning ecosystems; these are covered in Chapter 3.

Box 2.1
Inter-relationships of nature with other parts of this assessment

The systems within this report where these links to nature are most pronounced include:

- **Working Land and Seas.** Around 70% of land in England is used for agriculture. Land use change and pollution associated with agriculture, forestry and fisheries are drivers of biodiversity loss, while water abstraction by agriculture can also undermine the health of ecosystems and their ability to function.
- **Food.** The food system depends on a healthy, functioning natural environment. This includes diverse and abundant assemblages of biodiversity, which can pollinate crops and control pests. For example, diverse and abundant soil microbiota can enhance soil fertility, which supports crop yields and healthy grasslands.
- **Water.** Measures to improve the condition of nature support its capacity to supply clean water for consumption and use by the public and industry (e.g. improved water supply and filtration benefits through peatland restoration). However, overuse and pollution of water by society can harm nature.
- **Health and Community.** Nature helps to keep us healthy in many ways. Trees and hedgerows can improve air quality; access to nature can support mental health; certain plant species can absorb harmful minerals such as lead; and biodiversity has a crucial role to play in mitigating the threat of pests and diseases.
- **Flooding, Towns and Cities, and Infrastructure.** Ensuring adequate adaptation plans are in place using nature-based solutions (NbS), such as riverine tree planting, re-meandering rivers, and green/blue infrastructure such as urban ponds help increase infiltration of water, reducing run-off and downstream flooding that can impact infrastructure and urban areas.

1. Monitoring progress towards climate resilient nature

Healthy, diverse and well-connected ecosystems are less vulnerable to climate impacts because healthy biodiversity underpins ecosystem functionality, while connectivity allows species to migrate in response to environmental change. To increase climate resilience, it is vital to improve ecosystem health by protecting, restoring and connecting habitats, improving genetic and species diversity, and reducing the other pressures on ecosystems such as pollution, over-exploitation, and invasive species.

It is important to protect, connect and restore habitats, which supports genetic and species diversity, and can help build resilience to the impacts of climate change.

The Government has committed to halting the decline in species abundance and protecting 30% of land and sea by 2030. This will be supported by numerous statutory measures required under the Environment Act, including ambition to restore and create wildlife-rich habitats. To achieve this, nature recovery strategies must consider the impacts of changes in average climate conditions and climate extremes expected over the coming decades.

We focus our assessment on three biome-based outcomes needed to deliver this goal (Figure 2.1):

- **Terrestrial habitats are in good ecological health:** These include natural and semi-natural habitats (e.g. native woodland, scrub, grassland, heath); urban nature (blue and green space such as urban ponds, parks, gardens, allotments), farmland (arable, pasture, hedgerows, field margins), and the soils underpinning these habitats.

- **Freshwater habitats are in good ecological health:** These include rivers, streams, canals, ditches, lakes and ponds.

- **Coastal and marine habitats are in good ecological health:** These include saltmarshes, sand dunes, maritime cliffs, vegetated shingle, beaches, lagoons, estuaries, mudflats, reefs, seagrass, kelp, and marine sediments in both shallow and deep waters.

We assess the climate resilience of nature using a headline outcome that looks at overall ecological health. Supporting the delivery of this are various sub-outcomes, and enablers such as funding, skills and monitoring.

These outcomes focus on overall habitat ecological health, as habitats that are in good ecological health are more resilient to climate change. Underpinning these outcomes, we also consider progress towards certain sub-outcomes associated with reducing the vulnerability of nature to climate change. These sub-outcomes are primarily based on the principles set out in the Lawton Review (2010).[1]

- **Larger and more connected habitats.** Larger areas of habitat supporting larger populations of species, tend to be less vulnerable to climate stress. Greater connectivity of habitats enables species to track their preferred ecological niche as the climate changes.

- **Diverse habitats and species.** Diverse ecosystems with healthy populations of species that have high genetic diversity are better able to buffer and potentially adapt to changing pressures on their environments, including climatic impacts.

- **Protected and resilient habitats.** Protecting and restoring natural and semi-natural habitats, including by ensuring effective and sustainable management and monitoring, is vital for supporting the biodiversity that underpins resilience to environmental pressures such as climate change.

- **Reduced pressure on nature.** External factors that reduce resilience to climate change include: pollution; habitat loss; degradation and fragmentation; spread of pests, disease and invasive species; overuse of natural resources; and coastal squeeze from sea-level rise.

- **Use of nature-based solutions (NbS) for adaptation**.* NbS such as riverine planting or peatland restoration can help build nature's resilience to climate change impacts by delivering actions to protect, sustainably manage and restore natural or modified ecosystems.†

Managing external pressures that compromise the ability of ecosystems to function efficiently will be key to building the resilience of nature.

To support the delivery of these outcomes, various enabling factors are needed across the private and public sectors. Key enablers we identify are:

- **Funding and investment.** Delivering the outcomes listed above will require funding, such as for nature recovery action and monitoring. The benefits of adaptation flow to many different beneficiaries and can be difficult to quantify, so sustained public funding is vital. However, as public funding is likely to fall short of needed levels, accessible private investment streams will also be needed.

- **Skills and workforce.** More training is needed to build a bigger, more skilled workforce to protect and restore nature. This includes help with learning new skills, training and information to implement sustainable land/sea management and ecosystem restoration approaches and to measure and monitor the health of the ecosystems and their biodiversity.

- **Engagement and education.** Public understanding of the value of nature and the innumerable benefits it provides is vital to secure the acceptance and adoption of measures to protect and restore it.

- **Data and monitoring.** Improved data for measuring and monitoring ecosystem health across land and seascapes are needed to track if outcomes are being achieved. In particular, more robust and frequently collected indicators across a wider range of species and ecosystems are needed to monitor progress in reducing climate change risk, and the effectiveness of different interventions.

- **Regulation.** Effective and enforced planning regulation is important to protect against new developments resulting in habitat and biodiversity loss and to contribute to improved ecological condition.

- **Research.** More research is needed on the effectiveness of different interventions for restoring ecosystem health and improving climate resilience. Areas where this is particularly critical include: identification of climate-resilient native species; mapping of future UK wildfire risks; effectiveness of NbS for adaptation; impacts of changing ocean temperature and chemistry; and species dispersal projections.

- **Governance and policy co-ordination.** Achieving climate resilience for nature in England depends on the behaviour of natural resource managers such as landowners, farmers, foresters, fishermen and marine managers. These actors need to be listened to, supported and incentivised to adopt more sustainable practices, such as peatland restoration and the use of natural flood management techniques.

* Not included in the Lawton Principles.

† Please see the CCC 'Investment for a well-adapted UK' report for a definition of nature-based solutions.

Effective policy and governance, through practical and financial support coupled with consistent standards and regulations can help influence shifts to more resilient practices.

Policies and plans needed to build the resilience of nature to the impacts of changing climatic conditions include:

There are numerous policies and plans relating to the Agriculture Act (2020) and Environment Act (2021) that are needed to help build the resilience of nature to the impacts of climate change.

- **Planning.** Future climate change impacts must be accounted for in all the Government's upcoming action plans and strategies for the environment. The proposed UK Land Use Framework should identify synergies between climate adaptation, climate mitigation, food security, equitable development and nature recovery, and must be aligned with local level strategies. A soil health target should be also included as a priority in the Government's forthcoming Soil Health Action Plan.

- **Agriculture policy update.** Revisions to agriculture policy must consider and support biodiversity and climate resilience. Actions that reduce vulnerability and exposure to climate change across all environmental public good outcomes should be rewarded under the forthcoming Environmental Land Management scheme (ELM).*

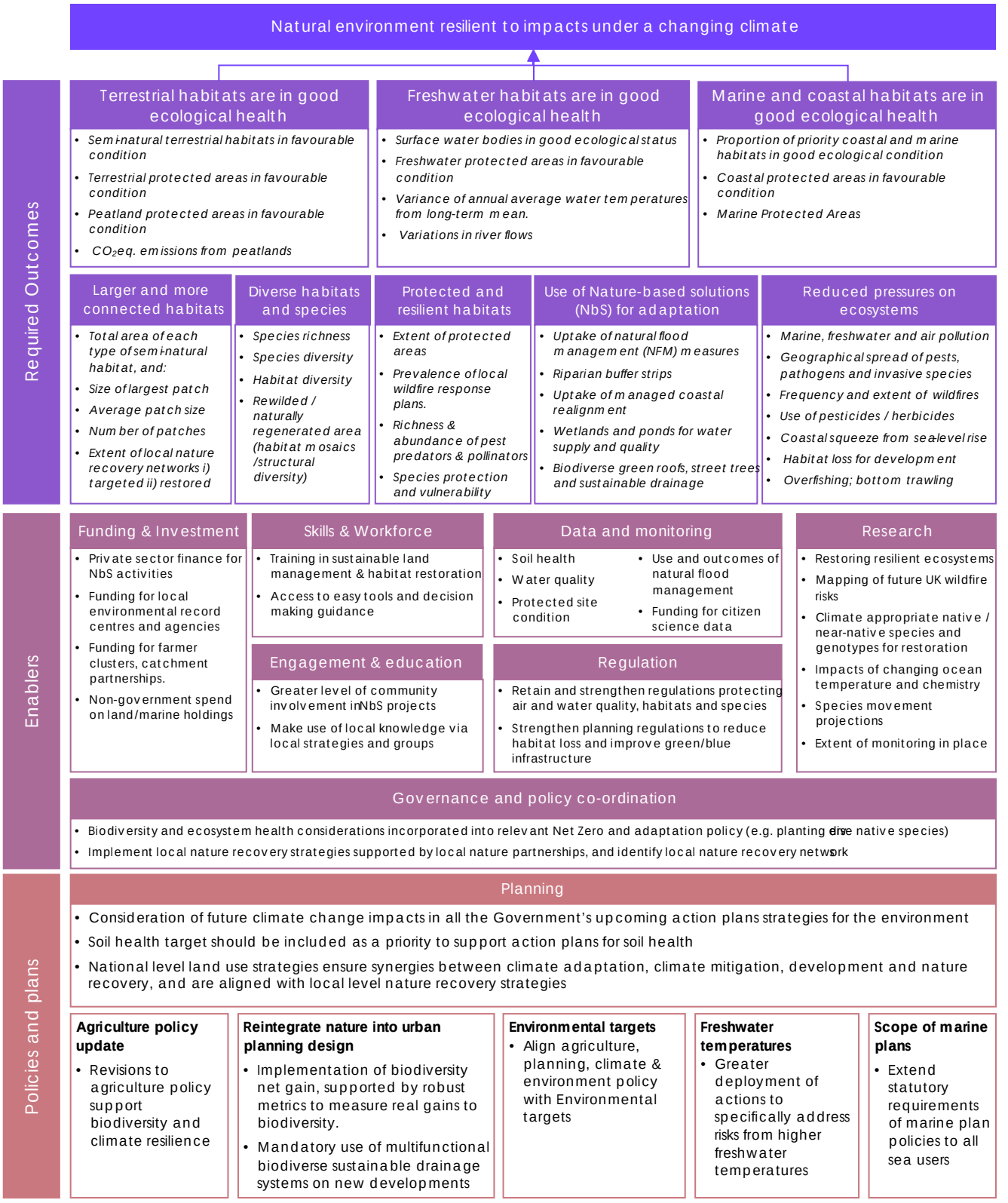
- **Environment Act targets.** The wide-ranging benefits delivered through meeting the proposed outcome-based targets must be clearly linked to the suite of climate, environmental and planning policies that support them.

- **Freshwater and sea temperatures.** There needs to be a clear mechanism to account for the consequences of higher water temperatures and low flows (including drying up) in water bodies for marine and freshwater habitats and species, and for meeting the Water Framework Directive (WFD) targets.

- **Scope of marine plans.** The statutory requirements of marine plan policies should be extended to the decisions of public and private organisations. At present, only public authorities are duty bound under law to apply the plan policies to their decisions. This leaves a significant gap in the protections they are designed to provide.

* Environmental public good outcomes refer to the Government's objectives to protect, improve and expand the natural environment to ensure it continues to provide the market and non-market goods and services that are essential to society.

Figure 2.1 Monitoring map for nature



Source: CCC analysis.
Notes: Italicised text indicates suggested measures for each outcome.

It is currently difficult to assess progress towards achieving climate resilience for nature due to the complexity of the natural world as well as wide-ranging data gaps.

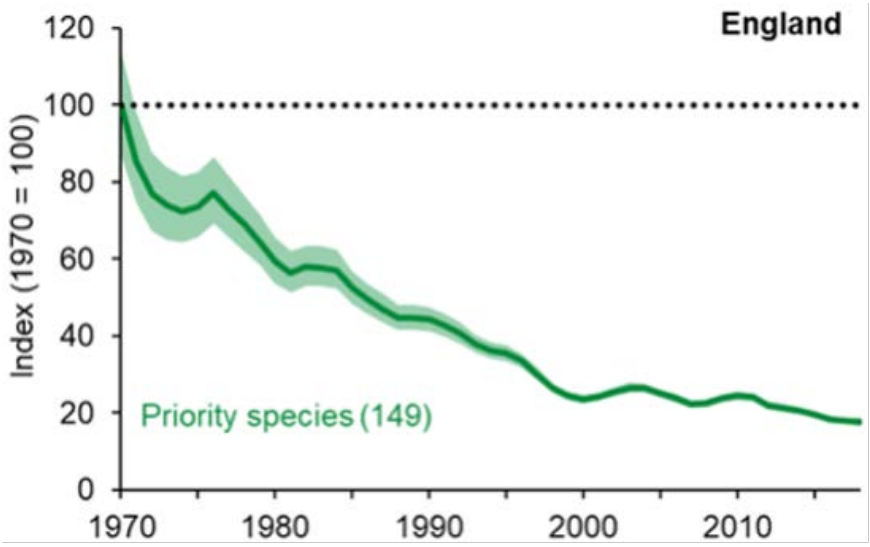
Quantitative measures of progress towards climate resilience outcomes for nature have several methodological challenges that need addressing. These include: technological challenges of measuring biodiversity and other metrics of ecosystem health above and below ground; having to rely on proxy indicators for some adaptation outcomes; and the lack of long-term, consistent datasets. The below assessments of progress are therefore based on a limited set of fragmented datasets whilst we await more detailed indicator development and monitoring. We will continue to update the monitoring map and indicators as more data become available. The outcomes and indicators are therefore likely to change over time as data improves. In this section, we summarise a selection of relevant and available indicators under each outcome. They were chosen based on a range of criteria including those with the most comprehensive datasets and/or those that represent useful key proxy indicators conveying trends within the outcomes.

There has been insufficient progress in ensuring terrestrial habitats are in good ecological health, with many indicators showing worsening trends since the last Progress Report.

Indicators suggest on average the health and resilience of nature across England continues to decline. Indicators of the overall health of nature in England (a key proxy of its climate vulnerability) necessarily aggregate across lots of different species and habitat types. The abundance of priority species indicator shows a large long-term decline over many decades (Figure 2.2).* Between 1970 and 2018, the average abundance of the 149 species of conservation importance for which abundance trends are available fell by over 80%.[2] The persistent, long-term decline will make meeting Government's statutory target to halt the decline in species abundance by 2030 increasingly challenging.

We document indicators of changing resilience for each of our identified adaptation outcomes in turn in the following sub-sections.

Figure 2.2 Abundance of priority species in England, 1970 to 2018



Source: Defra (2023) *England Biodiversity Indicators.*

* 'Priority species' are those listed under Section 41 of the Natural Environment and Rural Communities (NERC) Act in England, Environment (Wales) Act 2016 section 7, Northern Ireland Priority Species List, or Scottish Biodiversity List. For all four UK countries combined there are 2890 priority species. In England, there are 56 habitats and 943 species.

(a) Outcome 1: Terrestrial habitats are in good ecological health

This outcome is scored as **insufficient progress.** Available indicators generally show no change since the last progress report or a continued decline. This suggests measures delivered through government policies (including the 25-year Environment Plan) have had limited or no impact on managing pressures on biodiversity to date.

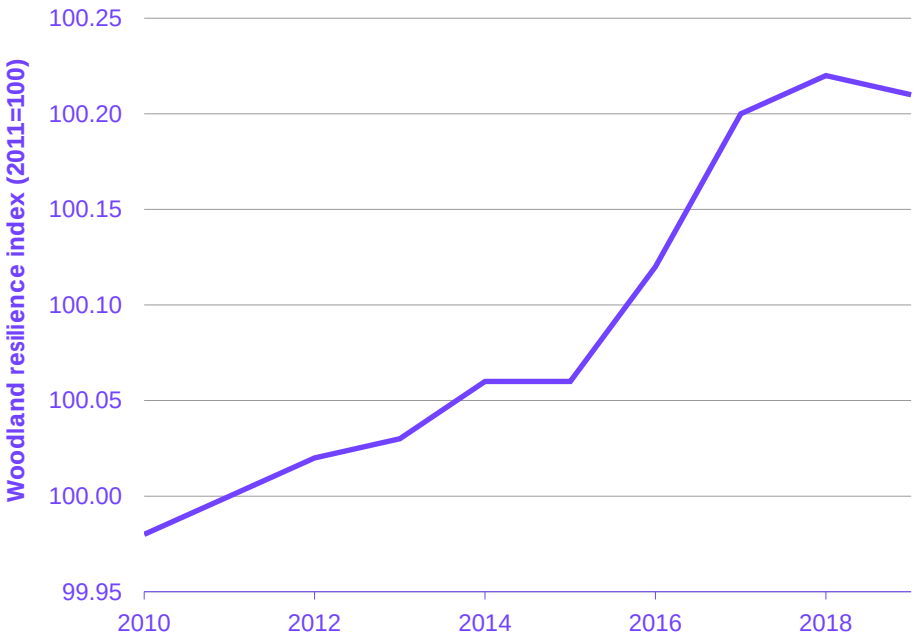
Indicators suggest measures delivered to date through government policies (including the 25-year Environment Plan) have had limited or no impact on managing pressures on biodiversity.

(i) Outcome 1a: Larger and more connected habitats

- **Indicators for the existence of larger and more connected habitats show a mixed picture.** There has been an increase in the connectivity of forests and woodlands in England between 2011 and 2019 (Figure 2.3), although progress has largely flatlined in recent years.[3] The growth in terrestrial protected areas has also flatlined in the UK and pollinator species are increasingly restricted in their distribution.[4,5]

- **The proportion of green and blue space in urban areas is declining.** The percentage of natural urban surfaces has decreased slightly from 51% to 49% between 2016 and 2022.[6] The Environmental Improvement Plan includes a commitment that the public should be able to access green space within a 15-minute walk from their home (see also Chapter 9).

Figure 2.3 Measure of woodland resilience to climate change



Source: Forestry Commission (2022) *Key performance indicators; Report for 2021-22.*
Note: Indicator based on the size and spatial configuration of woodland patches within the landscape.

(ii) Outcome 1b: Protected and resilient habitats

- **The state of priority habitats for biodiversity in England has declined recently.** Priority habitats are those identified as being the most threatened and requiring conservation action.

Data suggest 66% of all priority habitats* are either in favourable condition or unfavourable but recovering; from 2016 to 2021, the proportion of habitats in these categories decreased by 2% to total 1.23 million hectares.[7]

- **The proportion of terrestrial Sites of Special Scientific Interest (SSSIs) in England classed as 'recovering' has dropped.** Despite a 1% increase (to 26%) in sites classed as favourable from 2016 to 2022, there has been a 7% fall in areas classed in unfavourable recovering condition over the same period.[8]

(iii) Outcome 1c: Diverse habitats and species

Data on bird and pollinator species show overall declines in abundance, though some bat species have seen increases in abundance due to stricter protections and milder climates.

Data on species diversity is not reported as part of national biodiversity statistics so we use composite abundance indicators for groups of species as proxies.

- **Abundance indicators for terrestrial bird and pollinator species indicate long-term declines in most cases.** Trends for woodland and farmland bird species indicate steep long-term declines (down 27% and 58% respectively since 1970), while bird species at risk of extinction in Great Britain has been steadily increasing from 36 species in 1996 to 70 in 2022.[9,10] Butterfly numbers on farmland in England show little or no overall change since 1990, whereas the long-term trend for butterflies in woodland is significantly downward (reducing 60% from 1990 to 2021).[11]

- **Some bat species may have benefited from shifting climatic conditions**. Abundance indicators for bats show a significant improvement in the last two decades (up 46% between 1999 and 2020). This is thought to be due to stricter protections and milder climates.[12]

(iv) Outcome 1d: Reduced pressures on ecosystems

Indicators to assess pressures on terrestrial ecosystems show a mixed picture, with wildfire incidents increasing over time but the number of established invasive non-native species has stabilised.

- **Pressures on ecosystems from wildfires continue to rise.** Despite year-to-year variation, there has been an overall rising trend in the total number of wildfire incidents in natural habitats across England (Figure 2.4).[13] In 2012-13, there were 6,460 incidents compared to 14,176 in 2020-21, although annual frequency remains below previous peak years; 2009-10 to 2011-12 averaged around 20,000 incidents per year. Most incidents occurred on agricultural land (arable and improved grassland) and in broadleaved woodland. More recent data for the UK showed 2022 to be a record year for the number of fire incidents (155).[14,†] Weather conditions are likely to have had a significant impact on the likelihood and severity of wildfire incidents in England.[15] The CCRA3 Independent Risk Assessment stated that projections of drier springs and summers with increased soil moisture deficits would suggest an increase in the frequency and areas susceptible to wildfires.[16 ‡] Despite this, England does not have a strategy to identify and mitigate risks of wildfire in England.

- **Invasive non-native species (INNS) established in terrestrial habitats has stabilised** for those established in 10% or more of Great Britain's terrestrial environments since the early 2000s (62 recorded) but remains up over the long term (28 recorded over the 1960-69 period).[17]

* Indicator covers all terrestrial habitats, including freshwater and coastal.

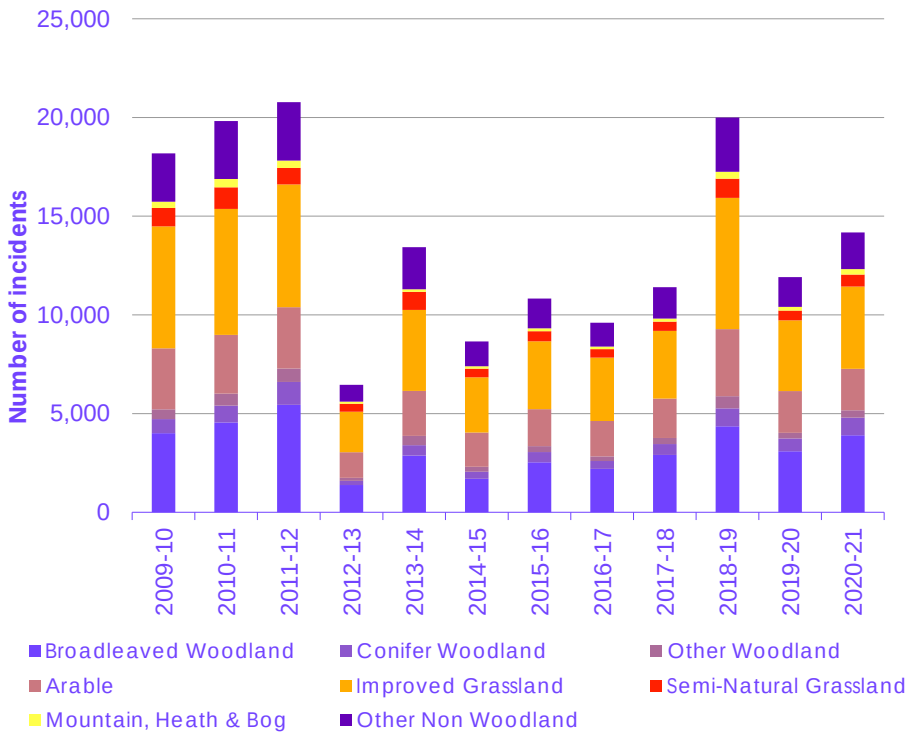
† This dataset is sourced from the European Forest Fire Information System (EFFIS). It is important to note that the EFFIS data is calculated by calendar year whereas the Forestry Commission data is presented by financial year.

‡ CCRA3 refers to the Third Climate Change Risk Assessment.

(v) Outcome 1e: Use of NbS for adaptation

We do not currently have access to datasets required to support measurement of progress against this outcome.

Figure 2.4 Total number of wildfire incidents in England per annum, split by land cover class.



Source: ADAS for the CCC (2023), *Research to update indicators which monitor progress in adaptation in England.*

(b) Outcome 2: Freshwater habitats are in good ecological health

This outcome is scored as **insufficient progress**. Indicators available show most surface water bodies in England are not in a good condition, although abundance data for freshwater species show populations have remained stable over the long-term.

There is insufficient progress in ensuring freshwater habitats are in good ecological health. The indicators show highly variable progress towards outcomes.

(i) Outcome 2a: Larger and more connected habitats

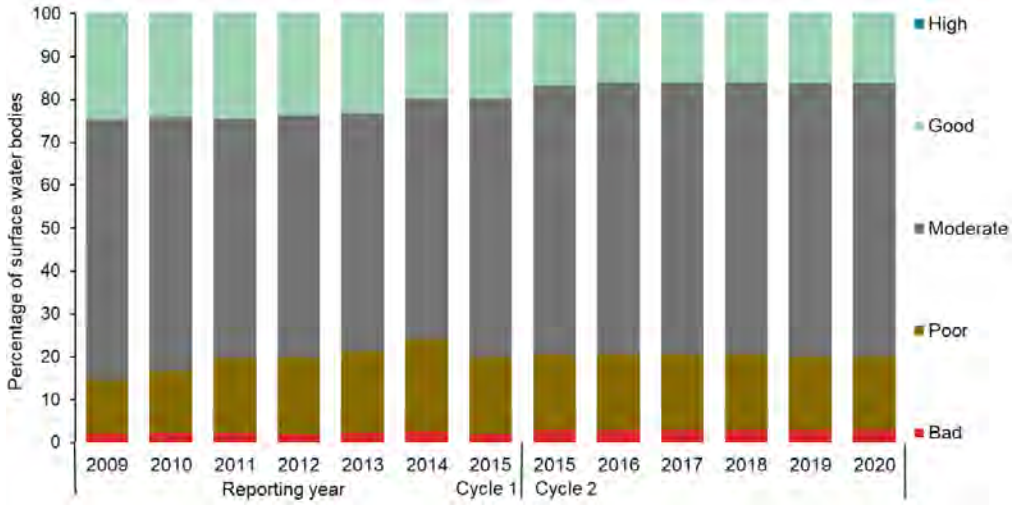
We do not currently have access to datasets required to support a robust assessment of progress against this outcome.

(ii) Outcome 2b: Protected and resilient habitats

- **Proportion of surface water bodies in England in good condition remains very low.** In 2020, 16% of surface water bodies were assessed under the Water Framework Directive (WFD) as being in high or good status, compared with 25% in 2009 (Figure 2.5).[18]

The slow progress will put increasing pressure on the Government's ability to meet requirements under the WFD for each surface water body* to aim to achieve or maintain good ecological status by 2027.† Meeting its statutory targets for water will improve biodiversity by reducing damage to local ecology, and pressures on species and habitats, as well as increasing the resilience of England's water supply to drought.

Figure 2.5 Status classifications of surface water bodies in England under the Water Framework Directive



Source: Defra (2020) *Biodiversity indicators 2020 update.*
Notes. 1. Based on the numbers of surface water bodies classified under the Water Framework Directive (WFD) in England. 2. Surface water status is a composite measure that looks at both the chemical status and the ecological (including biological and habitat condition) status of a water body. The classification scheme for surface water ecological status includes five categories: high, good, moderate, poor and bad. 'High status' means no or very low human pressure. 'Good status' means a 'slight' deviation from this condition, 'moderate status' means 'moderate' deviation, and so on. 3. In 2016, the Environment Agency moved to a triennial reporting system therefore the classifications for 2016 have been carried forward for both 2017 and 2018. The most recent classification was in 2019 and therefore these classifications have been carried forward to 2020.

(iii) Outcome 2c: Diverse habitats and species

- **Freshwater bird species' numbers have remained relatively stable since the 1970s.**[19] Freshwater habitats (including rivers, lakes, ponds, reedbeds, grazing marshes and lowland raised bogs) provide important habitats for breeding wetland birds.

Progress has been made in delivering the Environment Agency's Restoring Sustainable Abstraction programme. However, the number of INNS recorded in freshwater environments has increased significantly since the 1960s.

(iv) Outcome 2d: Reduced pressures on ecosystems

- **INNS have become more prevalent in freshwater habitats over the long-term.** Data shows INNS established in 10% or more of Great Britain's freshwater environment have increased from four over the 1960-69 period, to 14 in 2022, although recorded numbers have stabilised in the last decade.[20]

* Other than artificial or heavily modified water bodies.

† Target contained in the Water Environment (Water Framework Directive) (England and Wales) Regulations 2017.

- **Pollutant loads entering waters in England have declined significantly over the last decade.** Despite significant year-to-year fluctuations, riverine inputs of both selected metals and nutrients have declined significantly over the 2008 to 2019 period.[21] The total number of serious pollution incidents to water in England has fallen by 62% between 2001 and 2020.

- **Progress has been made in supporting the sustainable abstraction of water from the environment.*** Through the Restoring Sustainable Abstraction (RSA) programme, the Environment Agency has been investigating and changing permanent abstraction licences that cause environmental damage, reduce biodiversity and undermine ecosystem resilience to climate change. Since its launch in 2008, 88% of the RSA Programme had been delivered, equating to changes to 324 abstraction licences.

(v) Outcome 2e: Use of Nature-based solutions (NbS) for adaptation

We do not currently have access to datasets required to support measurement of progress against this outcome.

(c) Outcome 3: Marine and coastal habitats are in good ecological health

This outcome has been scored as **mixed progress.** While there has been some progress towards making marine habitats more resilient, the proportion of coastal habitats classed as in favourable or recovering condition has declined. Further marine indicators are expected to be developed under the Environmental Improvement Plan over the coming years.

There has been mixed progress on marine and coastal habitats being in good ecological health, with a large increase in the extent of marine and coastal protected areas but a decline in the condition of protected coastal sites.

(i) Outcome 3a: Larger, more connected habitats

We are unable to assess progress against this outcome at present due to limitations on the data we currently have access to.

(ii) Outcome 3b: Protected and resilient habitats

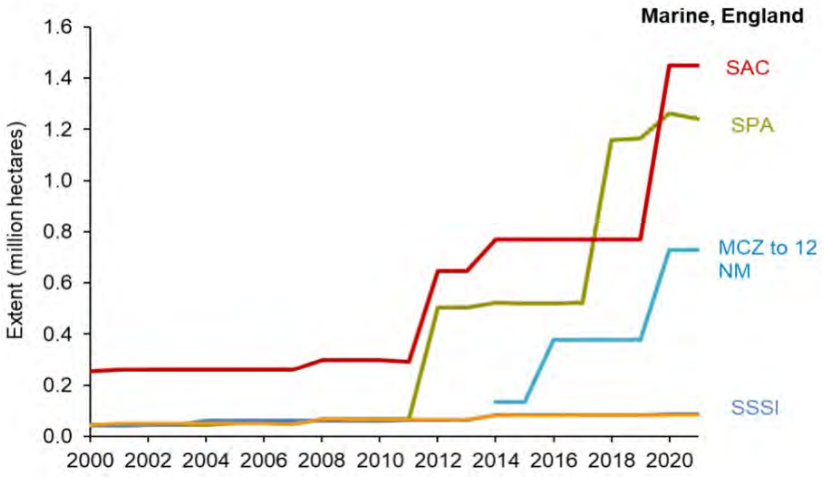
- **Extent of protected sites at sea in England has increased over the last five years**. The extent of sea around England protected through national and international protected areas increased by 83% over the last five-years to represent 47% of inshore waters (Figure 2.6).[22]

- **There has been a decline in the overall condition of protected coastal sites.** The proportion of coastal SSSIs classed as in 'favourable' or 'unfavourable recovering' condition declined from 96% in 2016 to 91% 2022.[23] This, however, remains relatively high compared to terrestrial and freshwater habitats.

- **Condition of seafloor ecosystems varies depending on habitat type.** The UK Marine Strategy target of 'Good' or 'High' Ecological Status was met for most surveyed locations for seagrass and rocky shore macroalgae, but the target was not met for large areas of saltmarsh and for some soft sediment invertebrate communities.[24]

* The RSA programme looks to review and revise permanent water abstraction licences that have resulted in impacts that undermine the resilience of freshwater ecosystem to climate change.

Figure 2.6 Extent of national and European protected sites at sea in England, by designation



Source: Defra (2020) *England biodiversity indicators 2020.*
Notes: 1. The extent of protected sites is the cumulative area assessed in March of each year shown. 2. Marine sites between mean low water and the 12 nautical mile limit are included; sites beyond 12 nautical miles, in UK waters, are excluded. These are included in the UK indicator on protected sites.

(iii) Outcome 3c: Diverse habitats and species

- **The breeding seabirds index for England shows a long-term increase, although the overall index hides considerable variation in individual species trends.** Seabird populations have been largely stable since the early 1990s, which is around 10% above levels first recorded in the mid-1980s.[25] However, the index contrasts with the UK-wide index (down 24% over the same period), which is largely due to differences in species composition.

There is mixed progress on addressing pressures to marine and coastal ecosystems. Hazardous substances entering the marine environment have reduced, but there has been an increase in INNS and a fall in large fish in the North Sea.

(iv) Outcome 3d: Reduced pressures on ecosystems

- **Declining inputs of hazardous substances to the UK marine environment.** Inputs are down 78% from 1990 to 2019, although there has been a slight increase since 2017 due largely to rising zinc emissions.[26] *

- **INNS established in marine and coastal habitats continue to increase along the British coastline.** Twenty-nine species were recorded in 2010-2019 period, up from two species in the 1960s.[27]

- **Percentage of large fish in the North Sea has fallen.** In 2019, large fish (by weight) in the North Sea survey made up 6% of the weight of the fish community, below the value of 15% recorded in 1983 but above the low of 2% in 2001.[28]

* The indicator covers the combined input of six of the most hazardous substances to the UK marine environment: five heavy metals (cadmium, mercury, copper, lead and zinc) and one organic compound (lindane).

(v) Outcome 3e: Use of NbS for adaptation

We do not currently have access to datasets required to support measurement of progress against this outcome.

(d) Summary of unavailable indicators

There are significant data gaps for many of the indicators needed to measure progress against each of the outcomes. These include, but are not limited to, indicators that measure:

- Pressures on biodiversity, such as overexploitation, habitat change, or pests and diseases.
- Resilience for species, such as genetic diversity.
- Progress related to enablers e.g. skills/workforce, data/monitoring/research.
- Uptake of NbS for adaptation across all headline outcomes.
- Geographic range shifts in communities of species.
- Individual and combined impacts of acidification, temperature and salinity on marine species.
- Changes in pressures on the seabed from human activity (e.g. bottom trawling or litter).

The backlog of delayed environmental policy commitments by Defra is easing, but confirmation on some key policies and actions to support adaptation in the natural environment is still outstanding in many areas. Several of the Government's flagship environmental policy initiatives still lack sufficient detail on how the accompanying actions will consider the impacts of a changing climate in the future.

Progress in policies and plans for terrestrial habitats has been limited. Whilst there have been many recent policy announcements, these typically lack detail on how adaptation is considered.

Greater policy coherence is needed between national and local government departments to integrate biodiversity health into other policy domains including Net Zero, planning, and agriculture, and to integrate consideration of climate adaptation into Local Nature Recovery Strategies. Facilitating Local Nature Partnerships and similar local stakeholder groups can encourage a participatory approach to landscape and seascape planning, which can maximise policy synergies between different goals and help manage trade-offs or conflicts.

Our 2021 Progress Report identified a range of legislation designed to help protect the natural environment in England - several of which contain key mechanisms for reducing climate risks. The current lack of a non-regression commitment within the Retained EU Law (REUL) Bill increases the danger of backsliding on environmental standards.

(a) Outcome 1: Terrestrial habitats are in good ecological health

The score for this outcome has been assessed as **limited policies and plans**. While some key policy commitments have been announced, including several required under the Environment Act, many lack sufficient detail on how climate adaptation will be considered and addressed. Confirmation on several other key policies to support the ecological health (and therefore build the resilience) of terrestrial habitats is also still outstanding, as is implementation in many areas.

Policies and plans announced:

- **Environmental Improvement Plan (EIP) has been published.** In our 2021 assessment, the CCC highlighted the need for the EIP to be strengthened to ensure it included time bound, specific measures, which are more explicitly linked to the delivery of the environmental outcomes. The new Plan includes several ambitious targets, including the "apex" goal of achieving thriving plants and wildlife, plus a target of getting 65-80% of farmers to adopt nature-friendly farming on 10-15% of their land by 2030. If met, this would significantly boost the resilience of terrestrial habitats to climate change, whilst supporting agricultural productivity. However, the EIP is vague on how the policies and investment outlined will meet the ambition of the targets.

- **The Nature Recovery Network (NRN) will support species resilience by encouraging habitat connectivity.** Five landscape-scale projects have been launched in 2023. The Nature Recovery Green Paper outlines initial government plans for meeting the commitment to protect 30% of land and sea by 2030 and halt species loss by 2030. A public consultation on the proposals closed in May 2022, but a government response is still outstanding. Climate adaptation is considered an outcome of the NRNs but is not represented as a key objective. Natural England is leading work

to explore how climate change considerations can be incorporated into the NRN's design, both spatially and as a core principle.

- **Environmental Principles policy statement (EPPS) outlines how five environmental principles should be "interpreted and proportionately applied by government" when making policy**.* The EPPS aims to support policymakers protect and enhance England's nature, within the context of building resilience to biodiversity loss and the effects of our changing climate. However, the links between how the principles will be applied and the consideration of climate change are not clear.

- **More comprehensive details on the Environmental Land Management scheme (ELMS) were published in January 2023.** Climate adaptation is identified as an overarching objective of ELMS, but how this will be implemented across all public good outcomes under the scheme remains unclear (see Box 2.2). Payments to enhance nature were increased in 2023. While this is welcomed, payments should be partly based on results, not only action. It is unclear if the budget for ELMS will adequately fund the required activities to reach the Environmental Targets.

Climate adaptation is identified as an overarching objective of the Government's Environmental Land Management scheme, but how this will be implemented across all public good outcomes under the scheme remains unclear.

- **A range of peatland policies and funding have been announced since the last Adaptation Progress Report**, which, if implemented effectively, will support these habitats and organic soils to adapt to climate change (Box 2.3). However, it is still unclear how these separate policies, funds and plans will combine to support the Government's overarching targets for the environment.

- **Key elements of the Nature Strategy have been announced** (e.g. new funding for NbS, environmental targets, and legislative reform). It is understood the Government is also in the process of updating its plans and strategies in response to commitments at the Convention on Biological Diversity (COP15) in December 2022.

There are a range of new strategies to support actions to reduce the threat of INNS due to climate change.

- **Several new strategies will support actions that reduce the threat of INNS due to climate change.** The Plant Biosecurity Strategy for Great Britain sets out a five-year vision for plant health, consisting of an action plan to secure national biosecurity, protect native species and drive economic growth. The update to the Great Britain (GB) Invasive Non-Native Species Strategy includes a new target to halve the number of harmful alien species from establishing in GB within the decade. It also sets out a desire to significantly increase the number of inspections and investigations against INNS. However, no new money or resources to deal with either issue have been announced.

- **Biodiversity Net Gain (BNG) becomes a legal condition of planning permission in November 2023**†. BNG require all new developments to create a 10% net gain for biodiversity. The £16 million funding will support Local Planning Authority delivery, though there are challenges around how BNG will be measured.

- **Natural England's Green Infrastructure Framework (GIF) provides a structure to analyse where greenspace in urban environments is needed most.** Aimed at planners and developers, the Framework will help increase the

* The five principles comprise the: integration principle; prevention principle; rectification at source principle; polluter pays principle; and precautionary principle.

† Requiring all developers to demonstrate how they will deliver a 10% improvement to the biodiversity value of any application site.

amount of green cover to 40% in urban residential areas. Adoption of the framework is at the local planning authority level (see also Chapter 9).

- **The Nature for Climate fund budget was raised from £640 million to £740 million** for the period 2021 – 2024. Funding for 2025 and beyond is unclear. The fund is the main source of public investment to create and restore woodland and peatland.

- **Big Nature Impact Fund managers were appointed in November 2022**, although it is unclear at this stage what projects will be funded. The focus of the fund must address trade-offs between food security, farmer livelihoods, climate mitigation & adaptation, and nature recovery.

A significant policy announcement for the Environmental Land Management scheme was made in January 2023, but detail on how this will address climate adaptation is missing.

Box 2.2
ELMS as a delivery mechanism for adaptation in nature

Farmers and land managers, if properly supported, will play a significant role in delivering the new Environment Act targets and actions within the Environmental Improvement Plan. The Government has set targets that 60 – 80% of farmers will participate in the scheme and that nature-focussed approaches will occur across 10 – 15% of farms by 2030. Policies that direct new land management approaches must deliver a range of ecosystem services, including climate adaptation and enhancing biodiversity.

ELMS will be the key mechanism to support this. Recently announced details on the scheme included further information on the types of actions:

- Sustainable Farming Incentive (SFI) – standard, universal actions to be delivered at scale within farm settings.
- Countryside Stewardship – local actions relating to specific species, habitats, and features.
- Landscape scale recovery – long-term projects that deliver environmental and climate benefits at scale.

There is uncertainty in how ELMS funding will be allocated. The UK Government has committed to maintain the £2.4 billion in subsidy payments during this parliament, but this will be targeted based on demand rather than used to promote delivery of environmental outcomes. Farmers could receive up to £1,000 per year supporting farmers in management payments designed to facilitate delivery of SFI actions, irrespective of their outcomes.

Adaptation to climate change is a high-level priority within ELMS, and how the natural environment underpins this is embedded throughout the tiers. An understanding of the need to build resilience in natural systems is evident, for example with actions to support increased connectivity and expansion of habitats, mitigate impacts of extreme events such as drought and flood, and promote more efficient use of nutrients. The CCC 2021 assessment highlighted the vital need for ELMS design to recognise adaptation as a necessary pre-requisite to meeting all the scheme's public good outcomes, and that this is reflected in actions the schemes will pay for. However, the full range of adaptation actions that will be eligible is not yet clear.

ELMS continues to be voluntary. Cross Compliance will be phased out by 2024, and the baseline regulations that will replace it remain in development. It is also unclear how land managers will be guided to deliver appropriate and robust approaches to deliver climate resilience. More detail is urgently needed on how locally specific actions that support adaptation can be targeted and effectively funded.

Numerous policies and plans are still waiting to be released, including a Land Use Framework that will address the multifunctionality of England's land.

Awaiting policies and plans:

- **Local Nature Recovery Strategy (LNRS) regulations are due in Spring 2023.** These aim to drive more focussed action to help nature and support the Government's BNG plan. Around 50 strategies will cover the whole of England. The recent ELMS update indicates LNRS will evolve, as Countryside

Stewardship uptake has increased. We await confirmation of whether this will happen.

- **Land Use Framework is due in 2023**. The framework must address the multiple objectives for land, including climate change adaptation and mitigation, food security, nature recovery and wider environmental goals. Policy should be coordinated and coherent across the UK to tackle the shared barriers to action.

- **A Soil Strategy is due in Spring 2023.** The Government has indicated the Strategy will include a target for soil health, which was omitted from the Environment Act targets (though noting the target on sustainable soil management). It is understood the draft Plan would be complementary to the existing England Peat Action Plan.

- **A Pesticides Action Plan was due to be released in 2022.** This followed a consultation on the draft plan in 2021. It will aim to minimise the risks and impacts of pesticide emissions to the environment, while ensuring pests and pesticide resistance can be managed effectively.

- **Green finance strategy is scheduled for late March 2023.** This will list principles for developing high-integrity nature markets that enable farmers and land managers to attract investment into nature's recovery. This is welcomed, though the markets must synergise climate mitigation and adaptation benefits to be most impactful.

Box 2.3
Updates in peatland policy

Around 80% of peat soils in England are considered degraded, which impacts their resilience, biodiversity, water quality, and ability to store carbon. There have been several policy developments relating to the restoration and sustainable management of peat since the 2021 Progress Report:

- A ban on the sale of horticultural peat to amateur gardeners in England will come into effect towards the end of 2024. This will not extend to professional gardeners and the horticulture sector, who make up 30% of the peat sold in the UK, or seek to mandate the restoration of extraction sites, leaving them vulnerable to continued degradation.
- The Peatland Grant Scheme within the Nature for Climate Fund remains the main funding incentive for peatland restoration at scale, aiming to set 35,000 ha of degraded peatland on a restoration trajectory by 2025. This is below the CCC Balanced Pathway estimate of 50,000 ha over the same period.*
  - The Paludiculture Grant Fund, launched in January 2023, allocates £5 million to projects that address the barriers to developing commercially viable lowland peat soils.
- In 2021, regulations were introduced in England requiring a license to practice burning management on protected sites with deep peat soils. This leaves most English peatlands vulnerable to burning, a potentially damaging process that impacts the resilience of peat systems.
  - The CCC is in the process of reviewing its previous recommendations on the practice of rotational burning as a land management technique.

* The CCC Balanced Pathway sets out that in England around 40,000 ha of degraded peat should be placed under restoration management, with a further 10,000 ha sustainably managed, during the period 2020 – 2024.

(b) Outcome 2: Freshwater habitats are in good ecological health

The score for this outcome has been assessed as **limited policies and plans**. Updates to key policies have now been published, which identify actions that will help reduce the vulnerability of freshwater environments to the risks presented in CCRA3. However, the scale to which these actions will be deployed is uncertain.

Policies and plans announced:

The River Basin Management Plan update identifies interventions to reduce vulnerability to impacts from higher water temperatures. More data is needed on the scale and rate of deployment of actions.

- **The delayed third cycle update to the River Basin Management Plans (RBMPs) is now published.** The RBMPs set the legally binding locally specific environmental objectives that underpin water regulation and are the foundation for delivering the EIP's clean and plentiful water goal. Our 2021 Progress Report highlighted the need for future RBMPs to set out a clear mechanism to account for the consequences of higher water temperatures and low flows (including drying up) in water bodies. An RBMP update for 2021-2026 was published in late 2022. The Environment Agency has incorporated findings from national-level risk assessments that consider climate impacts under 2°C & 4°C scenarios, plus the effects of other external pressures including pollutant emissions. The supporting document 'Implementing the RBMP' presents a set of nine principles, one of which directly relates to building the resilience of water catchments to a range of climate hazards.[29] The RBMP summary programme of measures also contains a Topic Action Plan, which identifies known measures that, if implemented, should reduce vulnerability to risks from higher water temperatures over the short, medium, and long-term.

- **Natural England published its Nutrient Neutrality 2022 advice for development proposals** that could affect water quality of designated habitats sites through nutrient pollution. More action is required to ensure compliance with existing regulations and setting targets on reduced nutrient loads to address the impact from existing developments, agriculture and wastewater.

(c) Outcome 3: Marine and coastal habitats are in good ecological health

The score for this outcome has been assessed as **limited policies and plans.** While the Government has announced a number of new (and updates to existing) policies, some lack sufficient detail, while several others are still outstanding. The EIP covers marine, though there is no clear mention of building the resilience of marine habitats to climate impacts, which is a missed opportunity. Government delays in providing responses to several consultations pertinent to the marine environment will hold up delivery of adaptation actions.

Policies and plans announced:

- **The Government has met its commitment to complete the full series of England Marine Plans by 2021.** The adoption of eleven regional marine plans means there is now a complete and integrated marine planning framework to manage how we use, develop, protect and enhance England's marine environment.[30] Our 2021 Progress Report recommended the statutory requirements of marine plan policies be extended to the decisions of public and private organisations. This has not yet been addressed.

- **Government has published marine monitoring programmes** to provide evidence to support the 2024 assessment of progress towards achieving good environmental status within the UK Marine Strategy area. Released as part of the Marine Strategy Part Two update, the new indicators will help fill gaps in the indicator set currently used to assess adaptation progress.

A recent policy announcement for marine and coastal habitats includes both long- and short-term environmental targets that are specific and time-bound.

- **Long-and short-term targets for the marine environment.** This includes a target for 70% of designated features in Marine Protected Areas (MPAs) to be in favourable condition by 2042 with the remainder in recovering condition. There is also an interim target of 48% of designated features to be in favourable condition by 31 January 2028, which, according to Defra, is in line with the trajectory required to achieve the long-term target. Many features for which the MCZs have been designated, however, are potentially vulnerable to climate change, meaning their ongoing utility as a conservation tool could be affected.*,31

- **Three new Highly Protected Marine Areas (HPMAs) have been announced** which will limit extractive activities like fishing and dredging to encourage nature recovery in these biodiverse marine areas. It is expected more HPMAs will be announced soon but original ambition for the HPMAs appears to have been reduced, with cuts to some sites and reductions to others. This will make reaching the marine nature recovery goals harder.

Awaiting policies and plans:

- **UK Marine Strategy Part Three update**. A consultation ran in 2021. This will update the programme of measures the UK intends to use to achieve or maintain Good Environmental Status of UK seas.

- **Marine net gain consultation response is overdue.** The consultation, which commenced in June 2022, outlines proposals to ensure infrastructure development produces net biodiversity gain for the marine environment. The fisheries sector was excluded in initial plans, and not including it in final plans will leave it as one of the few economic activities not required to assess its environmental impacts before the granting of licences.

- **Shoreline Management Plan (SMP) refresh ongoing.** Coastal groups are currently reviewing the policies and actions in their SMPs. It is understood the refresh will consider a range of future climate scenarios and is informed by the best available evidence, including the latest climate change projections. As noted in our 2021 Progress Report, the policy decisions within SMPS must be made statutory to ensure they are implemented and monitored (see also Chapter 9).

(d) Recommendations for closing policy gaps

Numerous policy changes are needed to improve the climate resilience of nature. These include setting interim adaptation targets and publishing full details on how the Environmental Land Management Scheme will address adaptation needs.

Table 2.2 lists the recommendations for improving climate resilience of nature. This should be read in conjunction with the recommendations in Chapter 3 - Working Land and Seas, given the close interlinkages between the two.

* Some features used for designations include the environment type (e.g. marine or estuarine), ecological significance (e.g. a specific habitat or species type) and environmental factors which influence species composition and community structure such as depth, substrate (e.g. mud, sand) and exposure (wave action, currents).

Table 2.2
Recommendations

Primary responsibility	Recommendation	Timing
Cabinet Office	The Retained EU Law Bill (REUL) should be strengthened by including an environmental non-regression safeguard. Implementation of the REUL programme should be supported by thorough and meaningful engagement and consultation with key stakeholders and technical experts across the UK.	2023
Defra	The Environmental Improvement Plan goals should be mainstreamed across all Government departments responsible for their delivery, and trade-offs with competing policies should be mitigated.	2024
Defra	Defra must clearly link the multiple benefits delivered through meeting the new Environment Act (2021) targets to the suite of climate, environment and planning policies that support them.	2024
Defra	Defra should set interim adaptation targets to drive early action to improve climate resilience of nature, enable progress assessments, and secure adequate resources (including for green jobs and skills) to facilitate delivery of the targets.	2023
Defra	Defra should publish full details on how the Environmental Land Management scheme will support healthy ecosystems to build climate resilience, and the actions that reduce vulnerability to climate change that will be eligible for payments under the scheme.	2023
DLUHC	DLUHC should add an expectation in the National Planning Policy Framework that Local Plans and Design Guides support delivery of Local Nature Recovery Strategies and Natural England's Green Infrastructure Standards. It should ensure that the Environmental Outcome Reports provide equivalent or stronger protection for biodiversity than the current system.	2023
DLUHC	Government should adopt the recommendations for revised technical standards for Sustainable drainage systems (SuDS) in England, to ensure that SuDS are multifunctional systems that support biodiversity, improve water quality and provide green space for people.	2024
Defra	The statutory requirements of marine plan policies should be extended to the decisions of public and private organisations.	2024
Defra	Government should invest in social and ecological research to understand how best to work with people to restore nature and build resilience to the impacts of climate change and other pressures.	2024

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Chapter 3

Working land and seas

Table 3.1
Progress summary – Working land and seas

	Delivery and implementation	Policies and plans	Summary
Outcome 1: Climate resilient agricultural production	Unable to evaluate	Insufficient policies and plans	• Data to measure how the productivity of the agriculture sector is changing in relation to climate change are not sufficient to support a robust assessment of progress. • Defra still lacks a plan to ensure the agricultural sector remains productive as the climate changes. Emerging details on the Environmental Land Management Scheme indicate some consideration of risks from future climate change, but this is not enough to strengthen the capability of agriculture to shift to more resilient production approaches.
Outcome 2: Climate resilient commercial forestry sector	Mixed progress	Partial policies and plans	• No change in the percentage of forests under active management or in the number of high-priority pests in UK forests. The diversity of trees planted in England remains above levels recorded in the early 2000s. • The UK Forestry Standard Practice Guide provides information on how to assess climate risks and adapt accordingly. An update to the Tree Health Resilience Strategy (due in 2024) will set out the Government's plans to improve the resilience of our trees and woodlands, but the forestry sector still lacks a measurable goal for managing and reducing the impact of pests and diseases on trees in England.
Outcome 3: Climate resilient commercial fisheries and aquaculture sector	Mixed progress	Partial policies and plans	• Some fish populations are declining but a greater proportion of UK fish stocks are now harvested sustainably. The number of invasive non-native marine species has increased. • There have been numerous fisheries policies, funds and guides announced, some of which will help build climate resilience in this sector, but it remains to be seen how effective these will be.

Relevant risks from CCRA3:
Risks to soils (N4); Risks and opportunities for natural carbon stores, carbon sequestration and GHG emissions (N5); Risks to agriculture and forestry (N6, N7, N8); Opportunities to agriculture and forestry (N9); Risks to aquifers agricultural land (N10); Risks to marine habitats and species, and fisheries (N14, N16); Opportunities to marine habitats and species, and fisheries (N15).

This chapter considers how climate change could affect the productivity of England's working land and seas (WLS), which include agriculture, commercial forestry, and fisheries and aquaculture. These sectors provide jobs, vital products and inputs to other sectors, whilst also underpinning food, fibre, timber and resource security. Weather and climate-related disruptions in these sectors can have significant cascading economic, environmental and social impacts.

There are many climate hazards affecting these sectors. Flooding, storms, drought and average temperature rises are already impacting agriculture, timber production and fisheries, and these impacts are likely to increase. Furthermore, less predictable precipitation will impact planting and harvesting times for agriculture.

There are many climate hazards that could affect the ability of the agriculture, forestry, and fisheries and aquaculture sectors to remain productive into the future.

Climate risks on WLS are determined both by the risks to the underlying natural systems on which these services depend and the management practices used. WLS are also impacted by other anthropogenic pressures, which can themselves undermine the resilience to climate change of the natural resource inputs, as well as the ability of these sectors to take advantage of any potential benefits from climate change.* These underlying drivers include other environmental pressures, such as water pollution and soil degradation, as well as policy-driven risks to international competitiveness and economic resilience.

The key policy levers for agriculture, forestry and fisheries are at the devolved level, with Defra assuming responsibility for all of these in England. Since leaving the European Union, the Government has enacted key legislation that could influence the ability of the respective industries to adapt to climate change. These include:

- **Agriculture Act 2020**, which replaces the EU Common Agricultural Policy and is shifting towards paying land managers to produce public goods such as nature restoration.
- **Fisheries Act 2020**, which replaces the EU Common Fisheries Policy and aims to build a strong, resilient fisheries sector.
- **Environment Act 2021**, which is the main legislative mechanism through which the 25-Year Environment Plan goals will be enacted and includes requirements to set Environmental Targets, have regular Environment Improvement Plans to address how Defra will meet these targets, and an Outcome Indicator Framework to monitor progress.

Climate risks to WLS are strongly interlinked with climate risks to other chapters in this report including:

WLS is heavily dependent on healthy natural ecosystems so reducing climate risks to the sectors within this system relies in part on reducing climate risks to nature.

- **Nature**. Healthy ecosystems support the production of resources (e.g. food, timber, fisheries and fibre) that are fundamental to economic activities in WLS. Healthy ecosystems provide regulating services (e.g. water filtration, erosion control and flood mitigation) that can protect WLS from the impacts of climate change, and supporting services (e.g. pest control, pollination, and soil fertility) that underpin the production of many crops.
- **Food**. Effective adaptation by the agriculture and fisheries will support a climate-resilient food system producing sustainable, nutritious and high-quality food. Almost 60% of UK food consumption is produced domestically.[1]
- **Water supply**. The agriculture and aquaculture sectors abstract fresh water from the environment to support production, yet agricultural run-off affects water quality. For the water system (including water used by homes and businesses) to be resilient to periods of future drought, actions to use water more efficiently and sustainably are needed to ensure all sectors have adequate water supply.

* Advantages such as from longer growing seasons, production from new crops, and migration of warmer-adapted fish species.

Well-adapted WLS are those that remain productive and economically sustainable in a changing climate, with businesses that are resilient even during weather extremes. Within each sector of WLS, we identify key adaptation outcomes to deliver this goal (Figure 3.1):

Building climate resilience for agriculture, forestry and fisheries depends on ensuring these sectors operate sustainably, such as in the case of the latter, harvesting fish stocks at levels low enough to allow natural replenishment of populations.

- **Climate-resilient agricultural production.** Agricultural soils need to be in good condition to support production, particularly under future weather extremes. Sustainable soil management techniques on farms (e.g. reduced tillage, using cover crops and incorporating organic matter to reduce erosion) will help deliver this. These actions will also help increase water-holding capacity in soils. This can be complemented by increasing on-farm water storage capacity (such as via reservoirs) and water-saving farming techniques to address drought risks. Pollinators needed for some crops can be supported by approaches such as agroforestry and wildflower strips. On-farm flood risk management and contingency planning need to be in place. Crop and livestock selection must be suitable to climate conditions and include greater diversity. Increased agroforestry and hedgerows can provide shade and shelter for livestock during heatwaves and offer co-benefits such as natural flood management and habitat for pollinators and pest predators. Integrated pest management and improved soil health will help improve resilience to climate change-driven risks from pests and diseases.*

- **Climate-resilient commercial forestry sector.** Commercial plantations should be under sustainable adaptive management (e.g. meeting the UK Forestry Standard) to help build resilience to climate impacts. They also need to contain climate-appropriate and ecologically suitable trees (e.g. avoiding water-hungry species or planted on incorrect soils). Diversity in species and genetics can help reduce risks from pests and diseases, while wildfire risk can be better contained through adaptation actions to sustainably thin dense forests and manage forest fuels and establishing fire belts.

- **Climate-resilient commercial fisheries and aquaculture sector.** Harvesting fish stocks must be undertaken sustainably to support resilience to climate change. Preventing water pollution (e.g. from discharge of power station cooling water and agricultural run-off) and controlling water temperatures where possible will help protect and improve the quality of water supplies vital to the aquaculture sector. Restricting ecologically damaging offshore fishing practices (e.g. bottom trawling) will ease pressures on the ability of marine habitats to support production. Fishing operations may need to adjust their locations, the species they harvest, and practices to adapt to changing species distributions and disease risk associated with changing water temperatures.

Delivering these outcomes requires enabling factors to be in place, the most critical of which are:

- **Governance and policy coordination.** A comprehensive, joined-up cross-departmental approach to policy is required. This must ensure that climate

* Integrated pest management (IPM) is a coordinated and planned strategy for the prevention, detection and control of pests, weeds, and diseases.

resilience is considered alongside other objectives for WLS, such as contributing to Net Zero, nature recovery and food security.

- **Funding and investment.** Access to finance is needed as actions to support WLS may have high upfront costs with relatively long periods before returns are fully realised. Agri-environment schemes, grants and funding for R&D will be key to support a just transition to sustainable and climate-resilient WLS. Harmful subsidies that compromise adaptation need to be eliminated or carefully repurposed.

- **Data and monitoring.** Robust data are required to track changes in climate risks, hazards and improvements in resilience of WLS, which will help target the most effective interventions. Priorities include metrics to track soil health, impacts of funding interventions on productivity, biodiversity and climate resilience, and data on missing indicators.

Numerous enablers will support delivery of climate resilience for WLS, including investing in a greener workforce that has the skills, capability and capacity to respond to climate change.

- **Research.** More evidence is needed to understand how a changing climate affects productivity across WLS, which can be used to target interventions that build resilience. This includes spatial variability in climate impacts, researching climate-appropriate species/genotypes for different locations, and understanding the impacts of changing ocean temperature and chemistry on fish stocks. Research into how best to balance multiple goals including food security, climate mitigation, adaptation and nature recovery is also vital.

- **Skills and workforce.** More training is needed to build the knowledge, understanding and capacity of practitioners to improve efficiency, sustainability and productivity across the sectors. This includes help with training and demonstration of more sustainable land management methods and new uses of land (such as agroforestry); government schemes to increase recruitment and retention of green jobs such as peatland restorers; and facilitating natural resource manager co-operation and participatory governance, such as land manager clusters and catchment partnerships.

Policies and plans needed to build the resilience of WLS to the impacts of changing climatic conditions include:

- **Planning.** The agriculture sector needs a clear plan outlining the steps needed ensure it remains productive under the shifting threats from climate change. Revisions to plans for adapting commercial fisheries and aquaculture must consider climate impacts under a range of warming scenarios.

- **Agriculture policy update**. Revisions to agriculture policy must consider and support nature recovery and consider climate risks to delivery. Greater flexibility is needed in the range of activities under agri-environment schemes (e.g. explicit funds for climate-resilient actions) and more funding is needed to ensure agriculture is resilient to climate change.

- **Governance and co-ordinated management**. The proposed UK Land Use Strategy must synergise between production, climate adaptation, climate mitigation, development, and nature recovery. Land management standards must be strengthened, while fisheries management arrangements must be made more flexible to ensure effectiveness under a changing climate.

The forthcoming Green Finance Strategy, together with NAP3, should clarify where the Government expects adaptation actions will be funded through public sources and where private investment is expected.

- **Green Finance**. Finance schemes such as carbon credits and nature offsets must adhere to high environmental standards and codes. The forthcoming Green Finance Strategy, together with NAP3, should clarify where the Government expects adaptation actions will be funded through public sources and where private investment is expected.

- **Delivery of the Fisheries Act objectives**. Sufficient support must be made available to improve the ability of the fisheries and aquaculture sector to adapt to climate change.

We will continue to update the monitoring map (Figure 3.1) and indicators to match this merged system. The outcomes and indicators are therefore likely to change over time as data improves for the relevant industries.

Figure 3.1 Monitoring map for working land and seas

Sustainable and climate-resilient working land and seas

Required Outcomes

Climate resilient agricultural production

- *Livestock mortality (%) and crop failure (per hectare) due to climate impacts.*
- *Abundance and diversity of pollinators and pest predators*

Take up of sustainable farming measures

- *Area of cropland under cover crops, reduced tillage, addition of compost or manure*
- *Area of agroforestry, hedgerows, buffer strips and species-rich field margins*
- *Reduced use of pesticides/ synthetic fertilisers*
- *Greater on-farm water storage capacity/lower abstraction*
- *Appropriate slurry store/silage clamp engineering*
- *Overgrazing/stocking rates*

Healthy soils

- *Soil erosion rates (t/ha/y)*
- *Increase in soil organic carbon, naturalsoil biota diversity/abundance and soil infiltration*

Climate resilient commercial forestry sector

- *Area of commercial forestry under sustainable adaptive management meeting UK Forestry Standard*
- *Area of commercial forestry planted with climate appropriate and ecologically suitable tree species (avoiding invasive or water-hungry species and damage to native biodiversity)*
- *Genetic diversity and species diversity of trees in commercial forests*

Climate resilient commercial fisheries and aquaculture sector

- *UK fish stocks maintained at healthy status*
- *UK aquaculture stocks healthy and resilient*
- *Freshwater, marine and estuarine waters achieve good quality*
- *Water temperatures controlled*

Responsible practices

- *Sustainable harvesting of UK fish stocks in line with scientific evidence*
- *Sustainable adaptive management of aquaculture production*
- *Restrict/ban bottom trawling activities*

Effective wildfire planning in place

- *Prevalence of local wildfire response plans, and sufficient fire-fighting equipment/personnellevels*
- *Management of vegetation and fuels (but minimising adverse biodiversity impacts)*
- *For carbon offsets, plant sufficient area to account for risk of reversal due to fires etc*

Climate resilient operations

- *Safe and secure vessel and aquaculture operations*
- *Reduced vulnerability of vessels and ports*

Manage and reduce the impacts from pest, diseases and invasive non-native species

- *Geographical spread of different climate-sensitive pests and pathogens*
- *Number of high priority pests and diseases recorded as present in UK plant health risk registers*

Enablers

Funding & Investment

- Agri-environment scheme uptake
- Payments for ecosystem services
- R&D funding for agroecology and agricultural adaptation
- Small port resilience infrastructure
- Public-private partnerships

Data and monitoring

- Soil health /erosion
- Agri-env scheme or natural flood management uptake and outcomes
- Pollinators /pest predator populations

Skills and workforce

- Training and demonstration in sustainable land management & agroforestry
- Funds to facilitate land manager cooperation (e.g. farmer clusters).
- Fisheries science and environmental awareness training

Research

- Climate appropriate species research
- Tree and biomass crop productivity
- Impact of changing ocean temperature and chemistry on fisheries' productivity
- Agroecology and agroforestry R&D
- Climate impacts by location

Governance and policy co-ordination

- Climate resilience incorporated into relevant Net Zero policies
- Synergies with nature recovery targets maximised and trade-offs minimised, e.g. use of diverse native species in plantations

Policies and plans

Planning

- Plan to ensure the agricultural sector remains productive under climate changes
- Plans for adapting commercial fisheries and aquaculture consider climate impacts under a range of warming scenarios

Agriculture policy revisions

- New agriculture policy supports biodiversity and climate resilience
- Flexible agri-environment schemes e.g. allowing natural flood management on farmland
- Funding support for agroecology, on-farm water infrastructure, hedgerows and agroforestry

Governance and co-ordinated management

- Comprehensive UK land use strategies ensuring synergies between production, climate adaptation, climate mitigation, development and nature recovery
- Improved land management standards
- Flexible fisheries management arrangements
- Better protection for Marine Protected Areas (as nurseries to replenish fish stocks)

Green Finance

- High environmental codes and standards to underpin private finance

Fisheries Act provisions

- Support delivery of climate objectives outlined in UK Fisheries Act

Source: CCC analysis.
Notes: Italicised text indicates suggested measures for each outcome.

We assess progress against a range of indicators but highlight key indicators in this chapter that were chosen based on their ability to show overall trends for each outcome.

(a) Outcome 1: Climate-resilient agricultural production

Limited access to the required datasets means It has not been possible to robustly assess whether progress has been made in reducing the agriculture sector's vulnerability to climate change.

This outcome has been scored as **unable to evaluate**. Significant gaps remain in the suite of indicators required to measure how the productivity of the agriculture sector is changing in relation to climate change. For instance, there is a lack of metrics to robustly assess soil health, on-farm water storage capacity, and losses to livestock/crops due to extreme weather events. It is therefore not possible to conduct a robust, comprehensive assessment of changes in the vulnerability of agricultural production to climate change since the last Progress Report. The limited indicators that are available show mixed progress.

Pollinators are vitally important to agriculture, however, there has been a 21% decrease in the distribution of pollinating insects in the UK since 1980.

- **Distribution of pollinating insects in the UK is declining both in the short and long term.** In 2019, the indicator had declined by 21% compared to its value in 1980; between 2014 and 2019 alone the indicator fell 6%.[2] Pollinators are vitally important to agriculture as they help many crops reproduce.

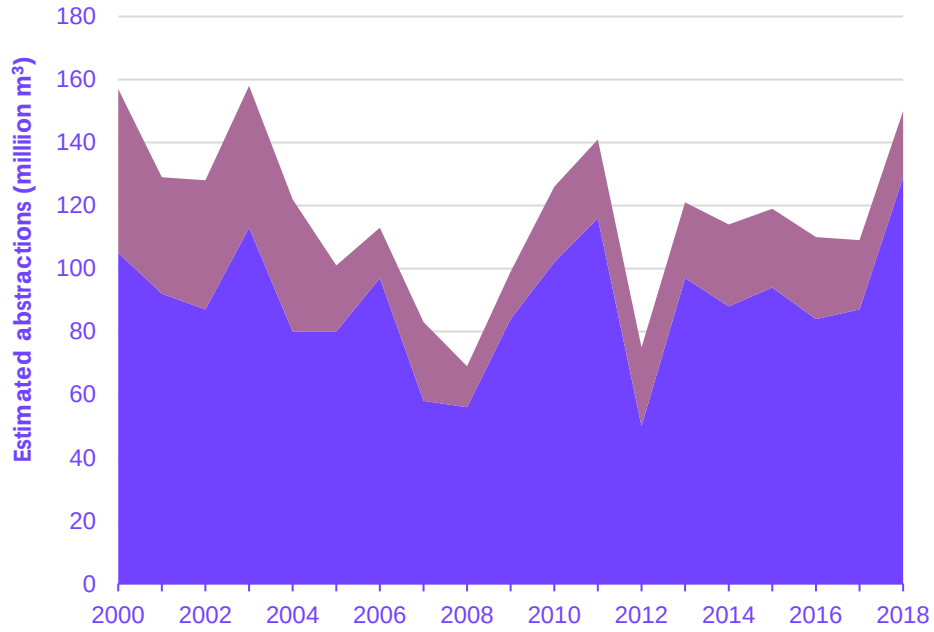
- **There has been a slight reduction in water abstracted for agriculture and spray irrigation since 2000**, but with major fluctuations between years (Figure 3.2).[3] The sharp rise in abstraction in 2018 coincided with a particularly dry summer in England. Further work is needed to understand the overall long-term trend and whether adaptation actions to reduce abstraction affect this.

- **Usage of inputs such as pesticides and mineral fertiliser has declined in recent decades.**[4] The reduced use of inputs can help improve climate resilience by enhancing the ability of agricultural land to support sustainable production. Overuse of pesticides harm pollinators, which can affect crop production, while overuse of fertiliser can cause eutrophication, affecting water quality, biodiversity and fisheries. It is not clear whether the decline in the use of inputs is linked to adaptation within the sector or other influences (e.g. fertiliser prices, crop prices and weather-related issues during the growing season).

Opportunities as a result of a changing climate include growing new crops that may not have historically grown in England. The area of vineyards in England has increased almost every year since 2004.

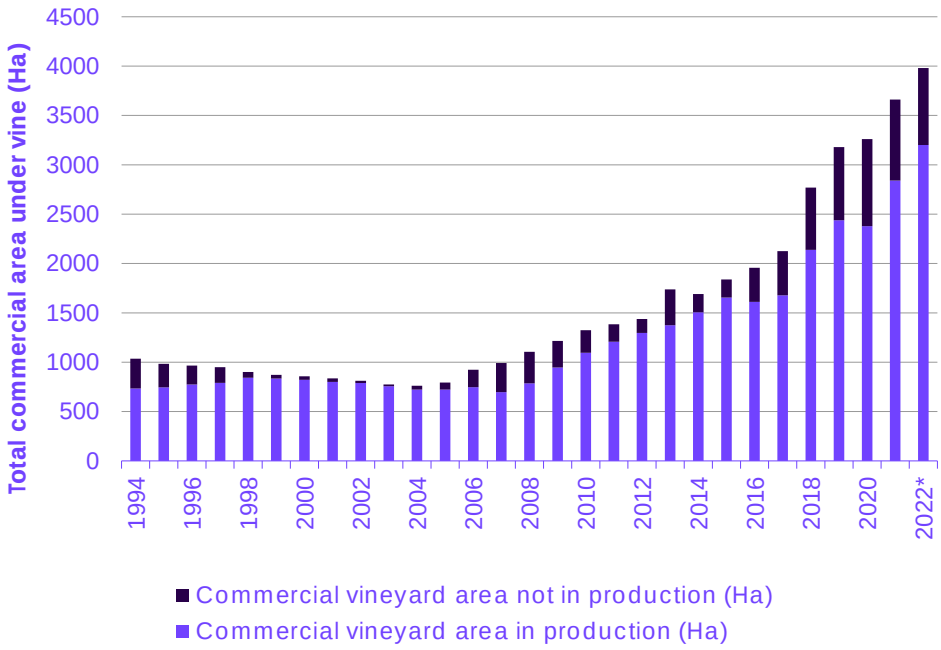
- **The area of wine production is increasing.** There is some evidence of land managers capitalising on opportunities for agriculture under a changing climate via new or alternative species becoming more climatically suitable to grow. The total area under commercial vine in England and Wales has increased by more than 250% in the last recorded decade, from 1,384 hectares in 2002 to 3,661 hectares in 2021(Figure 3.3).

Figure 3.2 Volume of abstractions from non-tidal water sources for agriculture, in England



Source: Environment Agency.

Figure 3.3 Wine Production: Area planted per year in England and Wales



Source: ADAS for the CCC (2023) *Research to update indicators which monitor progress in adaptation in England.*
Notes: * Provisional estimates.

(b) Outcome 2: Climate-resilient forestry

Available indicators for this outcome show **mixed progress**, with the percentage of woodland under active forest management still below the Government's aspiration, but the diversity of trees planted is now higher than the early 2000s.

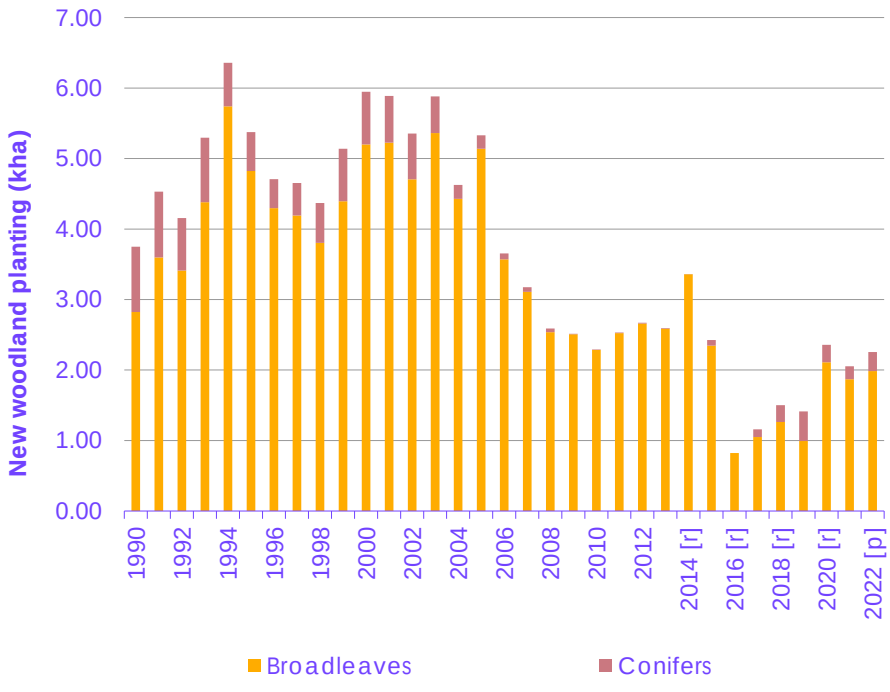
- **Sustainable management of woodland in England has flatlined** in recent years at around 50%.[5] In 2021, 81% of conifer woodlands were under sustainable management, compared to 46% of broadleaved woodlands.[6]

- **Planting diversity has increased.** There were 23 species of broadleaf trees planted in England's forests in 2020-21, up from 17 in 2010-11. For conifer species, 28 different species were planted by Forestry England in 2020-21, up from 20 in 2012-13. Increasing the diversity of tree species in new planting schemes is an important adaptation strategy to help reduce threats from pests and diseases, as well as manage uncertainties around the suitability of species to future climate conditions.

New woodland planting has declined since the highs seen in the 1990s and early 2000s but rates have slowly increased, since 2016.

- **Area of broadleaf species planted in England's forests has fallen** since the relatively high rates in the 1990s and early 2000s, though rates have rebounded since a low of 820 ha was recorded in 2016 (Figure 3.4).[7] Broadleaves dominate planting in England, making up 88% of the area of new woodland in 2022.[8] Diverse broadleaved woodlands support climate resilience by providing a healthier, more diverse ecological environment for the community of species it supports compared with conifer plantations; they are also less susceptible to wildfire and wind damage.

Figure 3.4 England broadleaf and conifer planting, per annum



Source: Forest Research (2022) *Woodland Statistics*.
Notes: Years containing [r] or [p] indicate the data has been revised or is provisional.

- **The number of wildfire incidents in woodland and forests shows no clear trend,** with significant year-to-year variation. However, 2020-2021 saw a dramatic uptick in the area of conifer woodland burnt by wildfires, rising sharply from 32.9 ha in 2019-2020 to 1,016.8 ha in 2020-2021.[9] Adaptation actions to mitigate forest wildfire risk involve better management of vegetation and other natural material that can increase wildfires, and creating woodland buffer zones to limit the spread of wildfire.

- **Number of high priority* forest pests in the UK Plant Health Risk Register have flatlined** recently, after an increase between 2016 and 2020 (from 12 to 19).[10] The relationship of this risk with climate change is complex, as each pest species has different biophysical and climatic requirements that can alter their presence and distribution.

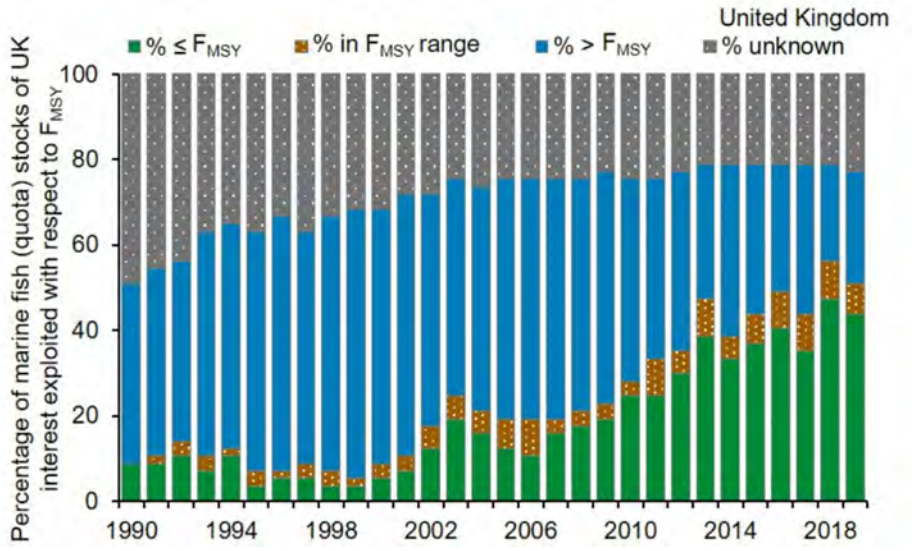
(c) Outcome 3: Climate-resilient fisheries and aquaculture

There has been **mixed progress** in delivering climate-resilient fisheries and aquaculture, with some indicators (e.g. sustainable harvesting of fish stocks) improving, but others declining (e.g. number of invasive, non-native species).

There has been mixed progress in actions to support climate-resilient fisheries and aquaculture. Some monitored fish populations have increased, indicating positive progress, but established invasive non-native marine species, which can undermine resilience, are also increasing.

- **Some monitored fish populations in English seas are showing increases, but others are not sustainable.**[11] Recent data shows a greater proportion of UK fish stocks harvested sustainably (Figure 3.5), but whilst trends for fish harvested within safe biological limits in the long term have increased, this has decreased in the short term.[12,13] The length of certain fish communities in the North Sea and eastern Irish Sea is increasing (suggesting healthier populations), but the balance of fish species has shifted towards smaller species in some areas, suggesting less sustainability. Salmon stocks have continued to decline in assessed English rivers.[14]

Figure 3.5 Percentage of marine fish (quota) stocks of UK interest harvested sustainably between 1990-2019



Source: Defra (2020) *England biodiversity indicators 2020.*
Note 1: The extent of protected sites is the cumulative area assessed in March of each year shown.
Note 2: Marine sites between mean low water and the 12 nautical mile limit are included; sites beyond 12 nautical miles, in UK waters, are excluded. These are included in the UK indicator on protected sites.

* Pests are ranked as high priority if they are assessed as having a mitigated relative risk rating of 15 or more.

- **The number of invasive non-native marine species established along 10% or more of the UK coastline is increasing**, from two in 1960-69 to 29 in 2020.[15]

(d) Summary of unavailable indicators

There are significant gaps in available indicators to measure progress against the WLS outcomes, which include, but are not limited to, indicators to measure:

Limitations on the range of datasets available restrict the ability to track progress towards many WLS outcomes.

- Impacts to agriculture from unpredictable and unseasonal weather, such as yield and profit changes, crop/livestock losses due to flooding/ heatwaves, and fish losses due to sea temperature rises or changes to ocean chemistry.
- Data on the actions taken by agricultural land managers to reduce vulnerability of production to changing climate conditions (e.g. on-farm water storage, tree shading, wildfire management activities).
- Soil health from a range of soil types and uses, though noting that this is in development by Defra.
- Resilience of commercial species, such as genetic diversity of crops, livestock, trees and fish.
- Prevalence of local wildfire plans in place and capacity of local firefighters to address wildfires in agriculture and forestry.
- Management of fuel load to mitigate wildfires.
- Number of local fish species extinctions and new fish species appearing in English seas.
- Localised, fine-scale marine and coastal water temperatures and acidification.
- Change in occurrence and abundance of pests, pathogens and invasive non-native species.
- Indicators to assess progress in relation to enablers.

The current policy landscape presents a mixed picture of climate adaptation preparedness within WLS. Numerous new and updated policies and plans have been published after delays, but it is too soon to determine the effect they are having on reducing the vulnerability of these sectors to climate change. Building the resilience of nature is fundamental to strengthening the resilience of the sectors covered under WLS. A key policy mechanism to support this is the Environmental Land Management Scheme (ELM), which is discussed in more detail in Box 2.2 in Chapter 2.

(a) Cross-cutting policies and plans

Numerous policies and plans have been announced that affect agriculture, forestry and fisheries, such as the Environmental Improvement Plan (EIP) and ELMS. These policies suggest greater consideration of the risks facing agricultural land in England and incentivise practices that will improve climate resilience in forestry and fisheries.

There have been numerous policies and plans announced since the last Progress Report that consider the range of climate risks facing WLS.

- **Defra's proposed Land Use Framework will have widespread implications for agriculture and forestry**. The Framework must consider the multifunctionality of the country's land to identify trade-offs and co-benefits between food, fibre and timber production, rural livelihoods, nature recovery, and climate mitigation and adaptation.

- **Several new initiatives to support WLS to build resilience to threats from INNS.** The announcement of creating a Non-Native Species Inspectorate is welcomed as this will help address the threat of INNS, though it is not clear when this Inspectorate will be operational or what their remit will be. The increased capacity for researching zoonotic diseases at the Animal and Plant Health Agency (APHA) is a helpful step in addressing climate-related disease outbreaks in plants and animals. Several new and updated strategies have also been announced (e.g. Plant Biosecurity strategy and INNS strategy update) which will support actions that reduce the threat of invasive species due to climate change (see also Chapter 2).

- **The need to build resilience to increasing wildfire risk is highlighted in the new EIP, but England still lacks a strategy to manage this risk.** Wildfire risk magnitude is of high local importance.[16] A Wildfire Framework for England was published by the Home Office 2021, which sets out the roles of, and the relationships between, the various wildfire stakeholders from central government through to regional fire groups. A national coordinated wildfire strategy across Departments and stakeholders is needed to identify and mitigate risks of wildfire to people, habitats, agriculture, property and infrastructure.

- **Government has committed to expand the use of natural flood management.** The Government's Natural Flood Management Programme, which ended in 2021, funded 60 NbS projects to reduce flood risk. Learnings from the Programme will be used to improve developing and delivering future NbS projects. The EIP includes a commitment to double the number of government-funded flood resilience projects using NbS. In 2022, 50 projects were funded via the £10 million Natural Environment Investment Readiness Fund. The fund provides grants to explore revenue generation

from NbS to reduce flood risk and address other challenges such as water quality.[17]

(b) Outcome 1: Climate-resilient agricultural production

This outcome has been scored as **insufficient policies and plans**. Defra still lacks a comprehensive plan to ensure the agricultural sector remains productive as the climate changes. The release of further details on ELMS indicates that some of the potential effects of climate change have been considered within plans, while the EIP includes some actions that will help build the resilience of farmland habitats. However, these alone will not be sufficient to prepare the sector for the climate risks and opportunities to agricultural production in England. This is particularly the case for improving the capability of agriculture to respond to threats such as changing pest and disease risks and water scarcity due to climate change. Published policies and plans:

Agriculture still lacks a plan to ensure the sector remains productive as the climate changes. Emerging details on the Environmental Land Management Scheme indicate some consideration of risks from future climate change, but this is not enough to strengthen the capability of agriculture to shift to more resilient production approaches.

- **The EIP lays out further details on how the Government will deliver its headline environmental goal to use resources from nature sustainably**.* Farm-specific commitments within the Plan that will build resilience include supporting farmers to create or restore 30,000 miles of hedgerows a year by 2037 and 45,000 miles of hedgerows a year by 2050, returning hedgerow lengths in England to 10% above the 1984 peak (360,000 miles).

- **Details published on agricultural funding under ELMS indicate a greater consideration of the range of risks and opportunities from climate change.** However, it is too soon to know what the rate of uptake will be like and whether this funding is sufficient, as details on what land managers will be paid to do under ELMS is still unclear (see also Chapter 2).

- **The Food Strategy does not include sufficient consideration of climate risks to food supply.** The Strategy is weak overall and does not take sufficient consideration of the adaptations needed to build the resilience of the domestic and international agri-food chain to future climate extremes.

- **A new National Pollinator Action Plan sets out how the Government will meet the objectives of the National Pollinator Strategy.** Pollinators are essential for most agricultural production but are threatened by pesticides, habitat loss and climate change. The Plan includes actions to build evidence on how resilient natural and agricultural systems are to changes in pollinator populations.

- **New government funding to encourage farm innovation and improved water management.** The £10 million Water Management grant helps fund on-farm improvements for efficient use of water and will help reduce the climate risk of drought for the agricultural sector. A further £168 million in grants will be available to farmers to drive innovation, support food production, improve animal health and welfare and protect the environment. The grants will sit alongside ELMS but significantly more investment will be needed in innovation and R&D if the agriculture sector is to remain productive under climate change.

- **A proposed Genetic Technology (Precision Breeding) Bill is currently being scrutinised by the House of Lords.** This will legalise targeted gene editing of crops and livestock, which can help improve climate resilience.

* Outlined in the 25-year Environment Plan 2018 and reiterated in the Environmental Improvement Plan 2023.

(c) Outcome 2: Climate-resilient commercial forestry

This outcome has been scored as **partial policies and plans**. Our 2021 Progress Report found that climate change adaptation plans (that contain clear actions and outcomes) exist for the forestry sector, but lack clear targets and are near-term in risk outlook. Since our last assessment, numerous new policies and funding commitments have been announced that should help build the resilience of commercial forestry to climate change.

There are a range of policies and plans emerging that will help build the resilience of commercial forestry to climate change.

Published policies and plans:

- **UK Forestry Standard Practice Guide provides further information on how to assess the risks associated with climate change**, and how to plan and adapt forest and woodland management. This guide represents a step forward for adaptation planning, but its effectiveness will rely on uptake by forestry and woodland managers, and it is unclear if or how this uptake is being monitored.

- **A range of new initiatives will target improved tree health in England.** Our 2021 Progress Report noted more work was needed to reduce risks to forestry from pests, pathogens and INNS that may increase in numbers due to climate change, especially in milder winters. Forest Research has launched a Climate Change Hub that brings together information and practical guidance about protecting our UK woodlands and forests from climate change via adaptive management. Last year, Defra and Forestry Commission launched the Holt Laboratory and the Centre for Forest Protection. The virtual Centre acts as a knowledge and research hub to help protect and enhance the future health and resilience of our forests, woodlands and trees. The Tree Health Pilot scheme, which runs to 2024, will test different ways of slowing the spread of pests and diseases affecting trees in England.

- **New funding commitments have been announced targeting innovation in forestry.** The Woods into Management Forestry Innovation Funds (£1.7 million) encourage innovation in forestry and support active management of woodlands to improve their ecological condition. The Tree Production Innovation Fund (£2 million) offers funding to help build woodland and forest climate resilience, including diversification of native species.

- **Additional support committed towards building capability within forestry.** The Woodland Creation Accelerator Fund (total £9.8 million) has provided support to over 60 local authorities - directly funding staff to enable woodland creation projects. In exchange for the grant support, authorities have committed to plant just over 6,800 hectares by 2025. Capital grants for this planting will come from existing Nature for Climate Fund programmes.

Awaiting policies and plans:

- **Government will set out its plans to improve the resilience of our trees and woodlands through the updated Tree Health Resilience Strategy.** This will include interventions to improve the capacity of woodlands to adapt under climate change through minimising the impact of pests and diseases, as well as building resilience through selection of species and provenance. It is understood the Plan will be published in Spring 2024.

(d) Outcome 3: Climate-resilient fisheries and aquaculture

This outcome has been scored as **partial policies and plans.** Adaptation plans are in place for offshore fisheries and aquaculture, and include a range of actions that will support adaptation across the sector. However, current plans do not consider climate impacts under a range of warming scenarios. The periodic requirements of the Fisheries Act have been met, while new Government funding commitments should support increased efforts to build resilience in the sector.

There are policies and plans in place to help ensure commercial fisheries and aquaculture are climate resilient. A joint statement released by the four UK administrations recognises the need for sustainable fisheries management, but it lacks sufficient detail on the adaptation actions to support this.

Published policies and plans:

- **The first joint Fisheries Statement by the four UK administrations**, as required by the Fisheries Act (2020), recognises the need for sustainable management of UK fisheries and to mitigate risks from and adapt to climate change. Delivering its objectives is fundamental to ensuring a resilient seafood sector and restoring and enhancing the marine environment. However, while the Statement sets out the policies in place for the fisheries' policy authorities, it lacks detail on the extent to which the supporting actions will be delivered.

- **New targeted fisheries funding will help support climate resilience within the sector.** The Fisheries and Seafood Scheme aims to help safeguard the long-term resilience and prosperity of the seafood sector by providing financial assistance to projects that enhance the marine environment. The UK Seafood Fund offers £100 million to support the long-term sustainability of the UK fisheries and seafood sector; the focus is economic prosperity of the sector but projects to improve the environmental sustainability are also funded. It is a missed opportunity to not specifically fund climate resilience projects.

- **Annual assessments of the sustainability outcomes of our annual fisheries negotiations**. This will be important for addressing climate risks; marine fish populations are not bound by territorial boundaries, so to improve the resilience of fisheries, global collaborative efforts are essential.

Awaiting policies and plans:

- **Forthcoming update to climate change adaptation plans in the UK wild capture seafood industry.** Seafish* is updating the 2015 climate change adaptation report for seafood sourced from capture fisheries in the UK and overseas. This will lay out the steps that the sector could take to respond to risks and opportunities associated with anticipated climate change impacts. Depending on industry appetite, future climate scenarios may be considered in the update.

- **Fisheries management plans due**. These will be evidence-based action plans, developed in collaboration with the fishing sector and other stakeholders, to deliver sustainable fisheries for current and future generations. The proposal for these plans is welcomed and we recommend they specifically address how climate risks will be mitigated. It is not clear at this stage when the plans will be published.

* Seafish is the fishing industry body with a remit to support the profitability and sustainability of the seafood industry.

(d) Recommendations to close policy gaps

Numerous policy changes are needed to ensure working land and seas in England are climate resilient, including investment in the development of data to monitor adaptation preparedness.

Table 3.2 lists the recommendations for improving climate resilience of WLS. This should be read in conjunction with the recommendations in the Nature chapter given their interdependencies.

Table 3.2
Recommendations

Primary responsibility	Recommendation	Timing
Defra	Defra should produce a strategy to ensure the agriculture sector remains productive under a changing climate, set targets for this and collect data to monitor success.	2024
Defra	The Land Use Framework should address the trade-offs and co-benefits of multifunctional landscapes to benefit climate mitigation, adaptation, food security, nature recovery, timber, recreation and rural livelihoods.	2023
Home Office	The Home Office should create and implement a cross-departmental strategy with external stakeholders to identify and mitigate risks of wildfire.	2023
Defra	Government should work with the private sector to enable more funding for building climate resilience for the agriculture, commercial forestry, and fisheries and aquaculture sectors, including (but not limited to) innovation, R&D, and jobs/skills.	2023
Defra	Government must strengthen policy and funding to restore coastal marine habitats by regulating bottom trawling, enforcing sustainable fishing quotas, and better protecting Marine Protected Areas to provide nursery areas to threatened commercial wild fish stocks.	2024
Defra	Defra should include a stretching and comprehensive soil health target as a priority in its forthcoming Soil Health Action Plan.	2023

Endnotes

[1] House of Lords Library, *Impact of climate change and biodiversity loss on food security*, 1 September 2022: https://lordslibrary.parliament.uk/impact-of-climate-change-and-biodiversity-loss-on-food-security/#:~:text=It%20reported%20that%20the%20UK,was%20resilient%20to%20potential%20shocks.

[2] JNCC (2023) *Biodiversity Indicators: Pollinating insects*: https://jncc.gov.uk/our-work/ukbi-d1c-pollinating-insects/.

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Chapter 4

Food security

Table 4.1
Progress summary – Food security

	Delivery and implementation	Policies and plans	Summary
Outcome 1: Disruption to food and feed import supply chains due to climate change is minimised	Unable to evaluate	Insufficient policies and plans	• Reporting by private sector companies is not currently mandated so it is not possible to evaluate progress on delivery. Recent imported vegetable shortages have highlighted the fragility of food supply chains. • Key policies, such as the National Food Strategy currently do not adequately consider climate adaptation.
Outcome 2: Vulnerability to food price shocks is reduced	Insufficient progress	Limited policies and plans	• Household food insecurity has increased this past year, leaving households currently more vulnerable to food price spikes. • Some support to low-income households is available but it appears to fall short of demand.

Relevant risks from CCRA3:
ID1 Risks to UK food availability, safety, and quality from climate change overseas; ID2 Opportunities for UK food availability and exports from climate impacts overseas; ID6 Opportunities from climate change on international trade routes; ID7 Risks associated with international trade routes; H9 Risks to food safety and food security; B6 Risks to business from disruption to supply chains and distribution networks; N4 Risk to soils from changing climatic conditions, including seasonal aridity and wetness; N10 Risks to aquifers and agricultural land from sea level rise, saltwater intrusion.

This chapter considers how the UK's food and feed supply chains (both domestic and international) can be made resilient to climate change. Access to high quality and reasonably priced food despite climate and weather extremes is also covered here, as well as climate-related changes in nutritional quality of food and food-borne diseases. Climate risks to domestic food production are covered in depth in Chapter 3 (Working land and seas).

Domestic and international food supply chains may be disrupted by extreme weather.

Food security will be affected by climate impacts on food production domestically and overseas in regions from which the UK imports food and feed*, as well as climate hazards affecting the supply chains (domestic and international) for food and feed. Food supply chains can be impacted by many types of weather extremes and climate conditions. This includes regions which don't export directly to the UK but are important for setting international food commodity prices, and regions which are important for the production of critical inputs to food production, such as fertilizer. Extreme heat, flooding, drought, sea level rise and increased agricultural pests and diseases associated with increasing global mean temperature are likely to affect crops, livestock, aquaculture and fisheries yields around the world.

* For livestock and fish.

Box 4.1
Climate risks and opportunities for UK food security

The last UK Climate Change Risk Assessment (CCRA3) found that the potential for systemic risks is growing through a more interconnected world, where risk cascades can lead to global food system-wide consequences (see Box 4.2). The resulting risks to food security in the UK will be varying access to food associated with supply-side disruptions and food price spikes. Food system interconnectedness can also improve resilience by allowing one production area to substitute for another. The risk to UK food availability, safety, and quality from climate change impacts overseas was scored as high in the present day and medium to high under future conditions, with more action needed to address the risk over the next five years.[1] The urgency of dealing with this risk has increased since CCRA2 due to more evidence of specific events and their impact on food availability and food prices; and the growing evidence of a lack of systemic resilience.

Global patterns of climate change may also alter the comparative advantage of the UK in trading food. The impact of climate change on global production patterns depends upon the relative importance of extreme events to more gradual changes in climate, which may vary geographically. For example, new areas may open for production due to gradual warming, so long as extreme events do not disrupt agriculture and productivity. However, there is a lack of evidence at present to suggest that food production opportunities will outweigh risks. The magnitude of this opportunity is considered low now and in the future.[2]

Source: Challinor, A. and Benton, T. G. (2021) *International dimensions. In: The Third UK Climate Change Risk Assessment Technical Report.*

Food security touches on many areas of policy, which is in some cases devolved to Northern Ireland, Scotland and Wales. Other aspects of food policy are reserved to UK Government.

Responsibility for the food system cuts across multiple areas of policy, and across Governments. Policy responsibility for food is largely devolved to Scotland, Wales and Northern Ireland. International trade policy is reserved to the UK Government, while matters relating to agriculture and fisheries are mostly devolved.* The Agriculture Act 2020 created a duty for Defra to report on UK food security every three years, with the first report published in 2021.[3] The role of Government includes setting standards for food quality and environmental impact; supporting domestic food production as part of food security; setting trade policy to enable diverse food supply chains; and supporting access to food, particularly for vulnerable groups. Outside of these roles Government does not directly participate in the food system with most roles falling to the private sector.

* Fisheries are legislated under the UK Fisheries Act 2020 and through the joint fisheries statement, but licensing for fishing boats is devolved and fisheries management plans may be published by Devolved Administrations under the Act. UK Parliament legislates for offshore waters.

Box 4.2
UK exposure to complex climate risks to the international food system

The UK is embedded within a complex international food system.

- Around 50% of food consumed in the UK is imported. Much higher import shares are seen for fruit and vegetables (65% of the fruit and vegetables consumed are imported,[4] and 84% of fresh fruit is imported)[5], and at particular times of year, for example, lettuce imports decline significantly in summer compared to winter.
- The UK imports approximately 50% of its ammonium nitrate (an important agricultural fertiliser), with 75% of imports for fertiliser use coming from the EU (predominantly Lithuania, Poland, and the Netherlands) and the remaining 25% from Georgia and Russia. There is only one UK manufacturer of ammonium nitrate fertiliser.
- £21.4 billion worth of food, feed and drink is exported, with the largest share (18%) exported to the Republic of Ireland.

The complexity and interlinkages of the food system allow climate change risks to be transmitted through trade, financial, cultural and political connections between countries. This means that an extreme weather event in one country can trigger an impact elsewhere in the world and risks can cascade across the globe in complex ways.[6]

Risks to UK food supply chains from climate changes overseas depend on many factors and can be highly specific to the supply chain or country impacted.

- Some parts of the world will face more severe climate risks to agriculture than others. Many of the countries the UK imports fruit and vegetables from are water stressed or classified as climate vulnerable.[7] The time sensitive nature of these supply chains make them particularly vulnerable to any climate related disruption, as any delays between harvest and consumption jeopardise quality and safety.
- Some supply chains are geographically concentrated. For example, Spain provides more than 10% of UK fruit and vegetables, and Italy provides between 5 – 10%.[8] The vulnerability of such concentrated sourcing was shown in 2017 when there was a shortage, and resulting dramatic price rise, in vegetables in the UK.[9] This shock resulted from two different but simultaneous climate hazards: flooding damaged crops in South-East Spain and cold temperatures damaged crops in Italy. The impacts on production were so severe that neither country exported food to the UK.
- Government responses to food system shocks may amplify risks. For example, when faced with a production shock, an exporting country may decide to halt exports to meet domestic demand or prioritise trade with another country which will have knock-on-effects which can exacerbate the shortage.[10]

Resilience planning for food supply chains requires the full range of climate change impacts to be integrated into other strategic considerations.

Source: Carter et al. (2021); Adams et al (2021); Goudie (2023); Defra (2021); Hess and Sutcliffe (2018); Challinor and Benton (2021).

1. Monitoring progress towards a well-adapted food system

The food system is key to achieving a wide range of societal goals. These include improving public health, reducing greenhouse gas emissions and restoring nature. In this chapter, we consider the requirements for a food system to be well adapted to climate risks, while recognising the importance and synergies with other goals for the food system (Figure 4.1).

We identify several key outcomes needed to deliver climate resilience:

- **Disruption to food and feed import supply chains due to climate change is minimised.** Large companies within the UK's food supply chains need to manage their operations and dependencies to address climate risks, including building capacity along the supply chain (domestic and international), diversifying sourcing regions and suppliers, increasing redundancy and undergoing contingency planning. A key part of this is UK international trade agreements upholding high food standards, to reduce food safety and quality risks.

Food price spikes may occur as a result of climate change. Low-income households are likely to be impacted more by any price volatility.

- **Vulnerability to food price shocks is reduced.** The impact of climate change on food in the UK will most likely be through food price spikes and temporary reduced availability of particular products. Low-income households, some households with children and other vulnerable groups are likely to be most impacted by these price shocks. Reduced vulnerability of society to these price shocks is part of holistic resilience to climate impacts on the food system.

- **Domestic food production is resilient to climate shocks.** Outcomes required to ensure that domestic food production is climate resilient are covered in Chapter 3 (Working land and seas). UK supply chain resilience is covered (for all sectors) in Chapter 13 (Business). We therefore do not assess this outcome within this chapter.

Enabling factors that need to be in place to deliver these outcomes will include:

- **Data and monitoring.** As much of the food system relies on the private sector, information on the performance of the food system will be particularly important to understand and guide how well-adapted it is to climate change. Food quality monitoring can provide information on any changes in nutrition or prevalence of food-borne pathogens. Climate stress testing by large food and feed companies would also provide important information on the resilience of the system to climate hazards. Reporting on food waste reduction initiatives is also important to understand the efficiency of the system.

Regional and local food strategies can support local resilience.

- **Governance.** Monitoring of food quality and surveillance of climate-sensitive food-borne diseases should be undertaken by respective Food Standards Agencies. Regional and local food strategies can also support local resilience. Food security should also be included on the national risk register to ensure appropriate oversight and monitoring, given its critical importance.

- **Engagement and education.** Climate risk assessment and supply chain management skills will be needed across large food and feed companies.

For small and medium-sized enterprises (SMEs), guidance and tools to support climate resilience would enable better management of their climate risks.

- **Funding and investment.** To reduce vulnerability to food price shocks, low-income households may need to be financially supported through food support initiatives, either at local or national level. Public funding to support food waste reduction can also help reduce vulnerability to food price shocks.

Research on the exposure of the food system to climate shocks and extreme weather overseas is needed.

- **Research.** Further research is needed on the vulnerability of different households to price shocks from climate impacts across food supply chains. Exposure of the food system and key food staples to climate shocks and stresses outside the UK also needs to be better understood.

To deliver the identified outcomes and help put in place their enabling conditions, there are several key policies and plans that will need to be implemented:

- **Legislation and regulation.** Mandatory reporting by large food and feed companies is needed to understand to what extent climate risks are being considered and addressed across key private sector actors.

- **Standards.** Minimum environmental and animal welfare protection standards for future free trade agreements are needed to support domestic food production and avoid further exposure to climate risks by encouraging cheaper (and potentially more climate vulnerable) imports. Robust resilience standards for supply chains would also be helpful for businesses to manage their climate risks.

- **Planning.** Key Government strategies for the food system, such as the National Food Strategy should include consideration of the resilience of food imports to climate risks as well as climate resilient agriculture, aquaculture and fisheries.

- **Financial instruments.** Targeted support to low-income households will be required to reduce vulnerability to food price shocks, requiring public funding. While there are many possible policy mechanisms for this kind of support, the mode of delivery is not a critical factor for responding to the climate risk.

Regular reporting from food and feed companies could build a greater understanding of the resilience of food and feed supply chains.

- **Information and reporting.** Information on food and feed companies' exposure and vulnerability to climate risks and adaptation actions being taken to address these could help to inform long-term supply chain planning. Regular reporting on this information from large companies, if reviewed by Government, would build a greater understanding of the resilience and potential fragilities of food and feed supply. An annual food security review could include this information as well as considering other data on the resilience of food imports, for example resilience of transport infrastructure.

The food system is included as a standalone chapter for the first time in this report. The Committee expects this chapter and its monitoring map to continue to develop as further evidence becomes available of climate impacts on the UK food system.

Box 4.3
Contextual factors for food security

The UK's food system is exposed to risks from climate change overseas by its reliance on food imports, through the supply chains (domestic and international) used within the food system and through transboundary climate risks. Climate risks to domestic production of food are covered separately in the Working Land and Seas chapter.

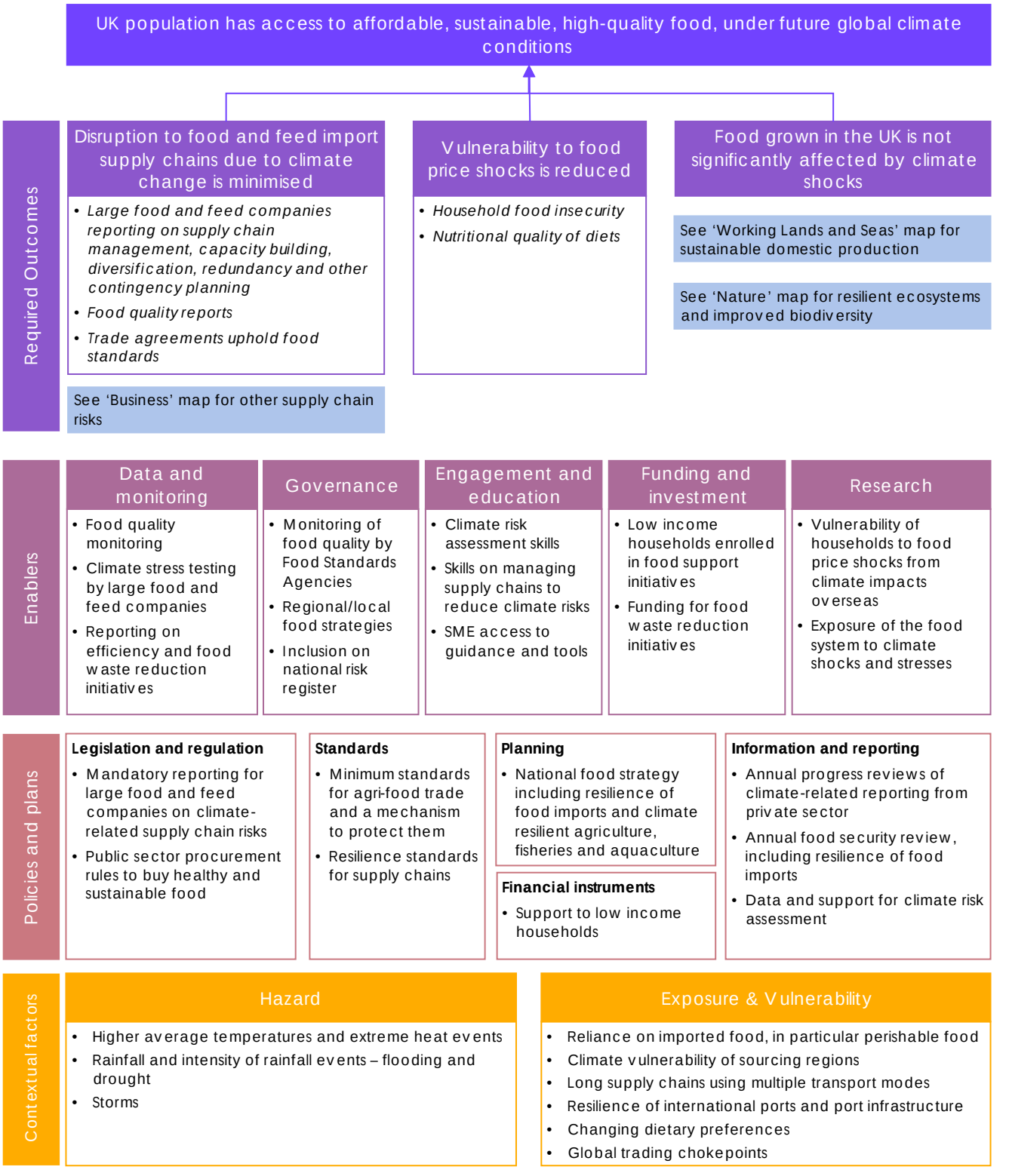
The total supply of fruit and vegetables produced domestically and imported is currently insufficient to allow UK citizens to eat the UK dietary recommended guidelines of seven fruit and vegetables a day.[11] In order to meet nutritional guidelines, demand for fruits and vegetables would increase significantly, even though current supply is already exposed to climate risks. In addition, the types of food consumers prefer is important. Between 1987 and 2013 there has been an increase in consumption of tropical fruits (such as bananas) and decreased consumption of some traditionally grown UK vegetables such as cabbage and peas.[12] The supply of legumes is also increasingly sourced from climate vulnerable countries.[13] The combination of preference and price impacts consumption, as some changes in preference have occurred due to lower prices for food imports as the global food system has evolved.

The resilience of international ports, port and hinterland infrastructure, and global trading choke points, such as the Dover Strait, also influence the exposure and vulnerability* of the food system to climate risks. Maritime trade routes are particularly vulnerable to climate change due to dependence on overseas maritime infrastructure and the future viability of maritime routes.[14]

Source: Goudie (2023); Scheelbeek et al. (2020); Verschuur et al. (2020)

* Exposure and vulnerability are not separated for this system as the distinction between them is sometimes indefinite and largely inconsequential.

Figure 4.1 Monitoring map for UK food security



Source: CCC analysis.
Notes: Italicised text indicates suggested measures for each outcome.

(a) Goal: UK population has access to affordable, sustainable, high-quality food, under future global climate conditions

A recent study demonstrated a link between the number of heatwave days and a slight increase in household food insecurity in the UK.

Desired indicators at the goal-level are not currently available for this system. However, empirical analysis suggests that, compared to the 1981–2010 baseline, increases in the number of heatwave days in 2020 resulted in 1.2% higher moderate or severe food insecurity in the UK.*,[15,16] This demonstrates the potential impact of extreme weather on the UK population's access to food.

(b) Outcome 1: Disruption to food and feed import supply chains due to climate change is minimised

Indicators for this outcome are currently very limited. Private sector reporting is very limited, and we are therefore **unable to evaluate** progress against this outcome. Recent shortages in early 2023 of imported vegetables in part due to extreme weather conditions affecting production and supply chains indicate that food supply chains are not currently resilient to climate change.

- **Private sector reporting is limited.** Reporting by private sector companies is not currently mandated by the Government, resulting in a significant information gap. While major food and feed companies may be managing their operations and dependencies to address climate risks along the supply chain (domestic and international), without public reporting it is not possible to assess the extent to which this is the norm, and it remains difficult to 'stress test' their resilience.

Shortages of imported vegetables in early 2023 have highlighted that supply chains may not be resilience to extreme weather overseas.

- **Recent supermarket shortages have highlighted fragile supply chains.** In February 2023, some UK supermarkets announced shortages of imported fresh vegetables, including tomatoes, peppers, cucumbers and lettuces. The shortages were caused by several interacting factors, including unusual weather conditions in Spain (unexpected cold) and Morocco (heavy rain and flooding) and transport disruption with cancelled or delayed ferries due to storms.[17] Other factors not related to climate change are also likely to have contributed to the shortages (such as higher energy and fertiliser prices leading to reduced domestic production) demonstrating the complexity of interacting risks (see Box 4.2).

- **Safety standards of imported foods have remained stable over 2020-2021.** The Food Standards Agency (FSA) reports on food imports and their impacts on food safety. A review of data on failed control checks (document check, identity checks, physical checks and sampling checks) found that failure rates remain low and are stable over the period reported.[18] Reporting has only recently begun so there are limited references to trends over time but future reporting will provide more data to compare.

* This analysis is based on an identified statistical relationship between food insecurity and climate data but does not provide a causal mapping of the relationship.

- **Recent trade agreements with countries outside the EU have not guaranteed the same environmental standards as the UK.** Increased imports of tariff-free food from countries which have less stringent environmental standards than the UK may undermine UK domestic food production. Any resulting increased reliance on imports could leave the UK more exposed to climate-related shocks or disruption across import supply chains.

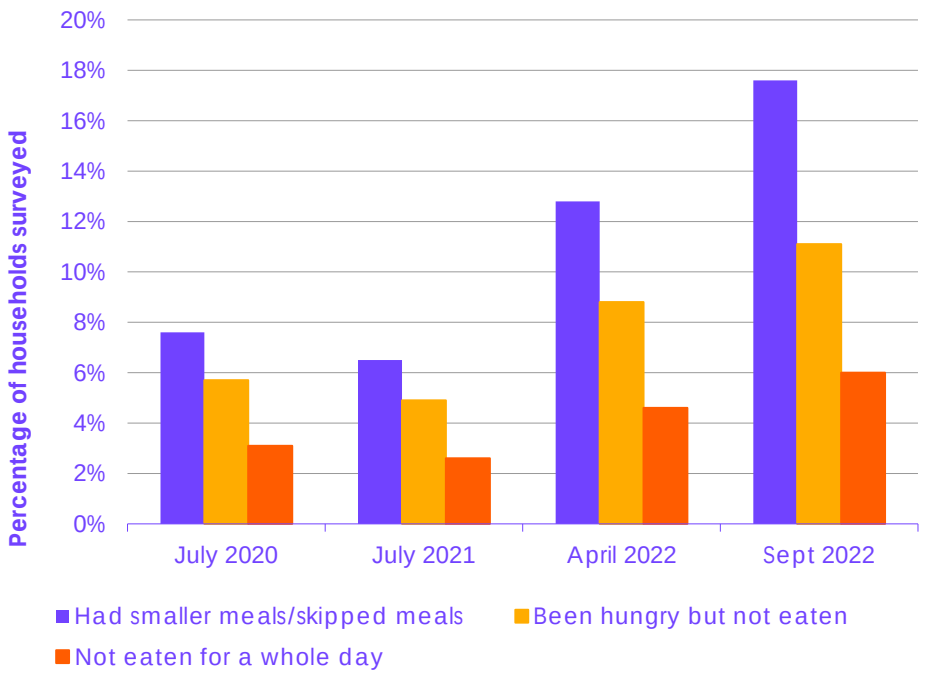
(c) Outcome 2: Vulnerability to food price shocks is reduced

There is **insufficient** progress towards meeting this outcome. Indicators for this outcome demonstrate an increase in vulnerability of the UK population to food price shocks.

The poorest 20% of households spend a higher proportion of their income on food and are therefore more exposed to food price volatility.

- **Household food insecurity has increased over the past two years.** While current trends in food insecurity are not driven by climate change, household food insecurity still provides an indication of the vulnerability of households to food price shocks overall, including food price shocks from climate-related disruption. The poorest 20% of households spend a higher proportion of their income on food and are therefore more exposed to changes in food prices.[19] 17.6% of adults in September 2022 reported they had skipped meals or had smaller meals in the last month, compared to 7.6% in July 2020 (see Figure 4.2 below).[20] Food insecurity is also higher in households with children (17.2%) compared to households without children (12.7%) in April 2022, indicating that these households are more vulnerable to food price shocks.[21] It remains to be seen how indicative this rise in food insecurity is of a longer-term trend or whether it will fall as the current inflationary spike recedes over coming months.

Figure 4.2 Household food insecurity in the UK



Source: Food Foundation survey.
Notes: Survey using United States Department of Agriculture's Food Security Survey module, a survey tool used to measure and monitor moderate and severe household food insecurity.

The UK currently produces a little more than half of the vegetables consumed domestically and only 16% of fruit.

- **Consumption of fruits and vegetables in the UK remains below nutritional guidelines, indicating vulnerability to further price volatility of imported foods.** The UK currently produces a little more than half of the vegetables consumed domestically and only 16% of fruit; reliance on imports of fruit and vegetables makes it exposed to climate-related disruption and resulting price spikes. People who already consume less fruit and vegetables on average will be more vulnerable to these price spikes as their diet will be more significantly affected by reduced access to fruit and vegetables.[22] Current consumption of fruits and vegetables can therefore be used as a proxy indicator for how vulnerable households are to future price volatility. The average consumption of fruit and vegetable portions between 2009 and 2017 was unchanged and consistently below the recommended five portions per day for both adults and children. Fruit and vegetable consumption increased overall with household income, indicating again that low-income households may be particularly vulnerable to price volatility of fruits and vegetables.[23] It should be noted that price is not the only determinant of poor fruit consumption, other factors are likely to affect this data as well.

(d) Enabling factors

There are very limited data available relating to enabling factors, although more people have been accessing food support schemes in recent years (not for climate-related reasons), indicating an increasing need.

- **More people are relying on food support schemes.** Some data are available relating to food support schemes, such as Free School Meals and Healthy Start Vouchers. The percentage of pupils eligible for Free School Meals has increased in England from 14.3% in 2015-2016 to 20.83% of pupils eligible in the year 2020-2021. This is in part due to changes to the eligibility criteria, as well as the impacts of the Covid-19 pandemic. Similarly, the take-up rate increased between 2019 and 2021 for Healthy Start Vouchers, a scheme to provide prenatal vitamins, infant milk formula, and healthy food for young children to people on low incomes.[24]

(a) Outcome 1: Disruption to food and feed import supply chains due to climate change is minimised

Key policy milestones for this system are not yet in place: mandatory reporting, public sector procurement rules, minimum food standards for trade and resilience standards for supply chains. However, the new requirement for a regular food security review was a positive step forward in the last two years (see Box 4.4).

The Committee has previously recommended that companies involved in food supply chains be included in the Adaptation Reporting Power.

- **Mandatory reporting.** There is currently no requirement for mandatory reporting by large private sector companies involved in importing food and feed to the UK, representing a clear gap in information about the status of supply chains. The Committee's latest report on the Adaptation Reporting Power recommended that companies involved in food supply chains be included in the next round of reporting.[25] Climate-related financial disclosures for the largest UK-registered companies will become mandatory from 2025, which will be a significant step forwards for understanding the resilience of UK food supply chains. Further guidance and data support will be required to ensure these reports are appropriately assessing exposure to climate risks across supply chains.

- **Minimum food standards for agri-food trade and a mechanism to protect them.** The UK's high standards for environmental protection should be protected under new free trade agreements. Recent trade agreements since the UK left the EU have raised concerns that UK domestic food production will be undermined which would leave the UK more exposed to climate shocks across the global food system.[26]

- **Resilience standards for supply chains.** There are no resilience standards for private sector supply chains for food and feed imports to the UK.

- **Annual progress reviews of climate-related reporting from the private sector.** Mandatory reporting from private sector companies managing food and feed supply chains should be reviewed by Government to analyse progress on adaptation to identify climate risks and overall resilience of supply chains.

- **Annual food security review.** Food security reviews are now required every three years, under the Agriculture Act 2020. More frequent reporting could be used to take into account private sector annual reporting under the Task Force for Climate-related Financial Disclosures (TCFD), review recent disruptions to supply chains and provide a more up-to-date picture of food security in the UK, to inform other policy decisions.

Further guidance and support to businesses is needed to enable robust climate risk assessments.

- **Data and support for climate risk assessments.** Some information is available to support businesses in conducting climate risks assessments, for example, through the Group on Earth Observations Global Agricultural Monitoring (GEOGLAM) initiative which provides crop monitoring for major food types. Further guidance and support for companies which will begin reporting under the TCFD is needed to enable comprehensive, robust risk assessments. Global initiatives can support improved decision making based on agricultural data and modelling, such as AgMIP, which aims to

assess the sustainability of agricultural systems, including impacts of climate variability and change.[27]

(b) Outcome 2: Vulnerability to food price shocks is reduced

Policies to reduce vulnerability of households to food price volatility are in place but may be insufficient to fully insulate vulnerable groups from price shocks. This outcome is scored **limited policies and plans.**

- **Support to low-income households.** Some support schemes are in place for low-income households, primarily focused on children, including Free Schools Meals and Healthy Start Vouchers. However, the rise in food insecurity in the UK indicates that Government support schemes are falling short of demand, leaving households vulnerable.

Box 4.4
Policy developments since 2021

Since the Committee's last progress report in 2021, the key policy developments relevant to the food system are:

- UK Food Security Review. Defra published the first UK food security report in December 2021, a new duty under the Agriculture Act 2020. The report included information under five themes: global food availability; UK food supply; supply chain resilience; household-level food security; and food safety and consumer confidence. While the remit of the report is wider than climate risks, there was reasonable recognition of the impacts of climate change on both domestic and global food production. The report also gathers several useful indicators from across Government departments which were not previously easily accessible and the discussion of household food security and access to food was also welcomed. Despite the section on food supply chain resilience, climate risks to supply chains were not explicitly considered and would be a welcome addition to future reports. The next report is due in 2024.
- Government Food Strategy. Defra published the Government food strategy in June 2022, following an independent review of the food system, the 'National Food Strategy'. The Government food strategy is considerably less ambitious on environmental improvement than the independent review and lacks detail on how to achieve many of its aims. The CCC's initial assessment in the 2022 Report to Parliament on Progress in reducing emissions, found the strategy falls short of what is required to tackle emissions from agriculture, land use and food production, and to create a sustainable food system.[28] The strategy commits to strengthening domestic supply chains and working with international partners to 'keep trade flowing and keep prices down' but remains vague on how this might happen. It also restates the Government's commitments not to compromise the UK's standards of environment protection and animal welfare through trade agreements but with little further detail.
- New trade deals. In December 2021, the UK signed a free trade agreement (FTA) with Australia as one of the first trade deals signed since the UK left the European Union. The agreement will remove most tariffs on trade between the UK and Australia when it comes into force, which has raised significant concerns about its impact on UK agriculture in relation to environmental, animal welfare and food safety standards.[29] The Government's Impact Assessment estimated there would be a negative impact on the agri-food sector. Tariff-free imports of food (in this case, particularly beef and lamb) from countries which have less stringent environmental standards than the UK may undermine domestic farming and wider environmental goals which are also important for adaptation. A binding commitment to the Paris Agreement in the trade deal was dropped during negotiations, which may also undermine the UK's climate commitments. Similar concerns were raised about the New Zealand trade agreement signed in February 2022, although the economic effect of the agreement is likely to be very small.

Source: Defra (2021); Defra (2022); Webb, D. (2022); CCC (2022).

(c) Recommendations to close policy gaps

Based on the assessment of policy and planning progress, we have identified recommendations to close key policy gaps for food security (Table 4.2).

Table 4.2
Recommendations

Primary responsibility	Recommendation	Timing
Defra	Set out specifically how the Government's food strategy will be implemented with regard to making UK food supply chains more resilient to climate risks. This should include improving data on current disruptions and future risks.	2024
Defra	Extend the scope of the fourth round of the Adaptation Reporting Power (ARP4) to include food supply chains.	2023
DBT	Uphold minimum environmental and climate standards for trade, which support the resilience of the food system as well as other Government goals such as Net Zero (as outlined in the National Food Strategy Independent Review).	Ongoing
DESNZ	Set out a clear Government vision on environmental and climate standards for trade in the upcoming 2030 Strategic Framework, setting out specific conditions that do more to ensure trade does not undermine our climate and environment objectives.	2023
DBT	Launch a specific work programme to investigate how and where resilience standards might be developed and applied to food supply chains.	2025

Endnotes

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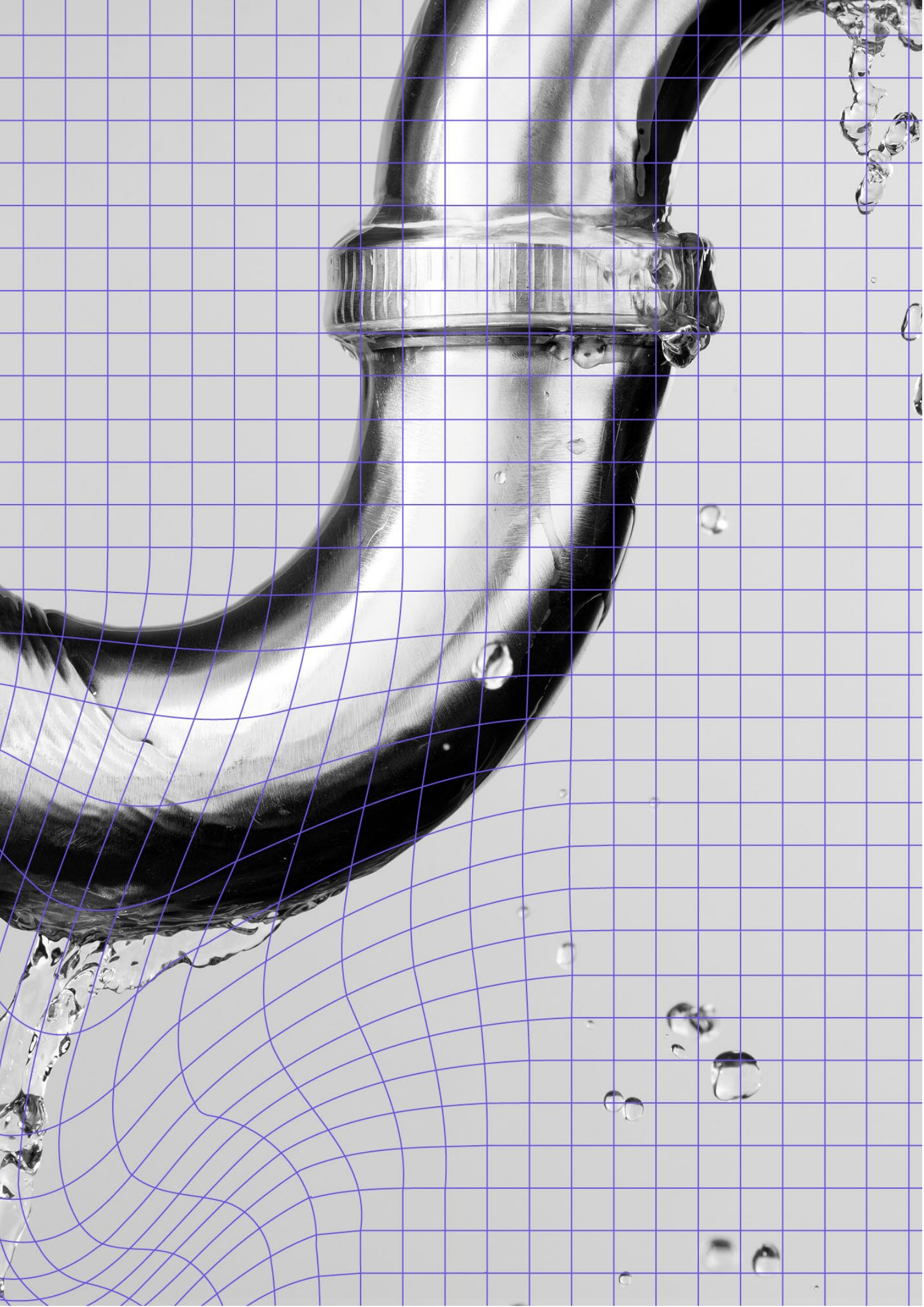


Chapter 5

Water supply

Table 5.1
Progress summary – Water supply

	Delivery and implementation	Policies and plans	Summary
Outcome 1: Reduced demand	Insufficient progress	Credible policies and plans	• Credible plans are in place to reduce demand, including new statutory targets for per capita consumption and a requirement to demonstrate resilience to a 1 in 500 year 'extreme' drought in the next round of water resource plans. • New Ofwat allocation of £100 million for demand reduction in next price review, mandatory water efficiency labelling confirmed and Government's roadmap for more water efficient buildings published. • Insufficient progress in reducing demand relative to targets.
Outcome 2: Improved system performance	Mixed progress	Credible policies and plans	• New statutory Environment Act targets for leakage and water company plans are required to demonstrate resilience to flooding and coastal change. • Limited progress in reducing leakage relative to targets. No large-scale interruptions to water supply due to weather have been reported, but more data is needed to better monitor this.
Outcome 3: Increased supply	Mixed progress	Limited policies and plans	• No new reservoirs have been built in the UK in the last 30 years but new schemes are emerging. • Emerging draft regional water resource plans show positive progress in more joined up planning between water companies and large water users. However, they propose few new interconnections of water resources between regions and the demand-supply gap in 2050 is bigger than previously estimated.
Outcome 4: Interdependencies identified and managed	Insufficient progress	Insufficient policies and plans	• Adaptation Reporting Power reports demonstrate limited progress on interdependencies by some water companies but gaps in reporting remain, including on supply chain risks.

Relevant risks from CCRA3:
Risks to infrastructure networks (water, energy, transport, ICT) from cascading failures (I1); Risks to infrastructure services from river, surface water and groundwater flooding (I2); Risks to infrastructure services from coastal flooding and erosion (I3); Risks to subterranean and surface infrastructure from subsidence (I7); Risks to public water supplies from reduced water availability (I8); Risks to health from poor water quality and household supply interruptions (H10).

The uninterrupted provision of clean water to households needs to be maintained in a changing climate

This chapter covers adaptation to climate change for public water supply. As only around 1% of water in England comes from private water supplies, this has been excluded from our analysis.[1] The uninterrupted provision of clean water to households and businesses is key to comfortable homes, functioning business premises and public health – this needs to be maintained despite the range of current and future weather hazards that could be experienced.

Almost half (47% in 2018) of the freshwater abstracted from rivers and aquifers in England is used for public water supply. Significant abstraction of freshwater is also required for energy (around 35%), industrial processes and a small amount for

agriculture, and at the same time sufficient river flow levels need to be maintained for environmental health.[2]

This means that the resilience of the public water system is inherently coupled to water management practices in these other areas and a whole system approach is required to assess the water system's climate resilience. The public water system will be affected by several expected changes in UK climate hazards.

- Projected decreases in summer rainfall and increased summer temperatures and heatwaves can lead to more prevalent and intense drought conditions and increasing water demand.

- Increases in winter rainfall, flooding due to extreme rainfall and sea level rise, shrink-swell, soil erosion and cold weather events (though the latter will become less common) can cause damage to water system infrastructure.[3]

Drought is already affecting water supplies and is projected to become significantly worse.

Drought is already affecting water supplies. Future projections of more frequent and intense dry periods combined with expected population growth lead to concerns around future availability of public water supplies. England's population is projected to grow more quickly than other UK nations (3.5% between mid-2020 and mid-2030 and 6.7% by 2045).[4] Southern and south-eastern England are at highest risk of drought (Box 5.1).

Box 5.1
Recent drought and pressures on the public water supply system

2022 saw significant pressures on public water supply, due to a very dry spring and summer. Parts of the UK still remain in drought at the time of publication. The National Drought Group reported that if rainfall levels through winter are 80% or less of the long-term average, large parts of the country will be at risk of drought continuing into summer 2023. In more severe scenarios, projections suggest drought conditions would be widespread, covering most of the country. Beyond impacts on public water supply, drought affects our ability to grow food and can have significant financial impacts on the agriculture sector. It also affects fish populations, natural habitats and can cause longer-term damage to watercourses.

Recent analysis completed for the CCC projects that, by the 2050s, changes in supply due to climate change and changes in demand due to population growth may lead to water deficits across many water resource zones in the UK. The vast majority of zones impacted would be in England, with those in the southeast the worst affected. Climate impacts on water supply are greater in the late-century compared to the mid-century. Population changes, similarly, affect demand and place additional pressure on water resources, leading to increased deficits across water resource zones in the UK, which are greatest in England. Reducing household consumption and leakage from networks can significantly reduce the projected deficits in the mid-century but is unlikely to be sufficient to return all water resource zones to a surplus in the late century.

Source: National Drought Group projections for winter water resources - Creating a better place (blog); HR Wallingford (2020) *Updated projections of future water availability for the third UK Climate Change Risk Assessment, Technical Report.*

Exposure of the water supply system to climate risks is influenced by the age, condition, and location of water supply infrastructure. Population growth, changes in water needs and usage patterns and pressure to manage the cost that consumers pay for water are among the key factors that will make us more vulnerable to water shortages. In England, the responsibility for water policy sits with Defra and the Environment Agency (EA). Ofwat regulates the operations of the (private) water companies who operate the public water system. The majority of funding for the water system is provided from customer water bills.

1. Monitoring progress towards a well-adapted water system

Successful adaptation to climate change within the water system aims to ensure a plentiful supply of water despite future climate change. This means there is sufficient water for public supply and private water use (which is limited in England). At the same time, there must be sufficient water for sustainable abstraction by energy, industry and agriculture (see Energy, Business and Working Land and Seas chapters), as well as sufficient water left to support the natural environment (see Nature chapter).

A package of demand and supply side actions are needed to make the public water supply system more resilient to climate change.

In Figure 5.1 we set out a monitoring map for assessing adaptation progress in the water system. We have identified four key outcomes that are needed for this goal of climate resilience to be delivered:

- **Reduced demand.** The demand for water through the public water system needs to fall. Average water use in households in England is currently 144 litres per day (l/p/d) (see indicators section). Government policy requires this to be reduced to 110 l/p/d by 2050 and new interim targets for 2038 under the Environment Act put this commitment on a statutory footing.[5] Reducing demand for water will require behavioural changes (e.g. favouring shorter showers over baths, rainwater harvesting for gardening), more water efficient appliances and buildings.

- **Improved system performance.** Significant amounts of water are currently lost from the water system through leaks and bursts; these occur both within the water network and around homes. Around 3,008 million litres of water per day was lost through leaks in 2020/21.[6] Reducing leakage will make the water system more efficient overall and help it be less vulnerable to drought.

- **Increased supply.** In some parts of the country demand and leakage reduction measures will be insufficient by themselves and new ways of accessing supply during periods of drought may be required (particularly in parts of South-East England under higher warming scenarios). This can include increasing reservoir capacity within, and enabling transfer of water between, water regions in times of drought. An increase in supply must be done sustainably – mindful of the needs of other water users and the natural environment.

- **Interdependencies identified and managed.** Maintaining a sufficient water supply requires functioning and reliable energy, telecoms, and transport services, all of which are similarly exposed to their own climate risks. Water companies must know and manage their risks resulting from reliance on other infrastructure networks to be resilient to climate change in the round. This includes managing supply chain risks.

Effective governance, data and monitoring and investment are needed to enable this.

There are several categories of enabling factors that will be needed if the outcomes identified above are to be implemented at appropriate scales:

- **Data and monitoring.** Effective monitoring and visibility of the network enables better identification of where water is going and who is using it, allowing interventions on demand and leakage to be better targeted. Monitoring and planning for transfers will help ensure areas affected by water scarcity do not face restrictions in water use during dry periods.

- **Funding and investment.** Delivering the outcomes identified above will require appropriately sized investment that is well-targeted. Investment in the water supply system is delivered by the private water companies, funded by customer bills and regulated by Ofwat. Outcome-based regulation (which enables flexibility in which actions are undertaken to achieve the desired outcomes) can be useful here as it will likely help foster cross-company and cross-sector collaboration on the resilience investment required to ensure the whole infrastructure system is resilient.

- **Engagement and education.** To deliver the demand reduction required there is a need for greater public awareness of the risks of future water shortages and the steps people can and should take to reduce their use of water. This is particularly important in times of drought and stress on the public water system.

- **Governance.** There are a range of organisations that have responsibility for key aspects related to the climate resilience of the public water supply system, including Defra, the Environment Agencies, water companies, regional groups and Water UK. Ensuring that these organisations are working well together with clear delineations of responsibilities is critical to ensure that the identified outcomes can be delivered.

Our monitoring framework highlights policy milestones which must be in place to help achieve these required outcomes for a well-adapted water supply and their enabling factors. These fall under the following categories:

Policy must provide the mechanisms to deliver the required outcomes.

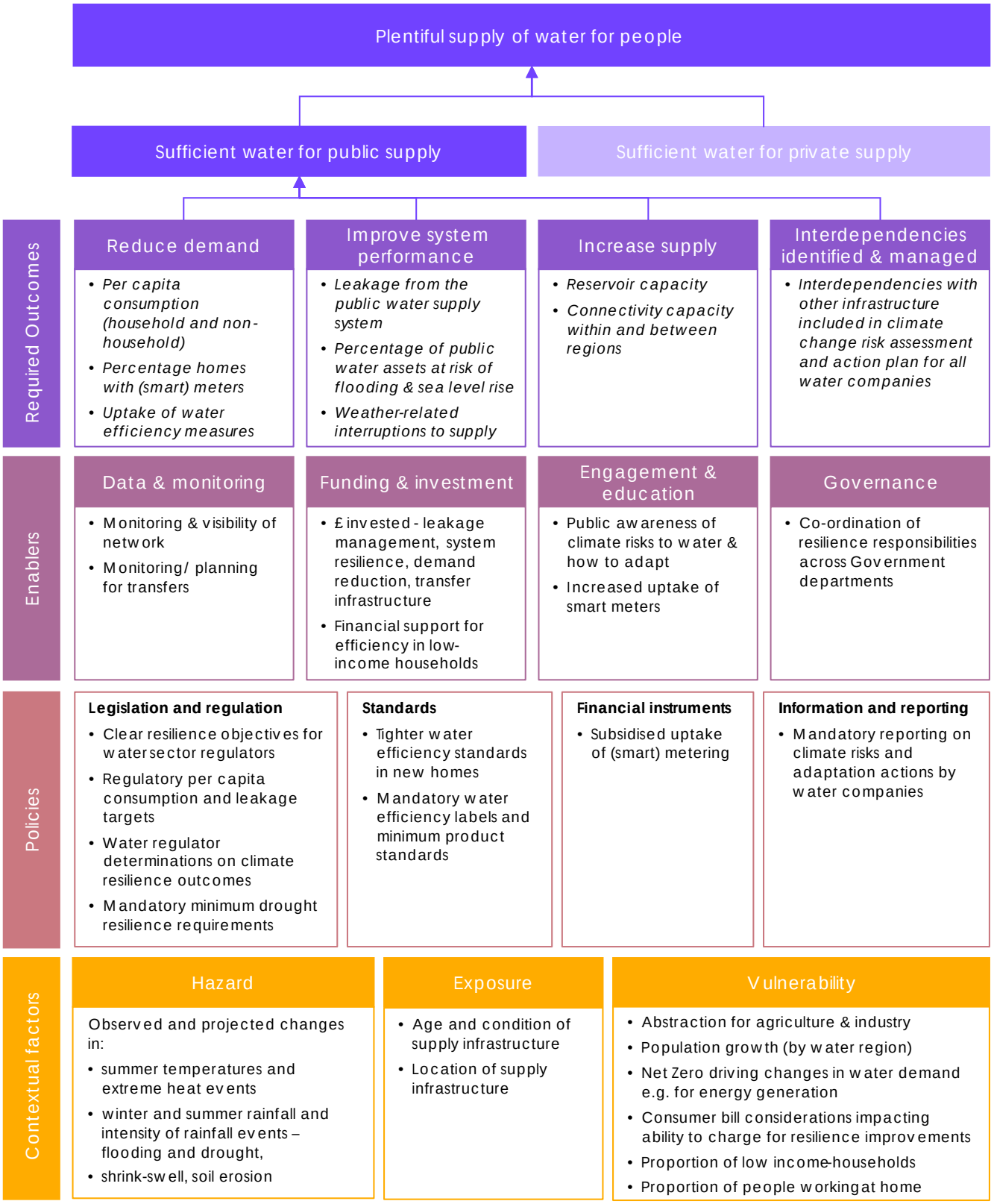
- **Legislation and regulation.** National policy must create legislation which enforces sustainable long-term plans for water management and provide appropriate frameworks for regulation. Planning must span across water catchments to ensure suitable national scale planning to manage water shortages. Legislation should also ensure that funding allocation is appropriate to meet adaptation goals.

- **Standards.** Well-adapted water supply will require policy to deliver and extend resilience standards, which deliver a water supply system compatible with future climate conditions.

- **Financial instruments.** Fiscal policy should incentivise adaptation actions (such as reducing demand, minimising losses from the supply system and building system level resilience to climate change) by water companies, home-owners and residents. Extra financial support may be needed to enable low-income households to understand and reduce their water use.

- **Information and reporting.** Reporting on some aspects of risk and adaptation planning and delivery should be mandatory. This will improve understanding of the national picture of adaptation in the public supply system, as well as in other sectors upon which the water system relies, including energy, transport and telecoms and ICT.

Figure 5.1 Monitoring map for water



Source: CCC analysis.
Notes: Italicised text indicates suggested measures for each outcome.

2. Delivery and implementation progress

This section documents available evidence on progress towards delivery and implementation of each of the climate resilience outcomes identified in the previous section.

In its 2022 review of emerging regional water resource plans, the Environment Agency concluded that for public water supplies, the gap between the amount of water needed in 2050 and what can currently be supplied is bigger than previously estimated.[7] The National Framework estimated that by 2050, this gap (or additional need) would be around 3,435 Ml/d. But combined figures from the regional groups' modelling now show the figure is nearer 4,000 Ml/d.

A package of demand-side, supply-side and system-level adaptation measures is needed to ensure sufficient water supply under a changing climate. Significant progress in one outcome may allow for less action in others. Decision makers need to continue to monitor progress and set policies to deliver the most effective combination of measures.

(a) Outcome 1: Reduced household

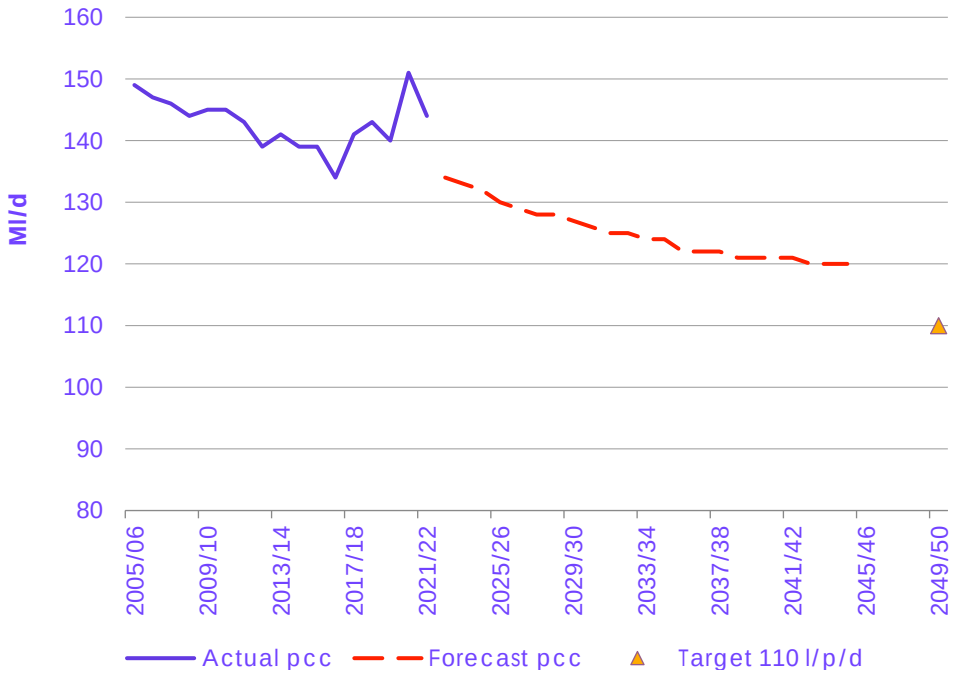
Demand for water is not falling and a step-change in delivery is needed.

Indicators for this outcome demonstrate **insufficient progress** towards reducing household demand for water.

- **Household water use in England has increased slightly since our last assessment and remains similar to 10 years ago.** Since our last assessment in 2021 average household per capita consumption (pcc) has risen to 144 litres per person per day (l/p/d) in 2021/22 (up from 140 l/p/d in 2019/20). This rise comes on top of a long-term trend of no significant reduction in consumption. Ten years ago consumption was 143 l/p/d (Figure 5.2). Many water companies attribute recent changes in household water consumption patterns to the COVID-19 pandemic and the subsequent continuation of home-working and hybrid working patterns. However, this does not account for the longer-term stagnant trend.

- **A significant step change is required if targets set out in the National Framework for Water Resources and new statutory water demand targets are to be met.** Current household demand is significantly higher than the target to reduce to 110 l/p/d by 2050 (Figure 5.2). In its latest review of water company performance, Ofwat expressed concern that companies are not placing enough importance on reducing household demand. Sixteen (of seventeen) companies in England did not meet their performance commitment level for a second year and the companies have provided little information on the steps they are taking to reduce per capita consumption.[8]

Figure 5.2 Actual and forecast household per capita consumption (Ml/d)



Source: Summary of actual and forecast data from Water Resource Management Plans (WRMP19) for all water companies in England. Data provided by the Environment Agency.
Notes: Forecast data to 2045 based on WRMP19. The target of 110 l/p/d represents the required level of per capita consumption (pcc) by 2050 to meet the expectations set out in the Environment Agency's National Framework for Water Resources.

- **Uptake of metering is slowly increasing, though only two out of seventeen companies met their planned metering figures for 2021/22**. Household metering rose slightly, to 60% across England and Wales in 2021/22. This represents an increase of 3% since our last assessment (2019/20) and 11% since 2017/18.[9] Several companies delivered less than a 1% increase since the previous year. There has been a long-term trend of steady increases in household metering uptake since 1999/2000. The latest water company plans show metering will increase to cover 83% of households by 2045.[10] Water companies continue to cite COVID-19 as a limiting factor in the delivery of their metering programmes. Recent analysis found that fitting one million smart water meters in the UK each year for the next 15 years could result in saving at least one billion litres of water a day (1,000 Ml/d) by the mid-2030s, as well as reducing the UK's current greenhouse gas emissions by 0.5% (2.1 $MtCO_2e$).[11] The proportion of water meters in England that are smart meters is not currently known.

Greater uptake of smart metering will be an important action to reduce demand.

- **Data on the uptake of water efficiency measures is held by water companies but is not collated to national scale.** Individual water companies should hold data on the number of water-saving packs distributed,* though this has not been collated for this assessment. Some water companies reported regional data in their ARP3 reports. For example, Anglian Water reported carrying out 180,000 home visits between 2015 and 2020, providing water saving tips and products, and checking for leaks.[12]

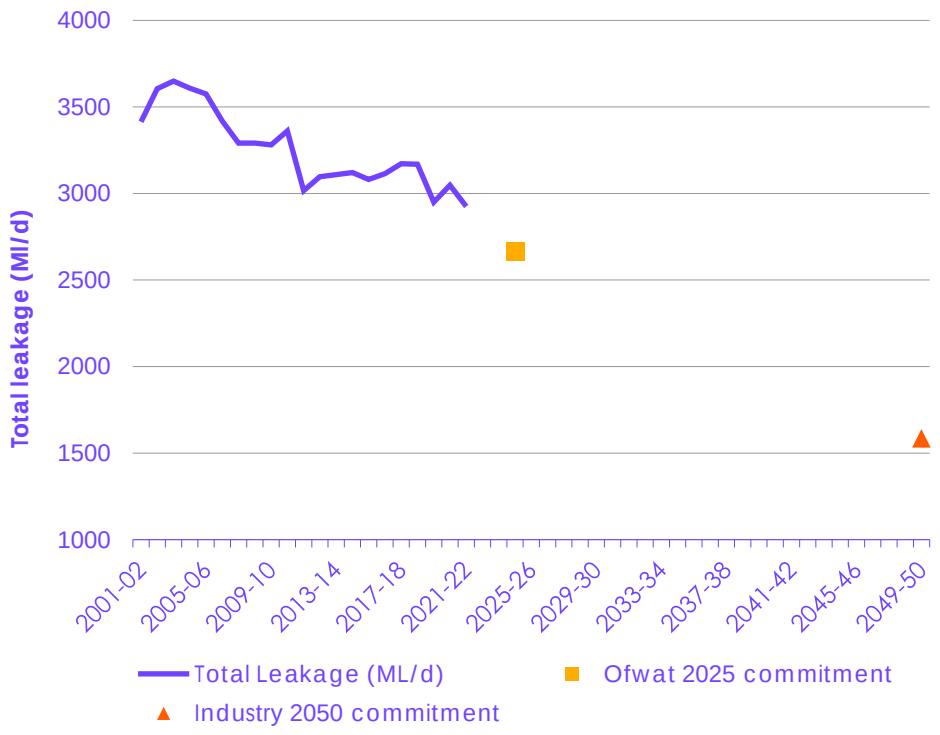
* Water-saving packs typically contain water saving tips and products such as shower regulators, shower timers and toilet leak detection strips.

(b) Outcome 2: Improved system performance

Indicators for this outcome demonstrate **mixed progress** towards improving performance of the public water supply system.

- **Leakage has decreased very slightly since our last assessment in 2021, and there has been little change in leakage from the public supply system over the last 10 years**. Four of seventeen water companies in England missed their leakage targets in 2021/22, compared with only one company in our last assessment.*,[13] Some companies reported increases in annual leakage in 2021/22, the largest increases being 14.2% and 7.3%.[14] Water companies have committed to delivering a 16% reduction in leakage from 2017/18 level by 2025 and a 50% reduction by 2050. An 11% reduction has been achieved since 2017/18 and Ofwat continue to monitor progress towards this target. Significant progress is still needed to meet the 2025 and 2050 targets (Figure 5.3).

Figure 5.3 Leakage from the public water supply system



Source: Total leakage data to 2019/20 from consumer Council for Water, Water and Wastewater Resilience Report 2019/20, Data Appendices. Leakage data for 2020/21 and 2021/22 from the Environment Agency. Ofwat 2025 commitment from 2019 Price Review for the 2020-25 period. Industry 2050 commitment from a letter from Water UK to the Secretary of State on 17/10/2018.
Notes: Definition of leakage has changed from 2020/21 and may not be directly comparable to previous years.

- **Though large-scale interruptions to water supply due to weather have not been reported, better monitoring is needed.** Water companies report on customer minutes lost due to planned, unplanned and third party interruptions. Average supply interruptions can fluctuate significantly from year to year. In 2021/22, water supplies in England were interrupted for, on average, less than 12 minutes per customer.[15]

* Leakage targets are averaged over three years as the weather can affect performance in individual years.

This represents a 20% increase since 2020/21 and is primarily attributed to two companies who cited storms Eunice, Dudley and Franklin as the cause of disruption. The current figure for average supply interruptions represents a 48% decrease since 2017/18.

- **Only a small number of water distribution and wastewater sites are currently at risk of surface water flooding, but this risk will increase due to climate change.** Analysis for CCRA3 found that 43 water sites* in England are currently exposed to a 'significant' risk of surface water flooding (1:30 or greater).† This is projected to increase by 31% by the 2050s and 47% by the 2080s‡ under a 2°C warming scenario. Under a 4°C warming scenario,§ the risk is projected to increase by 48% by the 2050s and by 74% by the 2080s.**,16

(c) Outcome 3: Increased supply

More supply infrastructure will be needed in parts of England, even if demand is reduced.

Even with ambitious action to reduce demand and improve system performance, more supply infrastructure will be needed in parts of the country. The National Infrastructure Commission (NIC) estimated that additional capacity of 4,000 Ml/day should provide resilience to an extreme drought (1 in 500 year) until 2050, even with high climate change and population growth, with most of it likely to be needed by the 2030s. That additional capacity will require a minimum of 1,300 Ml/day additional supply infrastructure.[17] Options include transfers, new reservoirs, re-use and desalination.

Progress in increasing supply is assessed as **mixed**.

- **There have been no new reservoirs built in the UK in the last 30 years though new schemes are emerging.** In 2021, planning permission was granted for a new 8.7 billion litre reservoir in Hampshire, due to be completed and operational by 2029. Anglian Water is currently working on plans to build two new reservoirs that will provide enough water for 750,000 homes. If plans are passed, it could be the late 2030s before it supplies drinking water.

Emerging regional plans do not go far enough to propose new sources of supply.

- **Data on new transfer capacity is not available.** Emerging Regional Water Resource Plans, overall, propose few new interconnections of water resources between regions. In some cases, they reduce transfers of water between regions (see policy and planning progress section below).

(d) Outcome 4: Interdependencies identified and managed

Indicators demonstrate **insufficient progress** towards this outcome. ARP reports demonstrate limited progress on identifying interdependency risks by some water companies. However, there are gaps in reporting and interdependencies are not being consistently assessed in risk assessments and adaptation plans.

* Water distribution and wastewater treatment sites.

† There are 1,433 water treatment works in the UK and 7,078 wastewater treatment works in England and Wales.

‡ Under current levels of adaptation, in a 2°C warming and low population growth scenario.

§ Under current levels of adaptation, in a 4°C warming and low population growth scenario.

** Almost all of the risk is attributed to climate change, with a minimal proportion (on average 1%) attributed to population change.

- Fourteen reports were submitted in ARP3, covering the operations of fifteen water companies. Five invited organisations did not report.
- All water companies who reported included a high-level assessment of their sources of interdependency risks.
- Around half included interdependency risks in their detailed climate change risk assessments and adaptation plans.[18]

(e) Progress on enablers

Understanding of interdependency risks is improving but more detailed planning is needed.

To achieve these four outcomes for a well-adapted water supply, multiple enabling factors must be in place. Enablers should ensure that delivering adaptation to climate change in the water supply system is sufficiently funded and effectively governed. Robust data, through monitoring and research, is an important enabler for well-targeted and maintained adaptation.

Enablers for well-adapted water supply are largely in place. There is generally good data and monitoring of resilience progress in the water sector, with some exceptions, and adequate processes for investment in resilience through Ofwat's price review process. Roles and responsibilities are well-defined.

Enablers for well-adapted water supply are largely in place.

- **Data and monitoring.** There is generally good data and monitoring of resilience progress in the water sector, regulated through the Ofwat price review process. Company performance is monitored annually by Ofwat to ensure companies are on track to meet the commitments set out in their five yearly water resource management plans. Data on the uptake of water efficiency measures could be improved – this is understood to be held by water companies but not collated to national scale. Collation of this at national scale would enable better understanding of actions being taken to reduce water demand within homes.
- **Funding and investment.** Ofwat's 2019 price review (PR19) final determinations set a five-year (2020 – 2025) price and service package for water companies in England and Wales of £51 billion, including an average of £2.6 billion per year allocated for new infrastructure to increase resilience (£13 billion over 2020-2024).
  - £643 million was allowed to increase the resilience of water and wastewater infrastructure against potential failures.
  - £469 million was allowed for drought resilience – developing new water resources and enabling transfer of water across the country.[19]
- **Engagement and education.** Most water companies reported their approach to customer engagement and education around water efficiency in their ARP3 reports.
- **Governance.** Roles and responsibilities are well-defined, through Ofwat's regulatory remit for climate resilience and the water resource management framework set up under the Water Industry Act (1991).

This section assesses progress in policy and planning to deliver the outcomes identified above. Key policy developments since our last statutory assessment of progress are summarised in Box 5.2.

Some key policy developments span across the identified outcomes for a well-adapted water supply, and these are reflected in the scores for each outcome.

- Under the Water Industry Act (1991), water companies must produce a statutory Water Resource Management Plan (WRMP) every five years which shows how they will manage water resources in their region for the next 25 years in light of climate change, using the latest Met Office climate projections. Progress against plans is monitored by Ofwat, the EA and Defra annually. Plans must be revised and consulted on every five years. The next round of plans requires water companies to demonstrate resilience to a 1 in 500 year 'extreme' drought, increased from a 1 in 200 year level of resilience in the last round of plans.

- Water companies must also produce statutory Drought Plans setting out how they will monitor water availability, the triggers for drought measures and supply and demand mitigation actions. They have also committed to review their performance in the event of a drought. Drought Plans are also reviewed and updated every five years.

(a) Outcome 1: Reduced household demand

Policies and plans to reduce demand are credible but faster delivery is needed.

There are **credible policies and plans** in place to deliver reduced demand for water, however a step change in delivery is needed to meet legislative targets and industry commitments by 2050.

- **There are statutory targets and planning requirements for household demand reduction.** Reducing household consumption is a key deliverable in water companies' WRMPs. The National Framework for Water Resources sets an expectation for water companies' plans to reduce demand to 110 litres per person per day (l/p/d) by 2050.[20] However, draft WRMPs for England, which are currently out for consultation, show that the majority of companies are planning to reach per capita consumption levels of between 110 and 120 l/p/d by 2050, falling short of Government and regulatory expectations of reaching 110 l/p/d. Most plans highlight the need for further Government policy to enable 110 l/p/d to be reached.[21] New interim targets under the Environment Act put delivery against this target on a statutory footing, with a target to reduce the use of public water supply in England per head of population by 20% from 2019/20 levels, by 2037/38.[22] Ofwat has proposed a new allocation of £100 million for demand reduction in the next performance cycle (PR24).[23] The statutory water resources planning guideline encourages increased meter penetration by requiring water companies to appraise and report their planned level of metering, including the installation of smart meters.

Promising recent developments in standards and building regulations should contribute to increased demand reduction.

- **Promising recent developments in standards and building regulations should contribute to increased demand reduction.** Building regulations require that new homes are built to a standard of 125 l/p/d. Local authorities in water stressed areas have discretion to ask for a higher standard through a Building Regulations Optional Requirement. In light of the national framework expectations for per capita consumption, a blanket rule of 110 l/p/d per day is required. Government recently consulted on a mandatory water efficiency label for water-using products (taps, showers, toilets, dishwashers and washing machines).[24] At the end of January 2023, Government published its Roadmap for more water efficient buildings as part of the Environment Improvement Plan.[25] This signposts a number of actions to help reduce water demand, including:
  - Reviewing water efficiency ambition in Building Regulations with a view to moving to a minimum expectation of 105 l/p/d, and 100 l/p/d in seriously water stressed areas.
  - Developing guidance around water-neutral or water-positive new development and reviewing the planning framework to encourage more water reuse.
  - Improving the integration of water efficiency into energy efficiency advice and retrofit.
  - Delivering the UK mandatory water efficiency labelling scheme.
- **A specific funding allocation for metering programmes would stimulate greater uptake.** Metering is a useful tool to help encourage lower water consumption by helping customers understand their usage. Ofwat expects all companies to consider smart meter solutions as the standard meter installation type. While there is no dedicated allocation of funding for metering in particular, a new water efficiency fund of up to £100 million in PR24 is intended to facilitate the development of transformative improvements to water efficiency at a regional and national level, to help to reduce demand for water. A specific funding allocation for metering programmes would help to stimulate greater uptake. Meters are often placed out of sight, for instance underneath manhole covers in driveways; meters must be visible to customers so they can track usage in real time.

Delivery of targets and plans requires sufficient investment, resources and progress monitoring.

- **A step-change is needed in delivery against targets and plans.** The Office for Environmental Projection (OEP) has recently criticised the Government's lack of progress in reducing personal water consumption, saying that the current pace and scale of action will not deliver the changes necessary to significantly improve the environment in England.[26] Despite having a credible set of policies and plans in place for demand reduction, there is a lack of progress in indicators (above). A step-change in delivery is needed against these policies and plans, in order to ensure a climate resilient supply of water for people under a changing climate. This includes ensuring there is sufficient investment, resources and progress monitoring to support delivery against demand reduction targets.

(b) Outcome 2: Improved system performance

There are **credible policies and plans** in place to deliver improved system performance, but delivery is not keeping pace with targets.

Statutory targets and industry commitments are in place, but delivery is not keeping pace.

- **There are statutory targets and planning requirements for reducing leakage.** Reducing leakage is a key deliverable in companies' statutory WRMPs. Ofwat have set performance commitments to cut leakage by 16% by 2025 (on 2017/18 levels) and the industry has committed to reducing leakage by 50% (on 2017/18 levels) by 2050 at the latest.[27] New interim water demand targets under the Environment Act puts delivery on a statutory footing, incorporating a requirement to reduce leakage by 36.9% on 2019/20 levels by 2037/38.[28] Water UK* published a Leakage Routemap in 2022, setting out how water companies will meet the 2050 target.[29] Ofwat has stated that companies should have the strongest possible incentives to deliver reductions in per capita consumption. As such, companies that don't meet their 2024/25 performance commitment levels should expect to incur underperformance payments.[30]

Water company plans are required to demonstrate resilience to flooding and coastal change.

- **Water company plans are required to demonstrate resilience to flooding and coastal change.** As a Risk Management Authority (RMA), water companies must act in a manner that is consistent with the National Flood and Coastal Erosion Risk Management Strategy (see Chapter 9). They also have a duty to cooperate with other RMAs. The National Flood and Coastal Erosion Risk Management Strategy Roadmap to 2026 includes an objective for water companies to plan for their infrastructure to be resilient to flooding and coastal change between now and 2030. The National Framework for Water Resources lays out how companies should consider opportunities for building flood resilience through their Regional and Resource management plans. In their emerging Drainage and Wastewater Management Plans companies must consider future risk on three timeframes and set out mitigations for flood risk both from and to their sewage assets. Water companies building reservoirs over 10,000m^3 must produce a Flood Plan specifying how flood risk will be mitigated.

- **A step-change is needed in delivery against targets and plans.** Water companies have committed to delivering a 50% reduction in leakage from the 2017/18 level by 2050. An 11% reduction has been achieved to date and Ofwat continue to monitor progress towards this target. Significant progress is still needed to meet the 2025 and 2050 targets. This includes ensuring there is sufficient investment, resources and progress monitoring to support delivery against leakage targets.

(c) Outcome 3: Increased supply

Only **limited policies and plans** are in place to deliver the necessary increases in supply. Emerging regional water resource plans should identify new solutions for increased supply.

- **There are statutory planning requirements for increasing supply, and emerging regional plans, currently under consultation, should enable more strategic planning**. WRMP guidelines require all water companies to forecast supply and demand over at least the statutory minimum of 25 years. If a deficit is forecast, they should consider supply-side options to increase the amount of water available (as well as demand-side options). If a water company does not have a deficit, they should consider whether they can identify options to supply other water companies or regional groups. The National Framework for Water Resources marked a move to strategic regional planning. Five regional groups have been set up in

* Water UK is a membership body representing the UK water industry. Members include all water and wastewater companies across England, Wales, Scotland and Northern Ireland.

England, made up of the water companies and major water users in each region. Each will produce a plan by September 2023, which is expected to identify solutions for new supply, including transfers and reservoirs, in each region.

Regional water resource plans need to demonstrate increased connectivity and supply capacity in areas projected to be water stressed.

- **Emerging regional water resource plans, overall, propose few new interconnections of water resources between regions.** In some cases, they reduce transfers of water between regions. The plans are showing that the pressures of a growing population, tackling climate change and protecting and enhancing our environment mean that water, which potentially could have been transferred between regions, is now largely being held within regions. The main exception to this is greater connectivity between Water Resources West (WRW) and Water Resources South East (WRSE).[31] It is important that emerging regional plans demonstrate increased connectivity and supply capacity in the parts of England that are projected to be water stressed under climate change and population growth.

- **Large scale water supply infrastructure projects are currently being submitted through a RAPID accelerated process**. The Regulators' Alliance for Progressing Infrastructure Development (RAPID) was set up in 2019 to help facilitate the development and funding of new large-scale strategic water supply solutions by the water companies. It is led by the EA, Ofwat and the Drinking Water Inspectorate (DWI). There are currently 18 solutions in the RAPID programme, 11 source-type solutions including reservoirs and effluent reuse, and six transfer-type solutions, utilising river, canal and pipeline transfer routes. These projects are currently being considered for continued funding for further development towards construction-ready status, with the next decisions due in June 2023.[32]

(d) Outcome 4: Interdependencies identified and managed

There are **insufficient policies and plans** to deliver this outcome.

There is an incomplete picture of interdependency risks across the sector.

- **Gaps in ARP reporting are limiting understanding of the scale of, and preparedness for, interdependency risks.** There is not a complete picture, within the water sector or across other interdependent sectors such as energy and transport, of the scale of interdependency risk facing infrastructure, and the steps being taken to manage them. ARP reports demonstrate some limited progress on interdependencies by some water companies. However, there are gaps in reporting and interdependencies are not being consistently assessed in risk assessments and adaptation plans. We assess the overall approach to reporting under ARP in Chapter 1.

Box 5.2
Key policy developments since the last assessment

Policy developments:

- **Water Resource Management Plans.** Current water resource management plans require water companies to plan for a 1 in 200 year 'severe' drought. In the next round of plans (2024) companies are required to demonstrate resilience to a 1 in 500 year 'extreme' drought. This is a positive improvement in the plan requirements, which must consider the latest UK climate change projections.
- **Regional planning.** Initiated by the National Framework for Water Resources in 2020, five regional groups have been set up in England, made up of the water companies and major water users in each region. Each will produce a plan by September 2023,

which is expected to identify solutions for new supply, including transfers and reservoirs, in each region.

- **Adaptation Reporting Power round three.** All water companies in England were invited to submit an updated climate change risk assessment and adaptation plan under the third round of the Adaptation Reporting Power in 2021 (ARP3). 14 reports were submitted in ARP3, covering the operations of 15 water companies in England and Wales. Five invited organisations did not report. The CCC conducted an evaluation of the submitted reports and made recommendations to Defra for round 4. In early 2023, Defra is consulting on the approach to the next round of reporting.
- **Mandatory water labelling.** Defra concluded a consultation on the introduction of mandatory water efficiency labelling for products that utilise water (e.g. taps, showers, toilets, dishwashers and washing machines) in late 2022. At the end of January 2023, Government published its Roadmap for more water efficient buildings as part of the Environment Improvement Plan. This signposts actions to delivering the UK mandatory water efficiency labelling scheme.
- **Water efficient buildings roadmap.** In early 2023, Government published its Roadmap for more water efficient buildings as part of the Environment Improvement Plan. This signposts a number of actions to help reduce water demand, including: reviewing water efficiency ambition in Building Regulations with a view to moving to a minimum expectation of 105 l/p/d, and 100 l/p/d in seriously water stressed areas; developing guidance around water-neutral or water-positive new development and reviewing the planning framework to encourage more water reuse; improving the integration of water efficiency into energy efficiency advice and retrofit; and delivering the UK mandatory water efficiency labelling scheme.

(e) Recommendations to close policy gaps

Table 5.2 provides a set of targeted recommendations for actions to close key policy gaps to better prepare for climate change in this sector.

Table 5.2
Recommendations

Primary responsibility	Recommendation	Timing
Defra	Ensure sufficient investment, resources and progress monitoring to support delivery against demand reduction and leakage targets, given the significant gap between targets and progress.	Ongoing
Environment Agency	Ensure emerging regional Water Resource Management Plans demonstrate increased connectivity and supply capacity in the parts of England that are projected to be water stressed under climate change and population growth.	2023
Ofwat	Collate data from water companies on uptake of water efficiency measures as a national indicator.	2025
Ofwat	Require water companies to report weather-related interruptions to supply to Ofwat, and collate this as a national indicator.	2025

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Chapter 6

Energy

Table 6.1
Progress summary – Energy

	Delivery and implementation	Policies and plans	Summary
Outcome 1: Reduced vulnerability of energy assets to extreme weather	Mixed progress	Partial policies and plans	• Climate change is a consideration in statutory planning applications for new infrastructure and reports submitted under the Adaptation Reporting Power demonstrate progress in some areas. • Some specific policies and standards exist to increase asset resilience, such as for flood protection of substations. • There is a need for minimum resilience standards and a clearer climate resilience remit for regulators. • Some progress in flood resilience, but more information is needed for other hazards, including heat and drought.
Outcome 2: System level security of supply	Mixed progress	Limited policies and plans	• Government has committed to a decarbonised, secure energy supply by 2035 and acknowledged the need for resilience, but there is no defined standard for system level resilience and delivery challenges remain. • More research is needed to understand possible climate impacts on the energy system, and this must be integrated into system design and investment processes.
Outcome 3: Interdependencies identified and managed	Unable to evaluate	Insufficient policies and plans	• Coverage of interdependency risks has improved in some adaptation plans but this remains an area of significant challenge. • It is not possible to assess progress in delivery across the whole energy system due to a lack of data for generators.

Relevant risks from CCRA3:
Risks to infrastructure networks (water, energy, transport, ICT) from cascading failures (I1); risks to infrastructure services from river, surface water and groundwater flooding (I2); risks to infrastructure services from coastal flooding and erosion (I3); risks to bridges and pipelines from flooding and erosion (I4); risks to hydroelectric generation from low or high river flows (I6); risks to subterranean and surface infrastructure from subsidence (I7); risks to energy generation from reduced water availability (I9); risks to energy from high and low temperatures, high winds, lightning (I10); risks to offshore infrastructure from storms and high waves (I11); risks and opportunities from summer and winter household energy demand (H6).

Our dependence on a reliable energy system is increasing at pace as we digitalise and decarbonise our economy.

This chapter covers adaptation to climate change for the energy system. This includes the generation of electricity and gas, and the operation of the electricity and gas grid to distribute energy to end users. Access to reliable and plentiful energy is essential for the functioning of the UK's economy and for the wellbeing of its population. Critical services such as health, banking, telecoms and infrastructure are already dependent on the functioning of the energy system. Continued digitalisation of the economy in coming years will further increase the scale of potential impacts arising from electricity system failures, as will increasing use of electricity for road transportation and household heating.

The UK's energy systems are undergoing a large-scale transformation to reduce and eliminate greenhouse gas emissions. This requires major investment and turnover of assets and networks which make up the UK's energy system, creating the opportunity to improve energy system climate resilience at the same time.

Changes in UK weather and climate will alter the types of weather hazards that the UK's energy system will face. Some will become more common and have potentially larger effects on the system than today.

- Higher summer temperatures and more intense heatwaves, leading to generation and transmission efficiency losses, faults from overheating components and increasing electricity demand for cooling.
- Increased risk and severity of summer drought, affecting water supply for cooling, hydro generation and hydrogen production.
- Increased winter rainfall and flooding, leading to risks of capacity loss due to inundation and flood damage.

Multiple climate hazards can and do cause large scale outages to the power network and the risk of many of these will increase due to climate change.

Snow and ice related events are currently important sources of weather-related power supply disruption. As the UK's climate continues to warm these will become less common but will still occur. Changes in some potentially important weather hazards remain uncertain, including wind strength, wind regimes, storminess and lightning (Box 6.1). These hazards can all potentially cause large scale outages and loss of network capacity and are some of the key system-level hazards. More evidence is needed to understand changes in these hazards, given the growing reliance on generation from weather-dependent renewable sources for Net Zero.[1]

Box 6.1
Uncertain climate impacts on the energy system

Storms. Recent events have demonstrated the potential impacts of storms on the electricity system and knock-on impacts which can cascade across society (Box 6.3). The Third Climate Change Risk Assessment (CCRA3) concluded that there is no clear observational evidence for increased UK storminess. Trends in storm activity depend on the time period analysed and can have significant multi-decadal variability.

High wind speeds. Wind turbines are designed to stop operation when wind speeds exceed a certain level, typically around 25 metres per second (around 56 miles per hour), to avoid mechanical damage from excess stress. Wind speeds consistently above that level can therefore lead to total wind generation dropping, potentially to near zero, in just a few hours.

In an electricity system with a large share of generation from offshore wind, the drop in available generation from such events could be significantly greater than the variations the system operator is accustomed to managing today and would require a large amount of replacement generation to be ramped up sufficiently quickly. There is currently no observational evidence for changes in the occurrence of strong wind gusts in the UK and limited understanding of possible future changes.

Wind droughts. Wind droughts are extended periods of low wind speed conditions. April to September 2021 was the least windy period for most of the UK and parts of Ireland in the last 70 years. SSE stated that its renewable assets produced 32% less energy than expected. In 2018, the power available from wind generation was reduced for a sustained period during the summer heatwave. National Grid reported that wind power was down from 12.9% to 10.4% of total electricity production in summer 2018, when compared to 2017, despite an additional 10% wind generation capacity.

CCRA3 assessed the observed seasonal changes in near surface wind speeds (1981-2000) and UK climate projections for wind under 2ºC, 3ºC and 4ºC warming thresholds (UKCP09 regional model, UKCP18 regional model and CMIP5 global model). The analysis concluded that in winter there is a large spread and no clear signal across the three sources of evidence, that would imply robust changes in wind energy supply. In other seasons there is a consistent, but small, signal of weaker winds, except in summer where the declines are larger, especially in the UKCP18 results.

Lightning. Lightning strikes can and do have large-scale impacts on the electricity system (Box 6.3). Lightning strikes are also an important cause of wildfire, which could have impacts on the electricity system. However, there is currently conflicting evidence suggesting significant changes in the frequency of lightning strikes over coming decades.

Long-term uncertainty also exists for other hazards, such as sea-level and coastal storm surges. Further research is needed to understand the potential implications of all of these hazards on the energy system.

Source: ource: Slingo, J. (2021) *Latest scientific evidence for observed and projected climate change*. In: The third UK Climate Change Risk Assessment Technical Report [Betts, R.A., Haward, A.B. and Pearson, K.V. (eds.)] Prepared for the Climate Change Committee, London; World Climate Service 2021.

Further research is needed to understand the potential implications of climate hazards on the energy system.

Exposure of the energy system to climate risks is influenced by the age, condition and location of infrastructure and the criticality of individual assets – the number of connections or the nature of the services they support. Changes in energy supply and an increasing reliance on electricity as we transition to a Net Zero UK economy will both make the power system more vulnerable to outages, necessitating high levels of resilience and reliability, and increase the extent of cascading impacts from power system failures across society. The implications of these changes for a climate resilient future energy supply are explored in our recent report on a reliable, decarbonised power supply.[2]

All other infrastructure systems and many critical services depend on energy supply to operate effectively.

The energy system is inherently linked to many other systems. All other infrastructure systems depend on energy supply to operate effectively (see Chapter 5 on Water supply, Chapter 7 on Telecoms and ICT and Chapter 8 on Transport). Failures in electricity supply will also impact on buildings heated by boilers and heat-pumps and will increasingly impact on transportation as the penetration of electric vehicles increases over coming years. Progress in managing interdependencies is assessed in Chapter 1.

Resilience can be delivered through reduced vulnerability of assets, security of supply and effective management of interdependencies with other systems.

Successful adaptation aims to ensure a reliable power supply in a Net Zero economy, despite climate change. This means that the number of homes and businesses affected by power outages is minimised and when outages occur their impact and duration is minimised, particularly for critical national infrastructure and essential services such as medical care.

We have identified three key outcomes, enablers and policy actions that will achieve this goal for improved climate resilience (Figure 6.1).

The key outcomes that need to be achieved to deliver on the goal of a well-adapted energy system are:

- **Reduced vulnerability of energy assets to extreme weather.** Increased frequency of extreme weather events poses significant risks to energy assets (power generation plants, electricity and gas transmission and distribution networks). The monitoring of asset-level resilience to floods, overheating of infrastructure and overall conditions is necessary to minimise the impact of climate change on the energy system.

- **System level security of supply.** Weather and climate can impact energy asset performance, and lead to costly disruption or in severe cases, loss of energy services entirely. Increased reliance on weather-dependent sources of generation necessitates robust system planning to deliver a reliable supply. Increased reliance on electricity supply increases consequences of power outages.

- **Interdependencies with other systems are known and managed.** Infrastructure services are increasingly dependent on one another. Risks of cascading failures from another service, such as transport, water or digital, also increases the risk of power outages. The energy system also relies on key infrastructure services to operate effectively. These interdependencies need to be accounted for in climate assessments and adaptation actions for all major electricity and gas producers, as well as transmission and distribution system operators.

A number of enabling factors are needed if the outcomes identified above are to be implemented at appropriate scales:

Governance arrangements for climate resilience in the energy system are complex and not always clear.

- **Governance.** Arrangements for governance of climate resilience in the energy system are complex. Many Government departments and organisations have a role in ensuring resilience, though their remits are not always clear. All actors will need to collaborate and communicate more effectively to deliver a resilient, decarbonised energy supply.

- **Data.** National data on weather and climate related impacts on the energy system, and the extent of adaptation actions being delivered, will enable a better understanding of how climate resilient the energy system is.

- **Funding and investment.** Climate resilience needs to be formally integrated into investment processes and long-term decisions. This includes large national-scale infrastructure projects and company-level investment cycles.

Our monitoring framework highlights policy mechanisms which must be in place to achieve these required outcomes for a well-adapted power supply (Figure 6.1). These fall under the following categories:

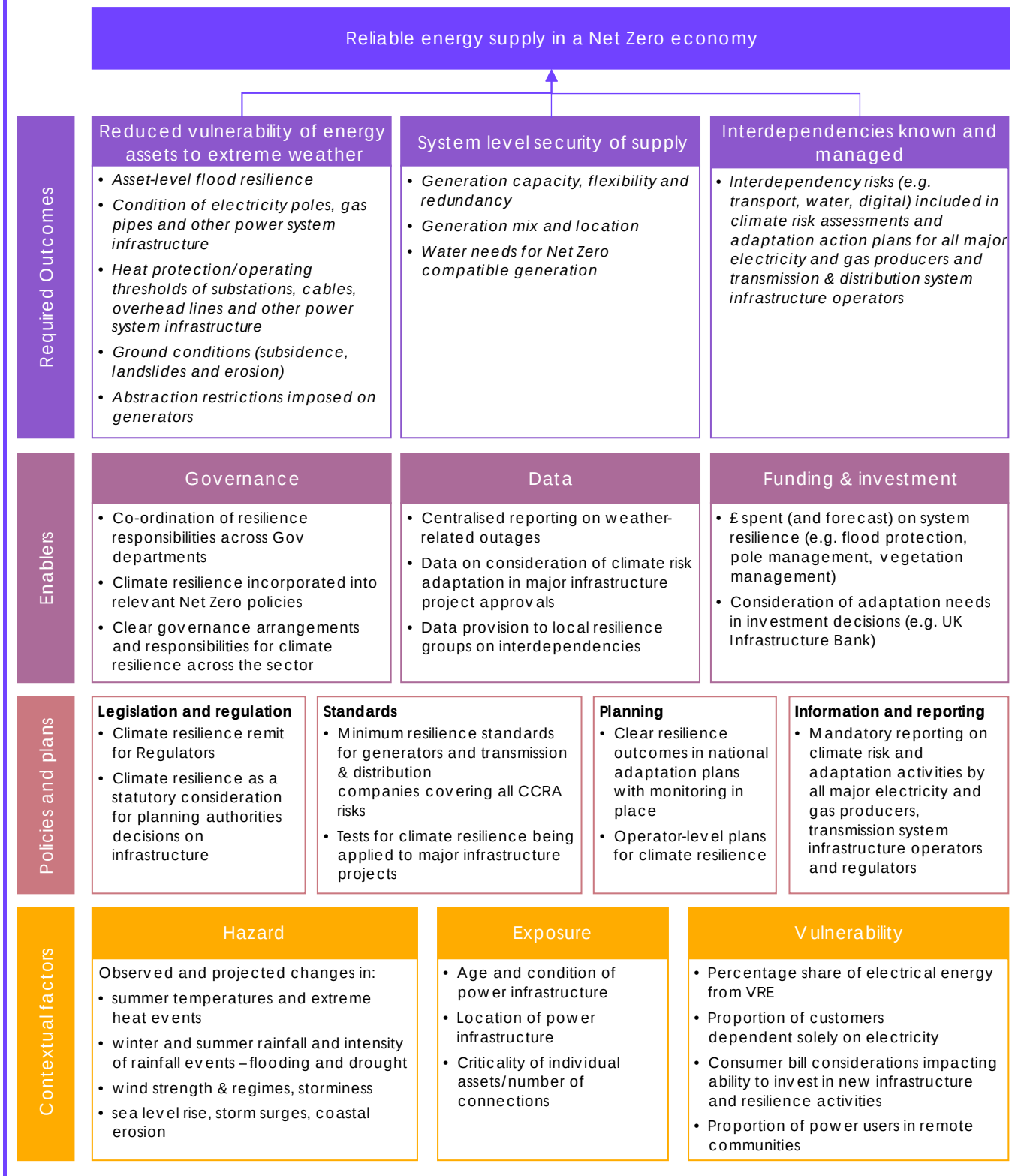
- **Legislation and regulation.** National policy must create legislation which enforces sustainable long-term plans for a resilient energy system and provide appropriate frameworks for regulation. Statutory resilience duties are needed for regulators and key system operators. Legislation should also ensure that investment allocation is appropriate to meet adaptation goals.

- **Standards.** A well-adapted energy system will require policy to deliver and extend resilience standards, which deliver an energy system compatible with future climate conditions.

- **Planning.** National adaptation plans must have clear resilience outcomes with monitoring in place. All key operators in the energy system must produce climate change risk assessments and adaptation plans which demonstrate progress in making the energy system more climate-resilient.

- **Information and reporting.** Reporting on some aspects of risk and adaptation planning and delivery should be mandatory. This will improve understanding of the national picture of adaptation in the energy system, as well as in other sectors upon which the energy system relies, including transport and telecoms and ICT.

Figure 6.1 Monitoring map for energy



Source: CCC analysis.
Notes: Italicised text indicates suggested measures for each outcome.

This section documents available evidence on progress towards delivery and implementation of each of the climate resilience outcomes identified in the previous section.

(a) Outcome 1: Reduced vulnerability of energy assets to extreme weather

There has been some progress in improving asset-level flood resilience, but more information is needed for progress with other hazards, particularly heat and drought.

Available indicators show **mixed progress** in reducing vulnerability of assets to extreme weather. There has been some progress in asset level flood resilience, but more information is needed for other hazards, including heat and drought, as well as a better understanding of the condition of key infrastructure assets. There have been a number of high-profile weather-related outages in recent years (Box 6.2).

- **The majority of critical electricity substations are flood-proofed and plans are in place to deliver the rest by 2026.** Around three-quarters of National Grid's critical (high and medium risk) substations identified in the RIIO T1 regulatory period (2013-2023) as at risk of flooding have been protected to a 1 in 1000 year flood.* Flood defences at the remaining critical sites are planned to be implemented by 2026. Ofgem collect data annually from distribution network operators on compliance with the ETR138 flooding standard, however, they do compile or report on these data.

- **Age and poor condition of overhead poles have contributed to recent weather-related electricity network damage.** Age and condition of overhead line poles were found by Ofgem to be contributing factors to the power network damage caused by Storm Arwen. Between 50 and 75% of damaged poles were over 40 years old.† Ofgem reported less correlation between damaged poles and their condition – between 13 and 38% of damaged poles assessed were found to be in poor condition. Ofgem's final report identifies the need for further work to understand the correlation between pole age and damage, and to identify improvements in pole condition reporting.[3]

- **Data on abstraction restrictions imposed on power generators is not available.** National figures have only recently begun to be collated during dry weather incidents. In August 2022, the Environment Agency (EA) observed 1500 'hands off flow' (HOF) conditions had been reached amongst abstraction licence holders across England. HOFs reflect a minimum river flow below which abstraction at that location must cease. In September 2022 the number had fallen to 1000. In the drought of 2019, there were 408 abstraction restrictions. Typically these restrictions are on agricultural licences as the dry periods often coincide with the growing and cropping seasons. Prior to that, the EA advises that power generation (cooling) abstraction will not have been restricted because the licences were issued before tighter HOF conditions became prevalent.[4]

* Under ETR: 138 the target is to achieve a 1 in 1000 year resilience level for all new and existing substations (as defined in UKCP18 (UK Climate Projections 2018)). To account for data errors and uncertainties in modelling, the flood depth is increased by 300mm.

† Across different distribution network operators.

There have been a number of high-profile weather-related outages in recent years.

Box 6.2
Recent weather-related disruption to the electricity system

In 2019 a lightning strike initiated a cascade of events that led to interruption of power supply to one million people in the south-east of England and caused significant knock-on effects on the rail sector, leaving passengers stranded on trains for many hours.

Storm Arwen, in 2021, caused extensive damage to the local grids across northern England and Scotland, initially leaving over one million homes without power. The northeast of Scotland experienced the equivalent of almost two years' worth of overhead line faults in a 12-hour period. Much of the damage was caused by wind gusts of almost 100 mph, with over 1,000 points of damage recorded in the northeast of Scotland and thousands of customers remained without power for days.

Storm Barra, also in 2021, brought gusts of around 80 mph along with blizzards and heavy rain. 59,000 people lost power in Northern Ireland, Wales and parts of England.

In 2022, extreme temperatures during the July heatwave caused power cuts due to conductors sagging and transformers overheating, with temperatures exceeding 40°C in some places. During the heatwave grid operators were forecasting a 70% chance that demand would outstrip supply, an outcome that would have caused blackouts across the network.

In early 2023, Storm Otto brought winds of up to 80 mph, leaving thousands of customers without power, closing schools and causing travel disruption.

These events demonstrate the range of hazards and scale of impact that can affect power supply.

Source: Ofgem (2022) *Final report on the review into the networks' response to Storm Arwen*; MacIver, C., Bell, K., & Nedd, M. (2021) *An analysis of the August 9th 2019 GB transmission system frequency incident. Electric Power Systems Research, 199*; various media reports.

(b) Outcome 2: System level security of supply

The Net Zero energy system must be designed, built and operated to be climate-resilient from the outset.

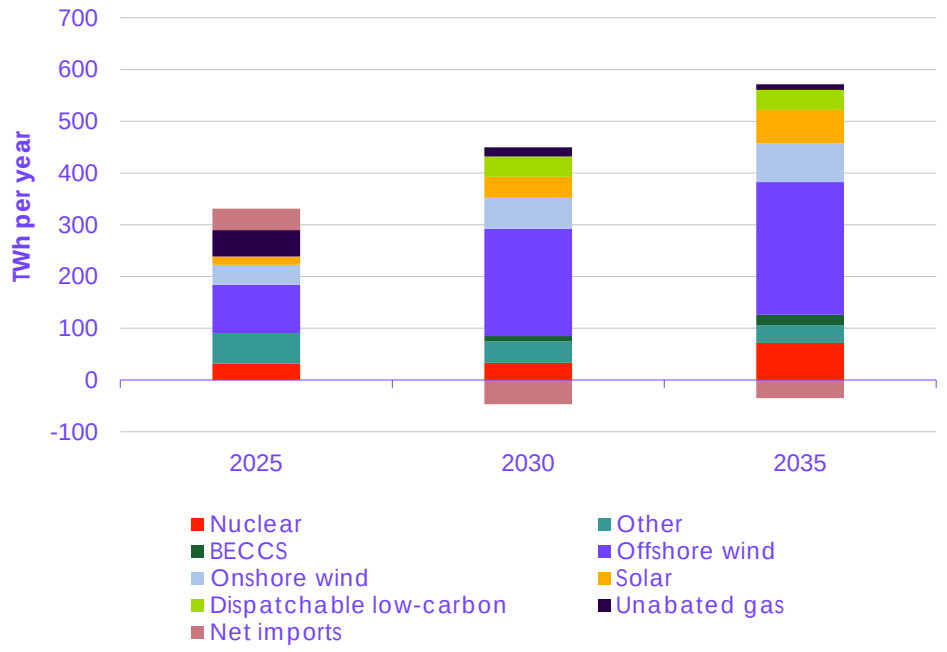
Available indicators demonstrate **mixed progress** towards system level security of supply. There have been no large-scale weather-related demand supply failures of the energy system over recent years. However, increasing electrification and diversification of the generation mix to deliver Net Zero will necessitate more action to ensure the future system is designed and built to be resilient to climate change.

- **Government has committed to deliver a decarbonised power supply by 2035.** The UK Net Zero strategy and CCC Sixth Carbon Budget report set out several viable pathways to achieve a decarbonised energy supply by 2035 with sufficient capacity, flexibility and redundancy to respond to changing weather conditions.

There are several viable pathways to a reliable decarbonised power supply by 2035.

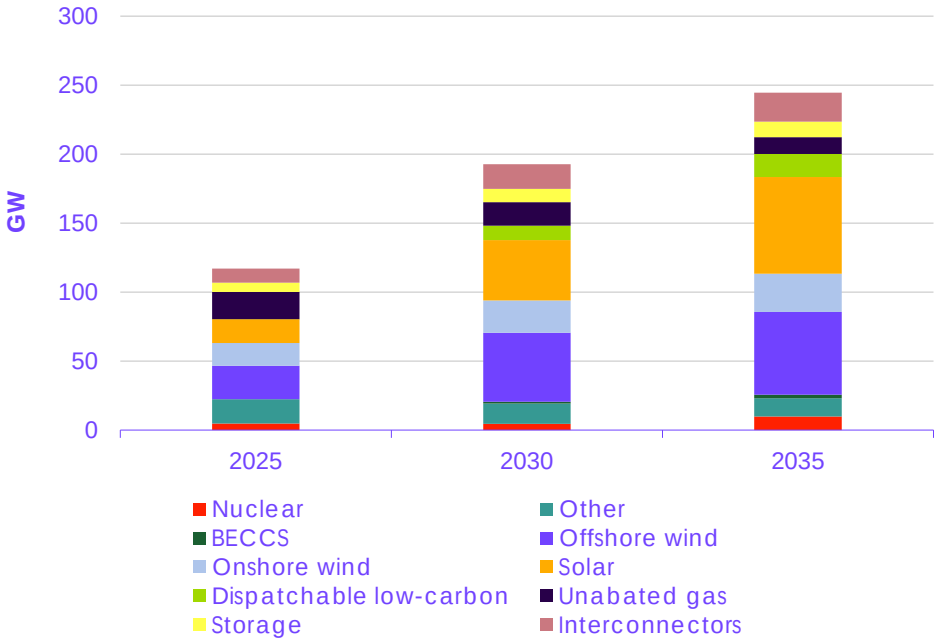
- **This will create greater weather-dependence (particularly wind) and increased exposure to outages due to weather extremes.** Our recent analysis shows that a decarbonised system, with a higher degree of weather-dependent generation, can be made both reliable and resilient.[5] A balanced supply mix could comprise around 70% of annual generation from variable renewables, complemented by around 20% from inflexible generation such as nuclear and BECCS (bioenergy with carbon capture and storage) and the remaining generation from low-carbon back-up generation and other forms of flexibility (Figures 6.2 and 6.3). We consider the occasional use of a small amount of unabated gas capacity (for up to around 2% of annual electricity production in 2035) to be consistent with ensuring security of supply in a cost-effective manner without excessive adverse impact on emissions.

Figure 6.2 Electricity generation mix to 2035 in the Central scenario



Source: AFRY (2023) *Net Zero Power and Hydrogen: Capacity Requirements for Flexibility*, CCC (2023) *Delivering a reliable decarbonised power system.*
Notes: Figures are before losses through the transmission and distribution system. 'Other' includes Combined Heat and Power (CHP) and unabated biomass. Dispatchable low-carbon includes gas CCS and hydrogen. Analysis representative of a 'normal' weather year. Central scenario using annual values from CCC Balanced Pathway.

Figure 6.3 Electricity capacity mix to 2035 in the Central scenario



Source: AFRY (2023) *Net Zero Power and Hydrogen: Capacity Requirements for Flexibility;* CCC (2023) *Delivering a reliable decarbonised power system.*
Notes: 'Other' includes Combined Heat and Power (CHP) and unabated biomass. Dispatchable low-carbon includes gas CCS and hydrogen. Analysis is representative of a 'normal' weather year. Central scenario using annual values from CCC Balanced Pathway.

Some parts of the UK will be particularly water stressed. System planning must account for this.

- **Water abstraction for the energy system is expected to decline in the short-term but significant rises are currently expected in the long-term.** Modelling of projected water use in electricity and hydrogen production to 2050 concludes that there is considerable uncertainty in future energy sector potential water needs at regional geographic scale.* This is largely due to the range of pathways that are compatible with Net Zero by 2050 and uncertainty in the extent to which some technologies will be used. Overall, water consumption for energy production reduces until 2025, after which it increases to 2050.[6] Given projected constraints on future water availability due to climate change, which are more severe in some parts of the country (see Chapter 5) this is an area of significant concern. Water availability considerations must be reflected in policy delivery for Net Zero.

(c) Outcome 3: Interdependencies with other systems known and managed

We are **unable to evaluate** progress in this outcome as there are insufficient data to assess progress in identifying and managing interdependency risks across the entire energy system. Reports submitted in the third round of the Adaptation Reporting Power (ARP3) in 2021 show that operators are starting to consider their interdependencies with other infrastructure systems. However, interdependency risks are not being consistently incorporated into climate change risk assessments.

Sources of interdependency risks are understood but detailed plans to manage them are lacking.

- **Electricity Transmission and Distribution.** In seven reports assessed (covering 19 companies), five identified sources of interdependency risk. Only one included these risks in their detailed risk assessment.

- **Gas.** All five gas network operators identified sources of interdependency risk. Only two included these risks in their detailed risk assessment.

- **Electricity generation.** Only a sector summary report was submitted†, therefore we could not identify the extent to which interdependency risks are being identified and managed by generation companies.

(d) Progress on enablers

Governance arrangements are not yet sufficient and climate resilience is not being reflected in long-term investment decisions.

Key enablers to deliver a well-adapted energy system are not yet in place. Government has acknowledged the importance of adaptation in the Net Zero strategy, but governance arrangements are not yet sufficient and climate resilience is not being reflected in long-term investment decisions.

- **There has been some acknowledgement of climate resilience considerations within energy system Net Zero planning, but it remains largely at a superficial level.** For example, the Government's Net Zero Strategy[7] acknowledges the need for incorporating adaptation into decarbonisation policy, yet subsequent key Government outputs such as the British Energy Security Strategy in 2022 are silent on climate resilience.[8]

- **Governance for climate resilience is complex.** Many Government departments and organisations have a role in ensuring resilience. All these bodies need to be engaged with the challenge of increasing resilience of

* Modelling based on 2020 Future Energy Scenarios and CCC Net Zero pathway scenarios.

† Energy UK reported on behalf of 11 electricity generators.

the energy system to climate change and to coordinate, collaborate and communicate more effectively between themselves, to deliver.

  - Department for Energy Security and Net Zero (DESNZ): sets energy policy and responsible for meeting carbon budgets.
  - Department for Environment Food and Rural Affairs (Defra): responsible for national adaptation planning.
  - Cabinet Office: critical national infrastructure, emergency response.
  - Ofgem and the Future System Operator (FSO): Ofgem regulates the electricity market. The new FSO will oversee the energy network.
  - National Grid: operates the electricity and gas transmission system.
  - Operators: Generation companies, gas and electricity transmission network owners, and distribution network operators (DNOs) responsible for generation assets and networks (power lines, underground cables).
  - Trade bodies: Energy Networks Association and Energy UK, setting standards and guidance for operators.
  - Planning authorities: approve applications for new infrastructure.

- **The scale of weather-related disruption to today's system is not known.** Lack of data are hampering efforts to achieve resilience outcomes in the most effective ways. For electricity, customer interruptions and customer minutes lost are reported to Ofgem but collated national information on the number and length of weather-related outages is not available. Adaptation Reporting Power reports and media provide some limited insights into individual events, but do not currently provide a holistic picture.

- **Regulatory price controls do not incentivise long-term resilience.** Ofgem sets price controls for gas and electricity network companies in Great Britain, but there is no formal requirement for climate resilience to be incorporated in investment plans.* There are reliability incentives and methods for determining asset maintenance and replacement, but current mechanisms do not incentivise long-term resilience. Ofgem are currently reviewing the future of price controls and are expected to consult on this in March 2023. Under the Flood and Coastal Erosion Risk Management Strategy Roadmap to 2026, the EA is working with the power distribution sector to share flood and coastal erosion risk information and explore joint investment opportunities to improve resilience of power distribution assets.

- **It is not currently possible to decouple investment in climate resilience from other investment.** Some limited data on resilience investment are available. National Grid has invested around £115 million in the first phase of its electricity Substation Flood Defence Framework, with an expected additional £59 million for further resilience investment for surface water risks.[9] The UK Infrastructure Bank (UKIB) was launched in 2021, tasked with accelerating investment into ambitious infrastructure projects, cutting emissions and levelling up the UK. However, to date the UKIB has focussed on emissions reduction in financing projects.

* The current price control period runs from 2021 to 2028.

This section assesses progress in policy and planning to deliver the outcomes identified above. Policy developments since our last statutory assessment of progress, including missed opportunities to integrate adaptation, are summarised in Box 6.3.

(a) Outcome 1: Reduced vulnerability of energy assets to extreme weather

Some key policy milestones for asset level resilience are not in place, such as minimum resilience standards and a climate remit for regulators.

Some key policy milestones required to ensure generation and network assets are resilient to extreme weather are not in place. Climate change is a consideration in statutory planning applications for new infrastructure and reports submitted under ARP3 demonstrate progress in some areas, but there is a need for minimum resilience standards and a clearer climate resilience remit for regulators. The next National Adaptation Programme needs to set a pathway to creating clear resilience outcomes for the sector.

Overall only **partial policies and plan** are in place for this outcome.

- **Climate change is a consideration in statutory planning applications for new infrastructure.** The National Policy Statement for new energy infrastructure (2011) and existing provisions under The Planning Act do require applications for new energy infrastructure to incorporate the potential impacts of climate change, including using the latest UK Climate Projections available and adaptation measures based on the latest UK Climate Change Risk Assessment (CCRA).[10] Ofgem does not have a statutory duty for climate resilience. Its duties were last reviewed in 2013. The Infrastructure and Projects Authority has added tests for climate resilience to its assurance processes for infrastructure projects of the Government's Major Projects Portfolio, although application of the tests is not being monitored yet.

- **There is only one standard that directly considers climate risk.** ETR138 requires all significant electricity substations (more than 10,000 connections) to be resilient to a 1 in 1000-year flood event. ETR132 considers high wind and extreme rainfall for overhead wires but is a framework for basing decisions on, rather than a specific standard to achieve. Ofgem does not enforce obligations to achieve standards such as ETR138 however, it does require annual data from operators. Distribution Network Operators (DNOs) are developing an outcomes-focused physical network resilience standard to set public and government expectations and industry targets to guide planning and funding decisions by industry and the regulator. This is expected to be implemented during the NAP3 period (2023-2028).

- **Some key climate hazards, such as heat, are not sufficiently covered and there are no direct long-term resilience standards for electricity and gas.** Coverage of other hazards is less apparent within existing standards, particularly heat. DNOs continue to use cables and overhead conductors designed and manufactured to international standards, however these are understood to be based on maximum temperature thresholds of 40°C, which are unlikely to be sufficient in parts of the UK under plausible warming scenarios. Wind turbines are designed for specific climatic conditions in accordance with IEC 61400, an International Standard published by the

International Electrotechnical Commission. The standard prescribes a set of design requirements to ensure that wind turbines are appropriately engineered to provide sufficient structural integrity against damage from all hazards within the planned lifetime of the asset.

- **Government has signalled a commitment to improve standards for resilience**. The UK Government has committed to new standards for resilience by 2030 under the new UK Resilience Framework. This presents an opportunity to ensure that the future energy system is resilient to the full range of climate conditions under which it will operate. Given the scale of work needed to agree and implement standards across the sector, in line with the regulatory cycle, a pathway to deliver these standards needs to be set out as a priority. Under the Climate Services Now (CS-N0W) programme, DESNZ is commissioning research on what standards and levels of service should be required for Net Zero electricity networks.

A pathway to deliver minimum climate resilience standards for the energy system needs to be set out as a priority.

- **Electricity transmission and distribution companies largely have good adaptation plans; gaps exist for other operators and Ofgem.** Energy generators, electricity transmission and distribution and gas transportation companies are invited to report their climate risk assessments and adaptation plans to Defra every five years, under the Adaptation Reporting Power (ARP). The CCC assessed all third-round reports and found good coverage of risk assessment and adaptation plans for electricity transmission and distribution, but a lack of detailed adaptation plans from generators and Ofgem declined to report.[11]

- **New climate resilience strategy requirements have been introduced for DNOs.** Under the RIIO-2 price control regime, network operators were required to include their climate resilience strategy in published business plans. The scope of these appears similar to what is provided under the ARP. Ofgem assessed these strategies against criteria broadly in line with aspects of the CCC's evaluation of the ARP3 reports and concluded that most DNOs performed well overall.

  – All DNOs base their strategies on UKCP18 RCP 8.5, with a small number considering more than one climate scenario.

  – All DNOs consider the impacts of climate risks on their networks and all but one consider these impacts over short (current climate), medium (2050s) and long term (2080s).

  – Most highlight interdependencies as important and cover adaptation pathways at a high level, but don't include details (such as specific trigger points).

- **There is an opportunity for climate resilience strategies to directly inform price review determinations.** Whilst the resilience strategies are useful to see what actions DNOs are taking, they do not appear to influence determination decisions. Ofgem do not set out how their determinations are consistent with meeting standards of resilience in both the short and long term. The criteria for and role of these DNO resilience strategies in future electricity price controls is not yet decided and is dependent on other factors within the price control review process.

GAPS in ARP reporting are limiting understanding of progress across the sector.

- **Gaps in reporting under the ARP are limiting understanding of progress.** Participation in ARP is voluntary and as a result there are gaps in reporting across the sector. Reporting under the ARP should be mandatory and the

requirements for reporting by generators and regulators should be reviewed to ensure sufficient coverage across the sector. Projects being carried out under the Government's Climate Services for a Net Zero Resilient World (CSNOW) programme are seeking to identify new resilience metrics for the energy sector.

(b) Outcome 2: System level security of supply

There are only **limited policies and plans** in place for this outcome. Government has committed to a decarbonised, secure energy supply by 2035, but delivery challenges remain.

A decarbonised energy supply will be more weather-dependent. This can be reliable and secure but needs suitable planning.

- **Government has committed to fully decarbonise energy supply by 2035 and make it resilient.**[12] While this will result in greater weather-dependence (particularly wind) and increased exposure to outages due to weather extremes, our recent analysis summarised above shows that a decarbonised system, with a higher degree of weather-dependent generation, can be made both reliable and resilient.[13] The Net Zero Strategy acknowledges the need for incorporating adaptation into decarbonisation policy. This needs to be followed by implementation of integrated policy decisions which address both mitigation and adaptation challenges together.

- **It is critical that the system is designed from the outset to be resilient to extreme weather, including low wind years and wind droughts.** Ofgem does not currently have a statutory remit to consider climate resilience in system design. The new Future Systems Operator (FSO) will have a leading role on system design and Ofgem is leading on determining FSO responsibilities. It will be essential to have solutions that can cope with extended periods of low renewable generation while continuing to meet demand. This must be informed by historical precedent alongside further research on the expected impacts of climate change. In our recent report we make a series of recommendations to Government for delivery of a reliable, climate-resilient, decarbonised energy system by 2035.[14] The key recommendations related to climate resilience are included at the end of this chapter.

Stress testing against plausible weather extremes will be crucial in designing a resilient energy system.

- **Stress testing will be crucial in designing a resilient energy system.** Ofgem does not currently require operators to conduct stress tests or enforce remedial action if they are not conducted, as this is not within their current remit. Ofgem and the Energy Emergency Executive Committee (E3C) carry out investigations following major events (such as Storm Arwen or the August 2019 power outage). The Electricity System Operator (ESO) conducted an exercise following the Texas winter storm in Feb 2021 to see if there were learnings for Great Britain.

(c) Outcome 3: Interdependencies with other systems known and managed

Policies in this area are **insufficient**. There is a lack of systematic planning for interdependencies and a lack of information on progress being made by individual energy system operators.

- **Coverage of interdependency risks has improved in ARP3 adaptation plans but this remains an area of significant challenge**. The next round of ARP should require all electricity generators, transmission and distribution

companies and gas network operators to include specific actions for managing interdependency risks in their adaptation plans. Guidance is needed to support this.

- **Gaps in ARP reporting are limiting understanding across sectors** of the scale of risk facing infrastructure they rely on to operate, and the steps being taken to manage them.

Our assessment of progress in managing interdependency risks across all sectors is in Chapter 1.

Opportunities to embed climate adaptation into energy policy have been missed.

Box 6.3
Policy developments since 2021

Policy developments

- **Adaptation Reporting Power round three.** The third round of ARP completed in December 2021 (ARP3). Overall, there is good coverage of climate risk assessments and adaptation plans for electricity and gas network operators. A sector summary report was submitted by Energy UK on behalf of generators, giving limited information on detailed risk assessments and adaptation plans for individual generators. Ofgem declined to report. The CCC conducted an evaluation of the submitted reports and made recommendations to Defra for round four. In early 2023, Defra is consulting on the approach to the next round of reporting.
- **Net Zero policy.** The Government's Net Zero Strategy[15] acknowledges the need for incorporating adaptation into decarbonisation policy. This needs to be followed by implementation of integrated policy decisions which address both mitigation and adaptation challenges together.
- **Operator level resilience strategies.** There is a new Ofgem requirement under the RIIO-2 price controls, for climate resilience strategies to be included in network operator business plans. Requirements are similar to ARP3 reports, therefore individual strategies have not been analysed as part of this assessment.

Missed opportunities

- Key Government outputs since the Net Zero Strategy such as the British Energy Security Strategy in 2022 are silent on climate resilience.[16] The Energy Bill presents an opportunity to legislate for climate resilience of future energy supply.

(d) Recommendations to close policy gaps

Table 6.2 provides a set of targeted recommendations to close key outstanding policy gaps identified within this sector.

Table 6.2
Recommendations

Primary responsibility	Recommendation	Timing
DESNZ	Conduct a review of governance arrangements for resilience to climate hazards in the energy system, to ensure they are fit for the new expanded and more diverse low-carbon system given increasing societal reliance on electricity.	2024
DESNZ	Designate Ofgem and parties responsible now and in the future (including the new Future System Operator) for the maintenance of energy sector codes and standards, with a clear mandate to ensure climate and weather resilience.	2024
FSO	Ensure that future system design explicitly plans for the range of climate hazards that will face the energy system over its lifetime.	Ongoing
Cabinet Office	Develop a pathway to setting appropriate minimum resilience standards (both at asset and system level) to relevant climate hazards identified in the UK Climate Change Risk Assessment (CCRA), covering all relevant parties.	2028 latest
Ofgem	Extend requirements for reporting on outages to include the cause, duration and customers affected for all outages, and collate this as a national indicator.	2024
Defra	Mandate reporting on climate risk and adaptation plans by all generators, network operators and regulators under the Adaptation Reporting Power.	2023
Defra	Coordinate a systematic assessment of risks posed from cascading impacts across multiple sectors due to failures of the decarbonised energy system as part of the next round of the Adaptation Reporting Power.	2025
DESNZ	Commission further research to improve understanding of how climate change is altering key weather hazards that will impact the energy system.	Ongoing

Endnotes

[1] Slingo, J. (2021) *Latest scientific evidence for observed and projected climate change. In: The third UK Climate Change Risk Assessment Technical Report [Betts, R.A., Haward, A.B. and Pearson, K.V. (eds.)] Prepared for the Climate Change Committee, London.*

[2] CCC (2023) *Delivering a reliable decarbonised power system,* https://www.theccc.org.uk/publication/delivering-a-reliable-decarbonised-power-system/.

[3] Ofgem (2022) *Final report on the review into the networks' response to Storm Arwen,* https://www.ofgem.gov.uk/publications/storm-arwen-report.

[4] Data from the Environment Agency, unpublished.

[5] CCC (2023) *Delivering a reliable decarbonised power system.*

[6] Joint Environmental Programme (2021) *Projections of water use in electricity and hydrogen production to 2050, under the 2020 future energy and CCC scenarios – regional analysis,* https://www.energy-uk.org.uk/index.php/publication.html?task=file.download&id=7942.

[7] HM Government (2021) *Net Zero Strategy: Build Back Greener,* https://www.gov.uk/government/publications/net-zero-strategy

[8] HM Government (2022) *British Energy Security Strategy,* https://www.gov.uk/government/publications/british-energy-security-strategy.

[9] *Climate Adapt Case Study, Flood defence framework for National Grid substations in United Kingdom*, https://climate-adapt.eea.europa.eu/en/metadata/case-studies/flood-defence-framework-for-national-grid-substations-in-united-kingdom.

[10] DECC (2011) *Overarching National Policy Statement for Energy (EN-1),* https://www.gov.uk/government/publications/national-policy-statements-for-energy-infrastructure.

[11] CCC (2022) *Understanding climate risks to UK infrastructure, Evaluation of the third round of the Adaptation Reporting Power,* https://www.theccc.org.uk/publication/understanding-climate-risks-to-uk-infrastructure-evaluation-of-the-third-round-of-the-adaptation-reporting-power/.

[12] HM Government (2021) *Net Zero Strategy: Build Back Greener.*

[13] CCC (2023) *Delivering a reliable decarbonised power system.*

[14] *Ibid.*

[15] HM Government (2021) *Net Zero Strategy: Build Back Greener.*

[16] HM Government (2022) *British Energy Security Strategy.*

Chapter 7

Telecommunications and ICT

Table 7.1
Progress summary – Telecommunications and ICT networks

	Delivery and implementation	Policies and plans	Summary
Outcome 1: Vulnerability of assets reduced	Unable to evaluate	Limited policies and plans	• There remains no visible plan or process by the industry or Government with actions to manage long-term climate risks to the sector. Flood resilience of critical telecommunications infrastructure was assessed in the 2016 National Flood Resilience Review. • Guidance for critical national telecommunications infrastructure includes design considerations and operational processes for resilience to physical threats, including extreme weather, floods and lightning, though specific climate scenarios are not mentioned. • Adaptation Reporting Power reports provide some insight on progress, but there is a lack of detailed risk assessment and adaptation plans for operators. • Some progress in flood resilience of telecoms infrastructure but a lack of data to evaluate progress overall.
Outcome 2: System level resilience	Unable to evaluate	Insufficient policies and plans	• Ofcom does not have a statutory remit for climate resilience. • There is limited consideration of climate resilience in existing industry standards. • There is a lack of data to evaluate progress.
Outcome 3: Interdependencies identified and managed	Unable to evaluate	Insufficient policies and plans	• ARP3 reports demonstrate an awareness of sources of interdependency risk at an overall sector level. • There is a lack of data to evaluate progress.

Relevant risks from CCRA3:
Risks to infrastructure networks (water, energy, transport, ICT) from cascading failures (I1); risks to infrastructure services from river, surface water and groundwater flooding (I2); risks to infrastructure services from coastal flooding and erosion (I3); risks to bridges and pipelines from flooding and erosion (I4); risks to subterranean and surface infrastructure from subsidence (I7); and risks to digital from high and low temperatures, high winds and lightning (I13).

This chapter covers adaptation to climate change for telecommunications (telecoms) and information communications technology (ICT) network infrastructure. This is infrastructure for the provision of telephone, mobile communications and internet services, including around 500 data centres across the UK and extensive networks of optical fibres, cables and masts.*,1 This infrastructure is at the core of the UK's service-based economy and needs to be protected from disruption associated with extreme weather now and in the future.

Many climate hazards are already affecting telecoms and ICT services today and will become more severe and intense.

Telecoms and ICT infrastructure will be affected by flooding, increased temperatures and occurrence of heatwave events, storms and winds. Many of these hazards are already affecting services today (Box 7.2) and will increase in frequency and intensity, with greater impact on the provision of telecoms and ICT services than we see today.

* Tech UK estimate around 500 recognisable facilities - minimum power supply of 240kW, over 200m^2 floor area, environmental controls and operational redundancy including emergency back-up power to allow continuous running.

For other hazards, evidence on future changes and therefore potential impacts on telecoms and ICT infrastructure remains uncertain (Box 7.1).

Box 7.1
Changes in hazards and impact on telecoms and ICT infrastructure

High summer temperatures, rapid fluctuations in temperature and humidity, pose challenges particularly to data centres, which need to be kept cool to operate. Higher temperatures are already affecting data centre operations in the UK. Data centres are also vulnerable to floods, high winds, wildfire, droughts and loss of power supply (Box 7.2).

An increase in the frequency or intensity of storms could increase the risk of wind, ice and snow damage to overhead cables and damage from wind-blown debris. However, these fixed line services are being replaced by wireless services (4G and 5G) from the nearest fibre node, and direct connection to fibre networks. During periods of severe cold, snow or flooding, telecoms providers can be affected by denial of access to affected sites, or loss of power. These risks decline as more robust, underground, fibre optic cables parallel or replace aerial cables and wireless links. Fibre and cables are vulnerable to flooding damage where they use bridges to cross rivers.

More intense or longer droughts and heatwaves can affect a range of ICT infrastructure because ground shrinkage can lead to failure of electrical, gas and water pipes, thereby damaging co-sited ICT infrastructure. The Third Climate Change Risk Assessment (CCRA3) concluded that further attention to the climate resilience of this sector and quantitative information on current and future risks under climate change is needed to better assess its vulnerability and exposure to climate change.[2]

Source: Jaroszweski, D., Wood, R., and Chapman, L. (2021) *Infrastructure. In: The Third UK Climate Change Risk Assessment Technical Report*. [Betts, R.A., Haward, A.B., Pearson, K.V. (eds)] Prepared for the Climate Change Committee, London.

Dependence on digital infrastructure is growing so the impacts of outages are likely to increase.

Continued digitalisation of key functions in society means our dependence on digital infrastructure is growing, and therefore the impacts of climate-related events causing outages are likely to increase over time. Remote communities and vulnerable groups such as those who rely on digitally operated health equipment are likely to be more vulnerable to climate risks affecting digital infrastructure. The digital transformation of the home phone network, replacing copper landlines with digital, means landlines upon which many critical functions are reliant (traffic lights, lifts, communications for healthcare), will all require a separate power supply to operate. Storm Arwen highlighted this increasing vulnerability, when hundreds of thousands of households across northern England lost power and people in remote areas without a mobile reception were left unable to call for help.[3]

A lack of publicly available information makes it difficult to assess vulnerability to climate change.

The ownership of a large proportion of ICT infrastructure, particularly data centres, base stations and network connections, is private. For commercial or sensitivity reasons, information on location and connectivity is often not publicly available, meaning it can be difficult to assess vulnerability to extreme events across the system. Infrastructure is complex and interconnected, and assets are often located on sites that are not owned by the operators. The Department for Digital, Culture, Media and Sport (DCMS) is responsible for Government policy related to the telecoms and ICT sector in England. Ofcom regulates operations in the sector. The telecoms and ICT system is inherently linked to many other systems, particularly its need for a stable and reliable power supply. All other infrastructure systems depend on telecoms and ICT to operate effectively (see Chapter 5 on Water, Chapter 6 on Energy and Chapter 8 on Transport). Effective community preparedness and response to extreme weather events depends upon a reliable telecoms and ICT system (See Chapter 12 on Community). Progress in managing Infrastructure interdependencies is assessed in Chapter 1.

Successful adaptation of telecoms and ICT networks to climate change aims to ensure that reliable telecoms and ICT services are maintained despite the range of present and future extreme weather events. To deliver on this ambition for climate resilient telecoms and ICT networks we have identified key outcomes that need to be achieved (Figure 7.1).

Achieving climate resilience means reduced vulnerability of telecoms and ICT assets, system level resilience and management of interdependencies with other systems.

- **Reduced vulnerability of assets to extreme weather.** Telecoms and ICT assets will be exposed to an increased frequency of extreme weather events due to climate change. Assets must be designed and operated to be resilient to the range of climate hazards they will be exposed to over their lifetime, including flooding, overheating of infrastructure and deterioration of asset condition. Monitoring is necessary to identify and minimise the impact of climate change on these systems.

- **System level resilience.** Increased digitalisation means the consequences of network failures due to extreme weather will be greater. Telecoms and ICT systems must be designed to operate in these changing conditions and have plans in place to respond quickly and effectively when outages occur. This includes redundancy in system design and operation, diversity of technologies and contingency plans for weather-related events (see Community chapter for emergency response).

- **Interdependencies with other systems are known and managed.** Infrastructure services are increasingly dependent on one another. These interdependencies need to be accounted for in climate assessments and adaptation plans for major operators.

A set of enabling factors need to be in place to support the delivery of these outcomes:

- **Data.** Data on weather and climate related impacts on telecoms and ICT networks, and on the extent of adaptation actions being delivered, will enable a better understanding of how climate resilient the system is.

- **Governance.** Clear, mandated remits for climate resilience and appropriate co-ordination across interdependent sectors are needed, to ensure that the identified outcomes can be delivered, particularly around interdependencies.

- **Funding and investment.** Climate resilience needs to be formally integrated into investment processes and long-term decisions. This includes for large national infrastructure projects and company investment plans.

To put in place the enablers and deliver the outcomes there are several important roles for Government:

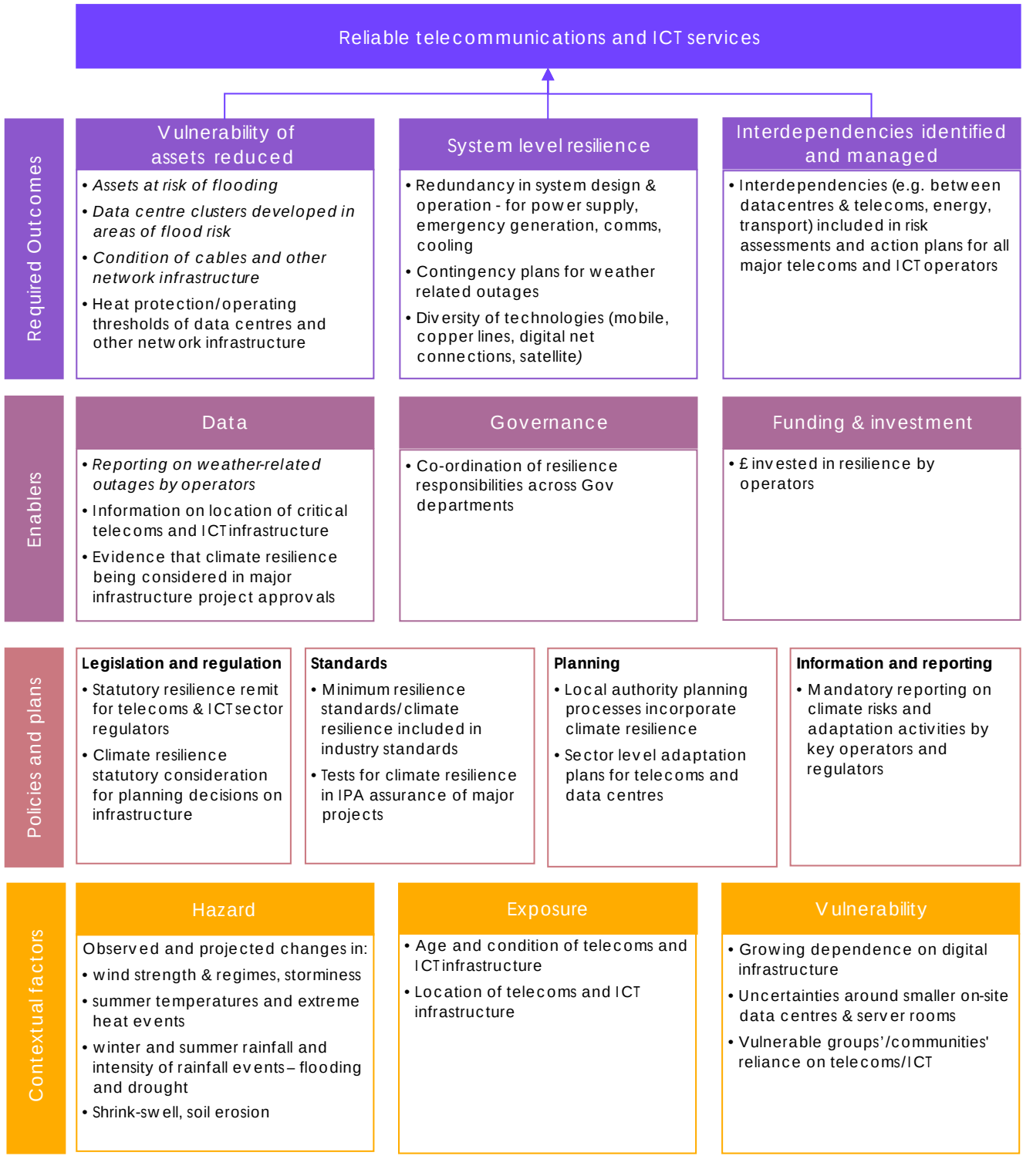
- **Legislation and regulation.** Government must legislate for long-term plans for resilient telecoms and ICT networks and provide appropriate frameworks for regulation. Statutory resilience duties are needed for regulators. Legislation should also ensure that investment allocation is appropriate to meet adaptation goals.

- **Standards.** New minimum resilience standards, or updates to existing industry standards, will be necessary to set expectations for operators and ensure the system continues to operate under a changing climate.

- **Planning.** National adaptation plans must have clear resilience outcomes with monitoring in place. All key operators must produce climate change risk assessments and adaptation plans which demonstrate progress in making telecoms and ICT networks more climate-resilient.

- **Information and reporting.** Reporting on some aspects of risk and adaptation planning and delivery should be mandatory. This will improve understanding of the national picture of sectoral adaptation, as well as in other sectors upon which telecoms and ICT networks depend, including energy and transport.

Figure 7.1 Monitoring map for telecommunications and ICT networks



Source: CCC analysis.
Notes: Italicised text indicates suggested measures for each outcome.

This section documents available evidence on progress towards delivery and implementation of each of the climate resilience outcomes identified in the previous section.

(a) Outcome 1: Reduced vulnerability of assets

Due to insufficient available data we are **unable to evaluate** progress for this outcome. Some limited data is available. There may be relevant adaptation measures being implemented for this outcome, but information is not publicly available.

- **Flood resilience of telecoms infrastructure was reviewed in the 2016 National Flood Resilience Review.** This identified 304 vulnerable fixed and mobile telecoms sites that were most at risk of a 1 in 1000 year flood event**.** Some of these have been relocated. Implementation of flood defences at other sites is ongoing.[4] Data on flood risk to data centres is not available.

Data on weather-related outages is unavailable but outages with significant implications have been reported in the media.

- **There have been weather-related outages in recent years, but collated national data is not available.** The Data Centre Incident Reporting Network (DCIRN) records incidents for data centres. It does not collect quantitative data on weather-related outages. Examples of outages to data centres from weather events have been reported in the media (Box 7.2).

Box 7.2
Weather-related outages to data centres and critical telecoms services

In the summer 2022 heatwave, temperatures of 40°C caused a 'catastrophic failure' of an NHS Trusts IT system. Two datacentres used to host the Trust's 371 legacy IT systems overheated and malfunctioned. A review into the event found that contributing factors to the failure included the age of the technology infrastructure, the 'sub-optimal cooling systems' it had in place and the 'overly' complex nature of its datacentre estate. The two sites, one located at Guy's Hospital and the other at St Thomas', were designed to act as backups for each other in the event of an IT failure, but both sites suffered failures as a direct result of the UK heatwave. The Trust declared a critical site incident and moved to implement a paper-based operating model to support clinical activity. The incident resulted in the Trust incurring £1.4 million in unexpected IT costs.

Datacentre cooling system failures at Google and Oracle were also reported during the same heatwave.

In 2015, BT and Vodafone data centre in Yorkshire suffered an outage due to flooding, cutting off phone lines to police and hospitals and affecting voice and data services in the North-East. South Tyneside Hospital reported that all main external phone lines to the hospital cut out after flooding took out the phone exchanges in York and Leeds. The 101 non-emergency police line and NHS 111 number were also affected.

Source: Computer Weekly (2023) *Guy's and St Thomas' NHS Trust warned in 2018 about datacentre cooling issues, outage report shows*; Computer Weekly (2022) *Burning up: Mitigation should sustain datacentre operations during extreme heat*; Data Centre Dynamics (2016) *Vodafone UK data center suffers outage due to floods*; Chronicle Live (2015) *Flooding in York cuts off North East phone lines to police and hospitals.*

Metrics are needed to monitor climate impacts and adaptation progress in reducing vulnerability of assets and improving system level resilience.

- **Metrics are needed to monitor climate impacts and adaptation progress**. Existing reporting mechanisms, such as the Adaptation Reporting Power, could collect information. Indicators that could be useful include:
  - Assets at risk of flooding
  - Conditions of cables and other network infrastructure
  - Maximum temperature operating thresholds of system components

(b) Outcome 2: System level resilience

There are no available indicators to assess progress – meaning we are **unable to evaluate** this outcome. There may be relevant adaptation measures being implemented for this outcome, but information is not publicly available**.**

- **Metrics are needed to monitor climate impacts and adaptation progress**. Existing reporting mechanisms, such as the Adaptation Reporting Power (ARP), could collect information. Indicators that could be useful include:
  - Level of redundancy in system design and operation for power supply, emergency generation, comms, cooling
  - Extent of contingency plans for weather-related outages
  - Diversity of technologies (mobile, copper lines, digital, satellite)

(c) Outcome 3: Interdependencies identified and managed

There is awareness of sources of interdependency risks at sector level but a lack of information on steps being taken by operators to manage those risks.

There is a lack of data to evaluate progress in this outcome. ARP3 reports do demonstrate an awareness of interdependencies at an overall sector level, with Tech UK and the Electronic Communications Resilience and Response Group (EC-RRG) identifying their main sources of interdependency risk as reliance on power supply; transport networks; and "pinch points" such as bridges that carry multiple utilities. However, there is no systematic assessment of interdependency risks at the operator level or set of plans to manage those risks.

While there is a general understanding of the interactions between ICT infrastructure and weather, quantitative projections assessing how climate change will affect the frequency and magnitude of these interruptions are lacking. This is compounded by a lack of public information on the location or specification of assets for interests of security and commercial sensitivity. Outages can have significant effects on local infrastructure networks and businesses and more broadly via interdependent infrastructure.

(d) Progress on enablers

Many of the enablers needed to deliver these outcomes are not yet in place:

Many key enablers are not in place including indicators to monitor progress and effective governance and investment models for resilience.

- **Data.** There is a lack of adaptation indicators for this system. To better understand the impacts of weather-related events, reporting by operators on outages caused by weather and the duration of those outages should be collated at national level. Further work is needed in the sector to develop suitable indicators for assessing adaptation progress.

- **Governance.** Telecoms and ICT is inherently linked to other infrastructure services. There is a need for better coordination across government departments with a role in infrastructure resilience (Chapter 1).

- **Funding and investment.** The extent of current investment in resilience and additional investment needs for telecoms and ICT are unknown. We made recommendations in our Adaptation Investment report on identifying and incentivising investment in adaptation more broadly.[5]

Most policy milestones required to ensure telecoms and ICT networks are resilient to extreme weather are not yet in place. Policies and plans for reducing vulnerability of assets are scored as **limited**. For the other two outcomes – system level resilience and interdependencies identified and managed – policies and plans are **insufficient**. There has been no notable progress in policy and plans since our last assessment.

Our assessments of policies and plans for the three outcomes are presented together in this section, as the policy milestones are largely the same across the three outcomes.

Ofcom has no statutory duty for climate resilience.

- **Ofcom does not have a statutory duty for climate resilience.** Ofcom's general conditions require communications providers to maintain uninterrupted access to emergency organisations "to the greatest extent possible", with significant fines for failures. National Policy Statements, which incorporate climate change considerations for other infrastructure types, do not apply to telecoms and ICT. Ofcom also has powers to take measures in response to "anything that compromises the availability, performance or functionality of the network or service", though climate change parameters are not explicitly stated.

There is limited consideration of climate resilience in existing industry standards.

- **There is limited consideration of climate resilience in existing industry standards.** Even where standards exist, they can be unclear (e.g. Ofcom's flood resilience standards) or may be inadequate (e.g. design standards for cables).
  - **Data centres**. EN50600 is an availability standard which covers all aspects of data centre infrastructure including power, cooling and telecoms. It also provides recommendations for operations and management, security and energy and sustainability.
  - **Design standards**. CCRA3 concluded that international design standards for equipment embed a resilience to a changing climate in the sector. For example, most cables are designed to operate in global extremes of temperature, and so current and projected changes to UK temperature extremes are unlikely to have detrimental effects. However, data centre failures due to extreme temperatures are already occurring.
  - **Commercial providers**. The level of resilience offered by commercial providers and the standards they adhere to are set out in contractual Service Level Agreements (SLAs).
  - **Ofcom powers and guidance**. Ofcom has powers under the Communications Act 2003 to investigate and fine operators that do not meet flood resilience standards, though the level of expected flood resilience is unclear. Ofcom's resilience guidance sets out the evidence they may seek to obtain from operators in response to a 'Resilience Incident' which includes single points of failure and physical damage (including fire, flood, severe weather or other natural phenomena). There is no discussion of climate change or plausible changes in climate hazards that may lead to these incidents in future.

- **A number of data centre facilities are designated Critical National Infrastructure**. The EC-RRG* Resilience Guidelines for Providers of Critical National Telecommunications Infrastructure do provide design considerations and operational processes to build resilience to physical threats, including extreme weather, floods and lightning. However, there is no consideration of climate scenarios and how these may affect the prevalence or impact of such events. The UK Government has committed to new standards for resilience by 2030 under the new UK Resilience Framework. This presents an opportunity to ensure that the telecoms and ICT system is resilient to future climate conditions.

The National Resilience Framework presents an opportunity to ensure that the telecoms and ICT system is climate-resilient.

- **There remains no visible plan or process by the industry or Government with actions to manage long-term climate risks to the sector.** Resilience planning in the data centre sector is conducted at corporate level by individual private operators, who compete on their ability to ensure business continuity for their customers. Tech UK and the EC-RRG were invited to report on climate risks and adaptation plans in ARP3, on behalf of their member data centre operators and telecoms providers respectively. At present, there is not enough information presented in the reports for this sector to understand its preparedness for climate change.

  - **EC-RRG report**. The report presents a summary of action for the sector for each relevant climate risk in CCRA3, but there is no information on the scale of risk to different operators or actions being taken at operator level. The risk assessment is based on CCRA3, no specific risk assessment appears to have been completed by the sector. Time horizons of 2020, 2050, 2080 have been considered, however there is no reflection of changing risks over time in the risk scores.

  - **Tech UK report**. The report presents a summary of steps the sector should take to address climate risks, including site selection, design and build and operation considerations, but does not present a programme of measures that is being implemented. The report is based on the 2018 UK Climate Projections (UKCP18) for the period to 2050, as data centre asset life is currently around 25-30 years. It also cites uncertainty in longer term projections for the sector.

Participation in the Adaptation Reporting Power (ARP) is voluntary and there are gaps in information.

- **Participation in the Adaptation Reporting Power is voluntary and there are information gaps.** We recommended to Defra in 2022 that the approach to sectoral reporting be reviewed, to ensure reports provide detailed and consistent information on the preparedness of key sectors for climate change, and that reporting should be mandatory.[6] Defra is currently consulting on the approach to the next round of ARP (ARP4).

(a) Recommendations to close policy gaps

Table 7.2 provides a set of targeted recommendations for actions to close key policy gaps to better prepare for climate change in this sector.

Table 7.2
Recommendations

Primary responsibility	Recommendation	Timing
DCMS	Designate Ofcom with a statutory remit for climate resilience.	2024
Defra	Specify outcomes and actions in NAP3 for Telecommunications & ICT resilience.	2023
Cabinet Office	Design a pathway to develop and implement minimum climate resilience standards for Telecommunications and ICT infrastructure.	2026
Defra	Develop a set of indicators to enable monitoring of the impacts of weather and climate on Telecommunications and ICT services and the actions being taken to manage them.	2025
Defra	Review the approach of consolidated sectoral reports before the next ARP round to obtain more detailed information on the preparedness of the sector.	2023

Endnotes

[1] TechUK (2021) *Sector Readiness for Climate Change Risks: Data Centres - Report to DEFRA under the Adaptation Reporting Power: Third Round,* file:///C:/Users/x945278/Downloads/techUK-ARP-response-to-DEFRA-2021-Data-Infrastructure-FINAL%20(3).pdf.

[2] Jaroszweski, D., Wood, R., and Chapman, L. (2021) *Infrastructure. In: The Third UK Climate Change Risk Assessment Technical Report.* [Betts, R.A., Haward, A.B., Pearson, K.V. (eds)] Prepared for the Climate Change Committee, London.

[3] Storm *Arwen: Why power cuts left people unable to phone for help - BBC News*

[4] Data provided by Defra, unpublished.

[5] CCC (2023) *Investment for a well-adapted UK,* https://www.theccc.org.uk/publication/investment-for-a-well-adapted-uk/.

[6] *CCC (2022) Understanding climate risks to UK infrastructure: Evaluation of the third round of the Adaptation Reporting Power,* https://www.theccc.org.uk/publication/understanding-climate-risks-to-uk-infrastructure-evaluation-of-the-third-round-of-the-adaptation-reporting-power/

Chapter 8

Transport

Table 8.1
Progress summary – Transport

	Delivery and implementation	Policies and plans	Summary
Outcome 1: Asset & system level reliability of rail network	Mixed progress	Credible policies and plans	• Rail infrastructure operators have credible climate resilience and adaptation plans and have reported under the latest round of the Adaptation Reporting Power (ARP3). • Indicators show some increased impacts on rail infrastructure from heat and wind, but reduced impacts from flooding.
Outcome 2: Asset & system level reliability of strategic road network	Mixed progress	Credible policies and plans	• The second Road Investment Strategy includes a vision for climate resilience. National Highways has reported its climate change risk assessment and adaptation plans under ARP3. • Overall road condition is unchanged since our last assessment and around 80% of inspected road structures in 2021/22 were rated as being in 'good' condition.
Outcome 3: Asset & system level reliability of local roads	Mixed progress	Insufficient policies and plans	• There is a lack of credible plans for local roads. Compliance with the Code of Practice for climate change is not known. Defra has proposed to include some local authorities in ARP. • No significant change in road condition, but additional indicators are needed for a more robust assessment.
Outcome 4: Asset & system level reliability of airport operations	Unable to evaluate	Partial policies and plans	• The two largest UK airports have mandatory resilience plans. • Eleven UK airports, including the seven largest, have reported their climate change risk assessments and adaptation plans in ARP3. • Unable to evaluate progress due to lack of indicators.
Outcome 5: Asset & system level reliability of port operations	Unable to evaluate	Limited policies and plans	• Four of the largest UK ports have reported their climate change risk assessments and adaptation plans in ARP3. Other key strategic port operators have not reported. • Unable to evaluate progress as there are coverage gaps due to voluntary reporting and lack of indicators.
Outcome 6: Interdependencies identified & managed	Insufficient progress	Insufficient policies and plans	• Identification of interdependency risks has improved in ARP3 reports for rail, strategic roads, airports and some ports, but interdependencies are not being consistently assessed in sufficient detail. • Unable to evaluate local roads progress due to lack of data.

Relevant risks from CCRA3:
Risks to infrastructure networks (water, energy, transport, ICT) from cascading failures (I1); risks to infrastructure services from river, surface water and groundwater flooding (I2); risks to infrastructure services from coastal flooding and erosion (I3); risks to bridges and pipelines from flooding and erosion (I4) risks to transport networks from slope and embankment failure (I5); risks to subterranean and surface infrastructure from subsidence (I7); risks to transport from high and low temperatures, high winds, lightning (I12).

This chapter covers adaptation to climate change for transport networks in England. This includes infrastructure networks for strategic and local roads, rail, ports, and airports. Functioning transport networks are necessary for personal mobility and public services, as well as key to corporate supply chains. Weather-related disruption to transport systems can cause significant cascading impacts across society with substantial financial impacts (Box 8.1), and weather conditions can also lead to the safety of transport system users being compromised.

Weather-related disruption to transport systems can cause significant cascading impacts across society with substantial financial and safety implications.

Transportation systems will be affected by a range of climate changes:

- Changes in rainfall intensity and frequency can lead to flooding and earthworks failures across road and rail networks.
- More frequent and intense periods of extreme heat events can cause damage and disruption to all transportation systems. For example, risks of rail buckling and failure of overhead power lines on the railways, risks of asphalt melting impacting the road network and airports.
- Long-term sea level rise and increases in the height of storm surges can affect port operations and damage or disrupt other coastal transport infrastructure.

Exposure of transport networks to these climate hazards is influenced by the age, condition, usage levels, and location of infrastructure. More critical networks (in terms of traffic volumes, areas or services supported) will be more exposed. The changes in the UK population, and the expected demands for transportation services (for example road miles per person) will influence the vulnerability of transport networks to climate risks.

Box 8.1
Financial impacts of weather events on transport infrastructure

In July 2021, deep floodwaters at Pudding Mill Lane DLR station cost an estimated £2 million in lost passenger revenue on the London Underground in July 2021 alone due to reduced services.

During the heatwave in 2022, which led to the worst grass fires seen in Greater London in a generation, Transport for London (TfL) estimated it lost £8 million. An estimated five million fewer passengers wanted to travel in 40°C heat, even though much of the TfL network is now fully air-conditioned.

The Environment Agency assessed the costs of the widespread flooding and storm damage in December 2015 and January 2016 following Storms Desmond, Eva and Frank. The best estimate for the impact on rail transport was £121 million at 2015 prices (with a range of £103 million to £129 million). This figure is based on Network Rail assessments of infrastructure damages and disruption payments. Further evidence from the Environment Agency (2018) assessment of the 2015-16 storms gives a best estimate for the costs to road transport as £220 million (with a range of £165 million to £275 million) based on Department for Communities and Local Government and Highways Authority data.

Source: MyLondon (2023) *TfL launches massive climate change plan after losing £10million due to flooding and heatwave*; Jaroszweski, D., Wood, R., and Chapman, L. (2021) *Infrastructure. In: The Third UK Climate Change Risk Assessment Technical Report.* [Betts, R.A., Haward, A.B., Pearson, K.V. (eds)] Prepared for the Climate Change Committee, London.

Infrastructure services are increasingly linked and dependent upon one another. This is true in the transportation network, for example where the rail and road network are dependent on the electricity and telecommunications systems (for example for signalling and increasingly as a fuel source). This means that any unmitigated risk connected to extreme weather has the potential to result in far-reaching consequences in the transport systems.

Other policy goals will also have an important impact on the exposure of the transport system to climate risks. Transitioning to a Net Zero society will facilitate and necessitate changes in transport mode demand (limiting growth in demand for aviation, shifts to lower-carbon forms of transportation, including active travel) and large transportation infrastructure investments currently planned (for example, High Speed 2 and Northern Powerhouse Rail). The Net Zero transition will also increase exposure to some climate hazards, for example heatwaves causing sagging of overhead lines and electrical outages, and storms causing network damage from fallen trees.

The Net Zero transition will necessitate changes in transport mode demand and large transportation infrastructure investments. It will also increase exposure to some climate hazards.

The Department for Transport (DfT) is responsible for transport policy in England. National Highways is the government-owned, arm's length body responsible for the strategic road network. Network Rail is the government-owned, arm's length body responsible for rail infrastructure. Funding for infrastructure investment comes from Government grants and tax revenues, with passenger fares covering some of the day-to-day operational costs of the railways. Strategic roads (motorways and major A roads) and rail are regulated by the Office of Rail and Road (ORR), regulating the economic and safety performance of National Highways, Network Rail and High Speed 1. Local road networks are operated by Local Authorities. Airports and ports are largely privately owned and operated. The Civil Aviation Authority (CAA) regulates all UK airports and monitors how the industry is adapting to climate change.

Within the transport sector, successful adaptation aims to ensure reliable Net Zero transport systems, despite climate change (Figure 8.1).

Net Zero transport systems need to be resilient to climate and weather impacts as asset and system level.

We identify key adaptation outcomes that need to be achieved for transport networks to deliver this:

- **Asset and system level reliability of rail network.** The impact of severe weather on rail assets and therefore rail services needs to be minimised. Tracks need to be protected from flooding and able to withstand the higher temperatures that we will see in the future (as well as remaining resilient to cold weather). Overhead lines, signalling, bridges and earthworks need to be maintained and protected from flooding, storm damage and heat impacts.

- **Asset and system level reliability of strategic road network.** Motorways and major roads need to be designed and maintained to withstand increased precipitation and higher risk of flooding. Earthworks and geotechnical assets need to be resilient to temperature changes, including deformation and expansion of concrete and changes to ground shrinkage and earth pressures affecting dependent assets such as structures and drainage.

- **Asset and system level reliability of local roads**. Local authority managed roads face similar pressures to strategic roads, and account for a significant proportion of the road network and of all traffic. Local Authority managed 'A' roads and motorways account for around 9% of the road network in England and carry approximately one-third of all traffic. Local Authority managed 'B' and 'C' roads account for around 28% of all roads in England.[1]

- **Asset and system level reliability of airport operations**. The impacts of climate change on UK aviation are expected to be the least significant of all transport modes. However, there is already evidence of impacts from flooding, for example Gatwick Airport suffered significant flooding in December 2013. Airport infrastructure, including asphalt and equipment, needs to be resilient to higher temperatures, be protected from flooding and be designed and operated to be resilient to storms and high winds.

- **Asset and system level reliability of port operations**. The top 10 UK major ports account for 68% of all cargo.[2] Ports need to be protected against rising sea levels, storms surges and coastal change. Half of the UK's port capacity is located on the east coast, where the risk of damage from a tidal surge is greatest. Sea-level rise of 50 cm or more by 2080 is a particular concern, especially for some ageing port infrastructure. Harbour infrastructure also needs to be resilient to flooding and physical damage. Supporting road and rail networks, crucial to port operations, need to be resilient to a different set of hazards as set out above.

All transport infrastructure operators need to identify and manage their risks arising from dependence on other sectors, such as energy. telecommunications and ICT infrastructure.

- **Interdependencies identified and managed.** All transport modes rely on energy, telecommunications and ICT infrastructure to varying degrees. All infrastructure operators need to carry out detailed assessments of their sources of interdependency risks, and work across sectors to manage those risks.

There are several categories of enabling factors that will be needed if the outcomes identified above are to be implemented at appropriate scales. These include:

- **Data and monitoring.** Effective monitoring of weather-related incidents and maintenance activities will improve understanding of the impacts of climate change on transport infrastructure and the actions being taken to manage them.

- **Funding and investment.** Delivering the outcomes identified above will require appropriately sized investment that is well-targeted. Sources of investment in the transport system vary across transport modes, including Central and Local Government funding, user charges and private investment. Regulation can facilitate the investment that is needed to ensure the whole transport system is resilient.

- **Governance.** There are a range of organisations that have responsibility for key aspects related to the climate resilience of the transport system and other interdependent infrastructure systems. System development required to deliver Net Zero makes it even more important that resilience remits are well defined and there is appropriate co-ordination to ensure that the identified outcomes can be delivered, particularly around interdependencies.

Our monitoring framework highlights policy and planning milestones which must be in place to achieve these required outcomes for a well-adapted transport system (Figure 8.1). These fall under the following categories:

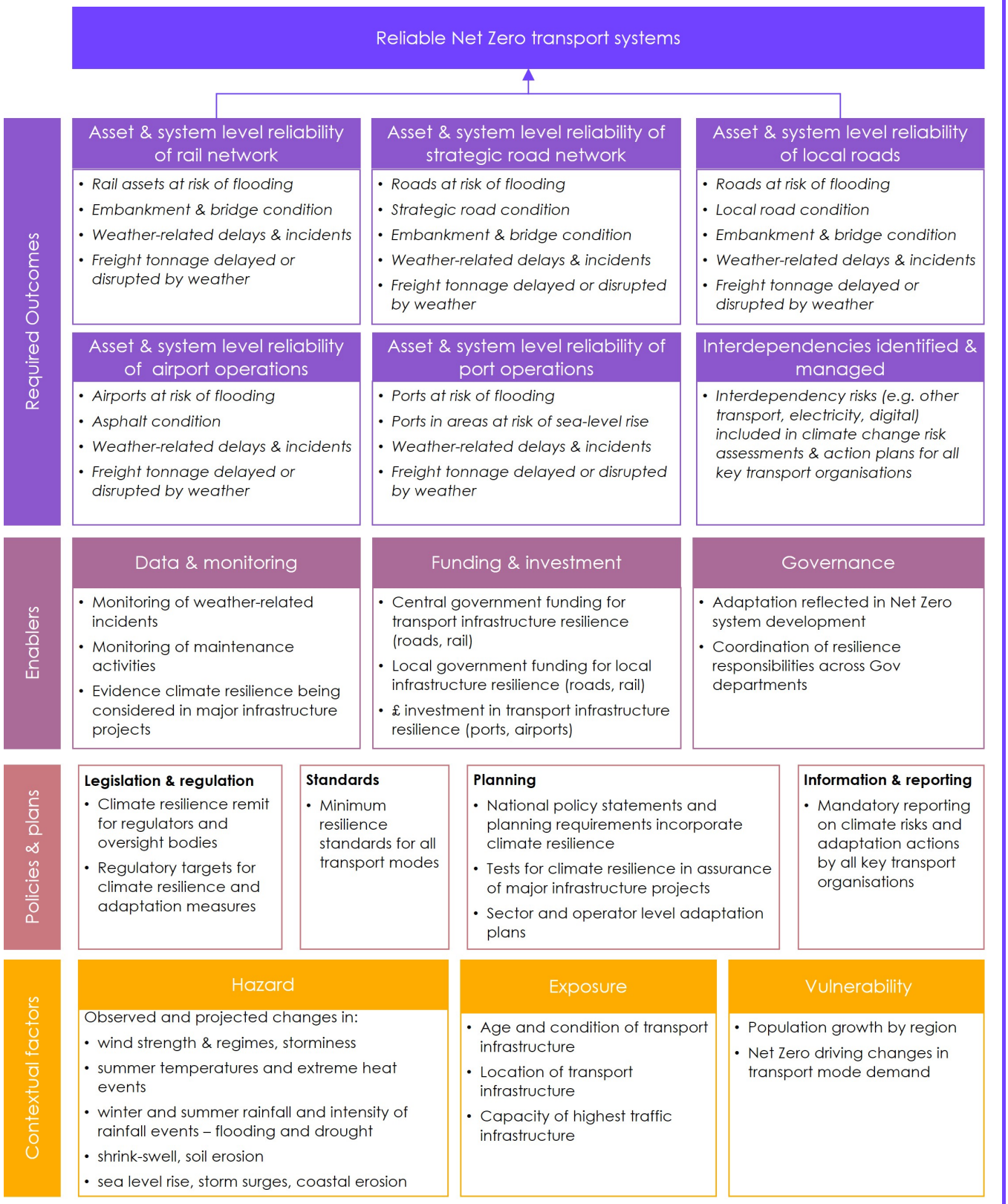
- **Legislation and regulation.** National policy must create legislation which enforces sustainable long-term plans for resilient transport networks and provide appropriate frameworks for regulation. Planning must span across regions to ensure suitable national scale planning. Legislation should ensure that funding allocation and investment is appropriate to meet adaptation goals.

- **Standards.** Well-adapted transport networks will require policy to deliver and extend resilience standards which deliver a transport system compatible with future climate conditions.

- **Planning.** National policy and consenting processes for new major infrastructure should incentivise adaptation actions by transport network operators. All key transport operators need robust climate change risk assessments and adaptation plans, which integrate adaptation into long-term planning and investment decisions.

- **Information and reporting.** Reporting on some aspects of risk and adaptation planning and delivery should be mandatory. This will improve understanding of the national picture of adaptation in transport networks, as well as in other sectors upon which the transport system relies, including energy and telecoms & ICT.

Figure 8.1 Monitoring map for transport



Source: CCC analysis.
Notes: Italicised text indicates suggested measures for each outcome.

This section documents available evidence on progress towards each of the climate resilience outcomes identified in the previous section.

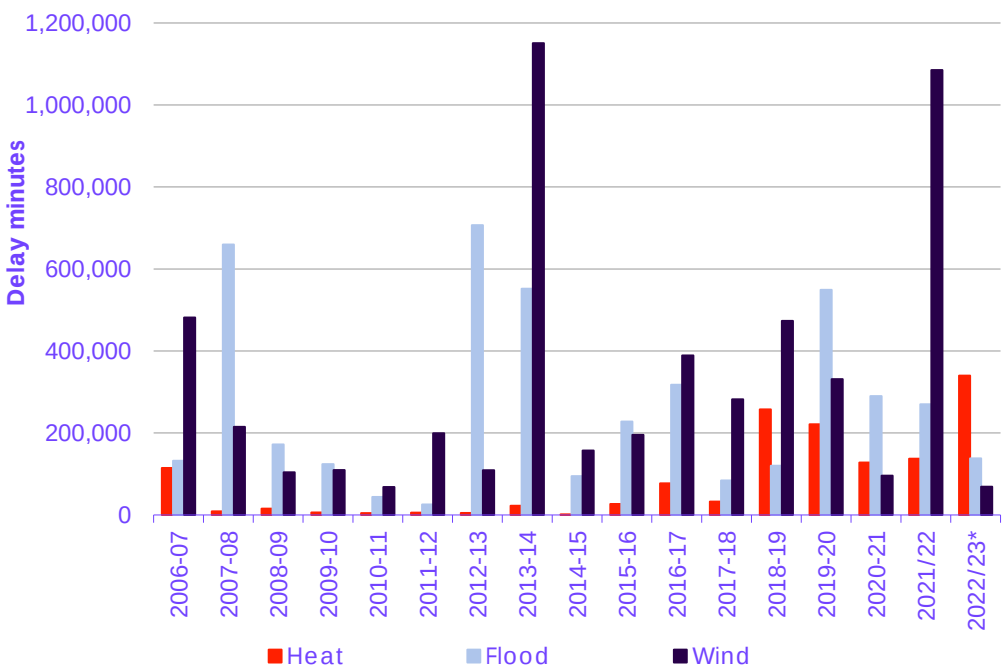
(a) Outcome 1: Asset and system level reliability of rail network

Available indicators show **mixed progress** towards this outcome. Rail network data show increased disruption from heat and wind events. Disruption from flooding has been lower in the two years since our last assessment but rail remains at increasing risk of surface water flooding in future due to climate change.

- **Heat and wind have caused significantly more rail disruption since our last assessment.** Weather-related delays and cancellations account for around 7% of all delays and cancellations on the network (in England and Wales).[3] Data on weather-related delays show how the network is being affected by weather, and the Committee is particularly interested in trends in heat, flood and wind impacts (Figure 8.2). Delay minutes due to extreme heat (either through speed restrictions or cancelled services) were 165% higher in 2022/23, compared with our last assessment (2020/21).* This is primarily due to the summer 2022 heatwave. Disruption from wind was significantly higher in 2021/22, with several large storms in that period.

Heat and wind have caused significantly more rail disruption since our last assessment.

Figure 8.2 Total delay minutes per type of weather-related incident in England



Source: Network Rail, unpublished.
Notes: 2022/23 data is for 11 months only.

* 2022/23 data is for 11 months only.

Flooding has caused less impact to rail services since our last assessment, but rail remains at increasing risk of surface water flooding in future due to climate change.

- **Flooding has caused less impact to rail services in the two years since our last assessment.** Under current levels of adaptation, the rail sector remains at increasing risk of river and surface water flooding. There are no new data available on the extent of rail network assets at risk of flooding. Analysis for the Third Climate Change Risk Assessment (CCRA3) showed that around 22% of railway stations and around 7% of railway track in England are currently exposed to 'significant' risk of surface water flooding (1:30 or greater).[*,4] Under a scenario with low population growth and current levels of adaptation, the risk of surface water flooding increases significantly in both the 2050s and 2080s. In a 4ºC world, by the 2080s, there is a projected 101% increase in length of railway track at risk and a 46% increase in railway stations at risk.

- **Network Rail continues to manage bridge sites at 'higher risk' and 'emerging higher risk' of structural damage or failure due to scour.**[†] The Train Accident Risk Reduction (TARR) measures achievement of key risk reduction activities planned. In Control Period 6[‡] (2019 – 2024), Network Rail committed to remediate 181 sites at higher risk of scour, and report that they are on track to complete all but 12 of these by the end of the control period.[5] They report that they have also remediated some emerging risk sites, which are additional to the TARR targets.

(b) Outcome 2: Asset and system level reliability of strategic road network

Available indicators show **mixed progress** towards this outcome. Roads in better condition should be better able to withstand extreme weather impacts. Overall road condition is unchanged, condition of most critical elements has improved but there was a slight decline in the average condition.

- **Overall road condition of National Highways managed roads is unchanged since our last assessment**, with 95.5% of the strategic road network (SRN) being assessed as not requiring further investigation (Figure 8.3).[§] National Highways met its key performance indicator (KPI) target for road condition in 2021-22. However, data collected in the current 'road period' (RP2, April 2020 - March 2022) so far only represents lane one (left-hand lane), as it was deemed to be the lane most impacted by vehicles, especially lorries. Government and National Highways updated the metric for the remainder of RP2 (April 2022 - March 2024) to include condition data from all the main lanes. This will better represent the overall condition across the network.

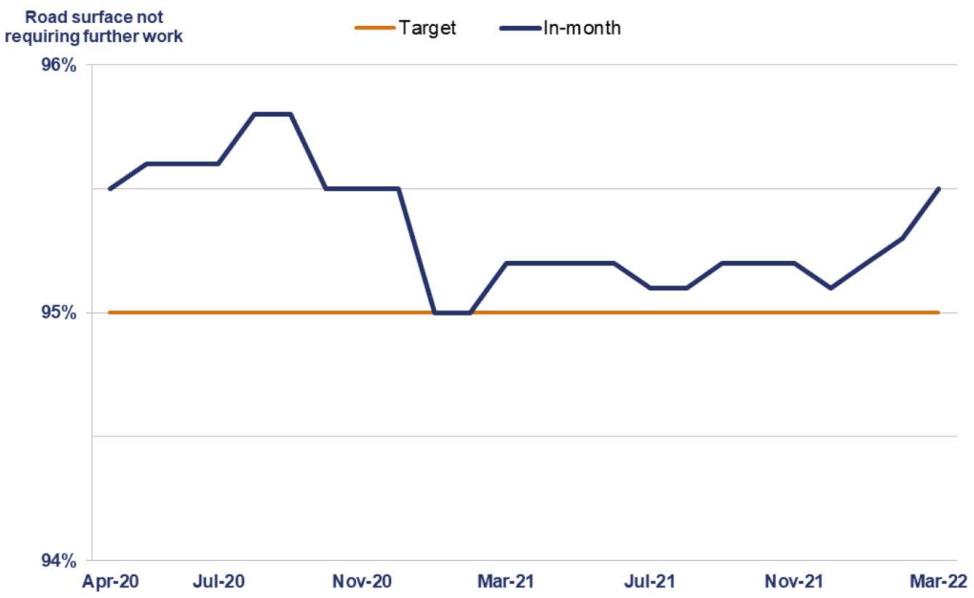
[*] CCRA3 analysis found 450 railway stations and 1,691 km of rail are currently exposed to this level of flood risk. As of 31 March 2022, there were 24,447km of track and 1,989 railways stations in England.

[†] Scour is the removal of material from the bed and banks of a channel and from around structure foundations by the action of water, leading to structural damage or failure. Scour is the leading cause of bridge failures in the last 100 years in the UK.

[‡] Control periods are the 5 year periods used by Network Rail to plan for financial investments and upgrades.

[§] National Highways (managed roads (motorways and A roads) account for around 2% of the road network in England and carry approximately one-third of all traffic.

Figure 8.3 Road surface condition – strategic road network



Source: Office of Rail and Road (2022) *Annual Assessment of National Highways' performance.*
Notes: Data prior to April 2020 are not comparable due to new metrics being defined for the current performance period. For the first two years of RP2, only lane 1 (left-hand lane) was considered as part of the KPI. This is because it is the lane most impacted by vehicles, especially lorries. Government and National Highways has updated the metric for the remainder of RP2 to include condition data from all the main lanes. This will better represent the overall condition across the network.

The condition of 'critical' road structures is slightly improving, but average condition of all structures is declining.

- **The condition of 'critical' road structures is slightly improving, but average condition of all structures is declining.** National Highways has a performance indicator for structure condition (culverts, gantries, retaining walls and bridges). National Highways does not have a set target for this metric, but it is used to monitor the resilience of the network. It measures the average condition of the stock, the condition of the assets' most critical elements, and the percentage of structures that have been inspected and rated as 'good'. In 2021/22, around 80% of structures that had been inspected were rated as 'good' condition.[6] The latest reported figures show that average condition has improved since 2015/16 but has declined slightly in the 12 months from March 2021 to March 2022. The condition of the assets' most critical elements has also increased since 2015/16 but is around 63% which is notably lower than the average condition, which was around 85% in March 2022.

- **Additional indicators would enable better progress monitoring against this outcome**. This includes data on weather-related delays and incidents, and freight tonnage delayed or disrupted by weather incidents.

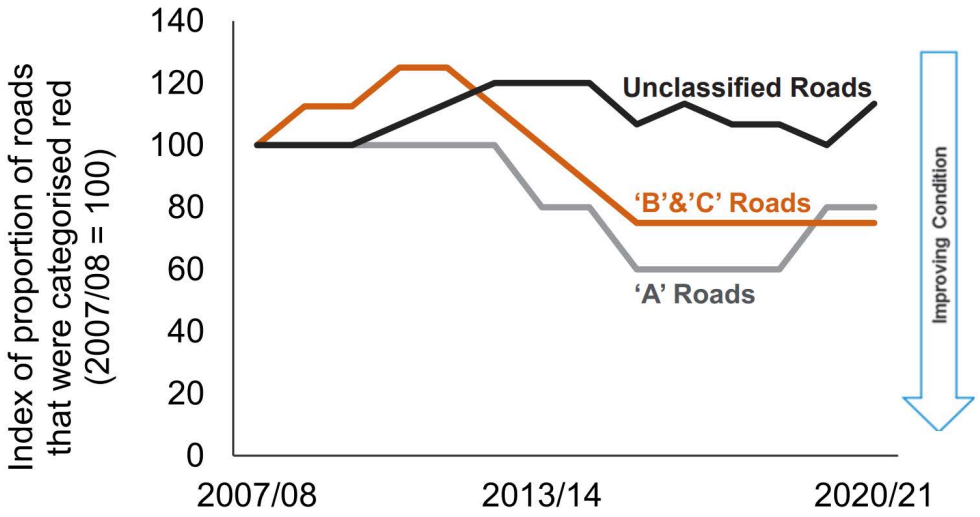
(c) Outcome 3: Asset and system level reliability of local roads

Local roads are likely to face greater impacts from extreme weather, but this remains a key information gap in the transport system. Available indicators show **mixed progress,** though more data are needed.

- Overall condition of local roads is largely unchanged since our last assessment and for some road classes is moving in the wrong direction.

In 2020/21, the proportion of local authority managed roads* that were categorised as 'red' (should be considered for maintenance) was: 4% of 'A' roads; 6% of 'B' and 'C' roads; 17% of unclassified roads (Figure 8.4).† Unclassified roads have seen greater year on year fluctuation than other road categories and the percentage of unclassified roads categorised as red increased in 2020/21.

Figure 8.4 Road surface condition – local road network



Source: Department for Transport (2021) *Official Statistics, Road conditions in England to March 2022.*

Additional indicators are needed, to better monitor progress for local roads.

- Additional indicators are needed, to better monitor progress against this outcome, including:
  - Local roads at risk of flooding
  - Embankment and bridge condition
  - Weather-related delays and incidents
  - Freight tonnage delayed or disrupted by weather incidents

(d) Outcome 4: Asset and system level reliability of airport operations

Insufficient data means that we are **unable to assess progress** against this outcome. There are no national indicators or datasets. Some limited information is available for particular airports in Adaptation Reporting Power reports (see Section 4d), but this is insufficient to assess national progress in improving the resilience of airports overall. Useful indicators could include:

- Airports at risk of flooding

* Local Authority managed 'A' roads and motorways account for around 9% of the road network in England and carry approximately one-third of all traffic. Local Authority managed 'B' and 'C' roads account for around 28% of all roads in England.

† C roads are classified, unnumbered roads which connect unclassified roads with A and B roads. Unclassified roads are local roads intended for local traffic – 60% of roads in the UK fall within this category.

- Asphalt condition
- Weather-related delays and incidents
- Freight tonnage disrupted by weather

(e) Outcome 5: Asset and system level reliability of port operations

There are no national indicators or datasets for airports or ports. Some limited information is available in operator reports but this is insufficient to assess national progress.

Insufficient data means that we are **unable to assess progress** against this outcome. There are no national indicators or datasets. Some limited information is available for particular ports in Adaptation Reporting Power reports (see Section 4e), but this is insufficient to assess national progress in improving the resilience of ports overall. Useful indicators could include:

- Ports at risk of flooding
- Ports in areas at risk of sea level rise > 50cm
- Weather related delays and incidents
- Freight tonnage disrupted by weather

(f) Outcome 6: Interdependencies identified and managed

The available information demonstrates **insufficient progress** against this outcome. It is not possible to assess progress for some transport sectors due to a lack of data.

Understanding of interdependency risks has improved at a high level for some sectors but there is a lack of detailed risk assessment and adaptation planning for interdependencies.

- **Rail**. Network Rail has completed an interdependencies mapping exercise in its Adaptation Reporting Power third round (ARP3) report and reflected this in the detailed risk assessment. The report recognises that they have more to do to improve understanding of the scale and nature of interdependencies, to identify priorities and what actions to take to address the risks. This includes further research on interdependency risks.
- **Strategic roads.** National Highways has identified its sources of interdependency risks in its ARP3 report, but these have not been incorporated into their risk assessment. Specific actions to manage these risks are not apparent.
- **Local roads.** There are no data to assess this for local roads.

  Airports. NATS (National Air Traffic Control) and individual UK airports have completed the mapping of interdependencies for each identified risk to airports and reflected this in the ARP3 report. The assessment of risks largely incorporates mapping of interdependencies, but the quantification of these risks based on climate projections has not been consistently carried out across UK airports.
- **Ports.** Risk assessments for ports have been grouped by the likelihood and impact of hazards in ARP3. Lack of consideration given to different warming scenarios and timescales is a critical gap. Planning to adapt ports to cascading failures of infrastructure services is limited.

(g) Progress on enablers

Enablers for well-adapted transport networks are in place for some transport modes, but others are lacking.

To achieve these outcomes for well-adapted transport networks, multiple enabling factors must be in place. Enablers should ensure that adaptation to climate change in the transport system is sufficiently funded and effectively governed. Robust data, through monitoring and research, are an important enabler for well-targeted and maintained adaptation. Enablers for well-adapted transport networks are in place for some transport modes, but others are lacking:

- **Data and monitoring.** Robust data exist for rail and strategic roads which broadly covers most key climate hazards. For other transport modes, indicators are needed (see progress in indicators above).

- **Funding & investment.** For some transport modes, regulated investment cycles present an opportunity to integrate long-term resilience. Limited data are available on the current scale of investment for resilient transport networks and the additional investment still needed.

  – Network Rail is now developing estimates of additional investment need for a climate-resilient rail network. Long-term adaptation pathways and investment strategies are expected to be developed for all regions in Great Britain by 2029.

  – The Road Investment Strategy 2 (2020 – 2025) includes a vision that the strategic road network is resilient to climate change and incidents, such as flooding, poor weather conditions and blockages on connecting transport networks. It includes performance indicators on structural, drainage and geotechnical conditions. However, in 2021 DfT reduced the total number of projects to be delivered under the strategy (down from 69 to 58) and reduced National Highways' budget for road enhancements by £3.4 billion (27%).[7]

  – In May 2020, the Government announced a £1.7 billion Transport Infrastructure Investment Fund for local roads and motorways (and railway). It is not yet clear what proportion of this funding will go towards improving strategic road condition or wider climate resilience.

  – Adaptation investment needs for ports and airports are not known. Examples of investment needed in these sectors include raising quay heights at ports exposed to sea level rise and tidal surges, replacing ageing infrastructure at ports and airports, and ensuring asphalt and electronic equipment can operate in periods of extreme heat.

Better coordination on climate resilience across Government departments is needed to manage critical interdependency risks and integrate adaptation into transport decarbonisation.

- **Governance.** Regulators across transport networks have limited statutory remits for climate resilience, and the extent to which climate resilience is incorporated into performance monitoring varies. Better coordination on climate resilience across Government departments is needed to manage critical interdependency risks and integrate adaptation into transport decarbonisation for Net Zero (see Chapter 1).

This section assesses progress in policy and planning to deliver the outcomes identified above.

DfT are developing an adaptation strategy for transport in England, which is expected to be in place for our next assessment.

(a) Outcome 1: Asset and system level reliability of rail network

There are **credible** adaptation policies and plans in place for the rail network.

- **The Office of Rail and Road does not have a legislative remit for climate resilience, but it is integrated into performance measures for Network Rail.** There is no reference to resilience or climate change in the duties of the ORR for the regulation of the rail network. Duties are typically defined around economic regulation, performance and efficiency, safety and maintenance. However, performance measures for Network Rail include measures related to climate resilience. A specific mandate for climate resilience for ORR would ensure long-term investment decisions incorporate, and are resilient to, the future impacts of climate change.

Standards and guidance for rail operation and maintenance reflect climate resilience requirements.

- **Standards and guidance reflect climate resilience requirements.** Network Rail have a range of standards, minimum requirements and guidance, including on environment, drainage and weather management:
  - **Environment and Social Minimum Requirements**.* It is mandatory for all construction and design works carried out by Network Rail and its contractors, as part of its formal 'PACE'† project management process, to carry out a weather resilience and climate change risk assessment.
  - **Drainage Standard**.‡ Require designs to include climate change uplifts in their design life and consider vulnerability of the assets. The uplifts used are in line with Defra recommendations at the time and will be revised as part of the ongoing revision of the drainage and water management strategies.
  - **Design For Reliability Standard**.§ Includes a reference to consider future climate changes in product development and design, accounting for expected climate changes during the product's operational lifespan.
  - **Operations weather management standards and processes.** Reviewed on a rolling basis and in response to serious events. KPIs have been developed for managing seasonality and this work continues in line with the 10-year Seasonal Weather Management Strategy.

* ESR' standard (NR/L2/ENV/015).

† Project Acceleration in a Controlled Environment.

‡ NR/L2/CIV/005/09 Module 9 - Drainage design.

§ NR/L2/RSE/0005.

- **Rail infrastructure operators have good adaptation plans.** Network Rail and Transport for London have specific climate change adaptation plans, while High Speed 2 is explicitly considering adaptation through its planning consent, design and construction programme:

  - **Network Rail.** Route Weather Resilience and Climate Change Adaptation (WRCCA) plans for all routes contain actions which prepare for warming scenarios exceeding 4ºC.[8] In March 2021, the target of 80% of milestones completed had been met or exceeded for six of the eight plans.[9] Adaptation pathways are being developed for the five Network Rail regions by the end of Control Period 7 (2029), which will include detailed plans for the entire network, highlighting areas with the highest level of risk or a need for transformational change. Network Rail has launched a new extreme weather resilience task force, in response to the impacts of the summer 2022 heatwave on the rail network. Led by independent experts, the task force will gather insights from international rail networks that are more used to dealing with extreme heat and fluctuations in temperature.

  - **Transport for London.** The first Transport for London Adaptation Plan (2023) sets a vision for a well-adapted and climate-resilient transport network that is safe and reliable for customers and colleagues, and sets an action plan to be implemented in the period up to 2030. The plan is based on a medium-high emissions scenario consistent with a 2-3 degrees Celsius increase in average global temperatures.* It also states that long lifespan projects and assets will be stress-tested using a high emissions scenario consistent with a 4-5 degree Celsius increase.†

  - **High Speed 2.** Its report submitted for the third round of the Adaptation Reporting Power (ARP3) demonstrates that climate adaptation and resilience is a fundamental part of the planning consent, design and construction programme. It sets out a detailed risk assessment and comprehensive action plan, aligned to climate change risks from the design and construction stages (the 2020s) to the operation stage of HS2 (represented by the last time period available for the 2009 UK Climate Projections (UKCP09) projections, the 2080s). Where applicable, risks in the mid-century (the 2050s) have also been assessed. A review of the potential implications arising from the 2018 UK Climate Projections (UKCP18) is underway.

Rail infrastructure operators have good adaptation plans and are reporting adaptation progress under the Adaptation Reporting Power.

- **Rail infrastructure operators report their progress in adaptation plans under the ARP.** Network Rail has reported its climate change risk assessment and progress in adaptation plans in all three rounds of the adaptation reporting power. In ARP3, the report includes a detailed risk assessment over appropriate timescales (present day, 2050s and 2080s) based on a medium-high emissions scenario under UKCP18.‡ This is accompanied by an adaptation action plan, though actions are not mapped to specific risks.

- **The Infrastructure and Projects Authority (IPA) has added tests for climate resilience for major infrastructure projects.** The IPA's assurance processes for infrastructure projects on the Government's Major Projects Portfolio now includes specific tests for climate resilience. This includes requiring projects to demonstrate compliance with the Green Book Supplementary

* RCP6.5 90th percentile.

† RCP8.5 90th percentile.

‡ RCP6.0 90th percentile.

Guidance on climate change. Application of the tests is not yet being monitored by the IPA.

(b) Outcome 2: Asset and system level reliability of strategic road network

There are **credible** adaptation policies and plans in place for the strategic road network.

The second Road Investment Strategy includes a vision that the strategic road network is resilient to climate change in 2050.

- **The second Road Investment Strategy (RIS2) sets a long-term strategic vision for the strategic road network (SRN) by 2050.** This includes a vision that, in 2050, the SRN is resilient to climate change and incidents, such as flooding, poor weather conditions and blockages on connecting transport networks.

- **Resilience is integrated into performance measures for National Highways.** There is no reference to resilience or climate change in the duties of ORR for the regulation of rail and strategic roads. Duties are typically defined around economic regulation, performance and efficiency, safety and maintenance. However, the Road Investment Strategy 2 (2020 – 2025) includes a vision that the strategic road network is resilient to climate change and incidents, such as flooding, poor weather conditions and blockages on connecting transport networks. National Highways has a regulated performance outcome of 'a well-maintained and resilient network'. This includes performance metrics for flooding (drainage management) and road condition.

- **Standards and guidance reflect climate resilience requirements.** The Design Manual for Roads and Bridges sets standards for road design.

  – Standard GG103 includes 12 sustainable development goals that design shall aspire to, including: 'be resilient to climate change'.[10] An accompanying National Application Annex for England includes a requirement that "resilience to future climatic conditions specific to the local and surrounding area shall be identified, assessed and incorporated into the design."

  – Standard LA114 sets out the requirements for assessing and reporting the effects of climate on highways and requirements for environmental assessments in relation to vulnerability to climate change.[11] Standards for drainage require flood risk assessments which apply the latest climate change allowances in accordance with relevant national legislation requirements.[12]

  – Standard CD529 requires culverts conveying a public watercourse to be discussed and agreed with the Environment Agency.

  – Multiple standards cover drainage, including increasing highway drainage capacity in line with climate sensitivities, Flood Risk Assessments for new road scheme including the latest allowances for climate change, and managing the maintenance of highways' geotechnical assets.

  – The UK Government has committed to review standards for resilience by 2030 under the new UK Resilience Framework. This presents an opportunity to ensure that the strategic road network is resilient to the full range of climate conditions under which it will operate in future.

Review of resilience standards for the strategic road network will need to be completed to coincide with the end of RIS3 in 2030.

- **National Highways has a credible adaptation plan.** National Highways Net Zero 2030/2040/2050 plan acknowledges climate resilience in its wider environmental ambitions and references their climate change risk assessment. National Highways has reported its climate change risk assessment and adaptation plan in all three rounds of the adaptation reporting power. The risk assessment is based on UKCP18 and considers RCP 4.5 and RCP 8.5 (broadly aligned to 2ºC and 4ºC above pre-industrial levels respectively). Risks have been assessed over appropriate timeframes – 2030s, 2050s and 2080s. This is accompanied by an adaptation action plan which identifies a number of planned adaptation actions, including the weather normalisation of the drainage metric, alignment of drainage standards with National Planning Policy Framework climate allowances, and the prioritisation of maintenance and renewal activity in areas where there are known flooding issues.

National Highways has a good adaptation plan and is reporting progress under the Adaptation Reporting Power.

- **National Highways continues to participate in ARP.** In collaboration with the University of Nottingham, they are conducting a study looking at enhancing the climate resilience of asphalt pavements. The study looks at the potential exceedance of critical thresholds using UKCP18 data to highlight the potential for changes to design and specifications.

- **The Infrastructure and Projects Authority (IPA) has added tests for climate resilience for major infrastructure projects.** The IPA's assurance processes for infrastructure projects on the Government's Major Projects Portfolio, now includes specific tests for climate resilience. These include requiring projects to demonstrate compliance with the Green Book Supplementary Guidance on climate change. Application of the tests is not yet being monitored by the IPA.

(c) Outcome 3: Asset and system level reliability of local roads

Current policies and plans for adaptation of local roads are assessed as **insufficient**.

Adaptation planning for local roads is insufficient.

- **A Code of Practice asks authorities to take account of climate change, although it is unclear how widely this is adhered to**.[13] The Code of Practice for Well-Managed Highway Infrastructure (2016) states that the effects of extreme weather events on highway infrastructure assets should be risk assessed and ways to mitigate the impacts of the highest risks identified. Highway Authorities should review and apply the latest UK Climate Projections, as developed by the Met Office and Environment Agency, when assessing future risk and vulnerability. There is no data to understand the extent to which this is being applied to the local road network. Local authorities are understood to be completing initial risk assessments of the impact of severe weather on their network.

- **Local roads are not covered by the scope of ARP.** Defra has indicated an interest in broadening the scope of the next round of reporting (ARP4) to include some local authority functions.[14] This is in line with previous CCC recommendations.[15]

(d) Outcome 4: Asset and system level reliability of airport operations

Adaptation policies and plans for airports are assessed as **partial**. Credible plans exist for most, but for some the quality of plans is more limited.

Credible resilience plans are in place for the largest UK airports, though gaps remain for others.

- **Gatwick and Heathrow have mandatory resilience plans, while other airport operators continue to be responsible for their own resilience planning.** The mandatory preparation of resilience plans for Gatwick and Heathrow airports continues to be governed by economic licence conditions. These require resilience plans to be incorporated into business plans. Other airport operators continue to responsible for their own resilience planning and flood risk is assessed by airports with over five million passengers per year through their annual resilience plans. The aviation sector follows CAA legal requirements to review safety margins within risk calculations to allow for unforeseen variations in surface access and runway conditions. Critical infrastructure such as runways and taxiways undergo a programme of daily, weekly and annual inspections. Commercial airports undertake monitoring programmes which include regular maintenance schedules of infrastructure and assets and regular reviews of contingency and response plans.

- **The seven largest UK airports have reported their climate change risk assessments and adaptation plans in the latest round of the adaptation reporting power.** Strategic UK airports are invited to report their climate change risk assessments and adaptation plans to Defra every five years.

  – Eleven UK airports, including the top seven largest by passenger number, and National Air Traffic Control (NATS), reported in ARP3.* Most reports have assessed risks under a very high (RCP8.5) global emissions scenario consistent with reaching and exceeding 4ºC global warming above preindustrial levels by 2100. A small number are limited to a scenario (RCP6.0) more aligned to the upper end of current policy projections for global emissions. All have assessed risks to at least 2050s and most have assessed them to 2080s.

  – Two thirds of the reports have presented a comprehensive programme of adaptation actions with actions linked to risks.

  – Over half of the reports have timescales attached to actions and almost all have appropriate monitoring and evaluation in place.[16]

(e) Outcome 5: Asset and system level reliability of port operations

Adaptation policies and plans for ports are assessed as **limited**.

- **Ports are not subject to regulation.** Regulation of activities around resilience would enable a more consistent approach across the sector.

- **Resilience standards for ports are left to individual operators**. Due to their commercial nature, there is limited information available on the extent of planning for climate change impacts.

* The busiest airports in the UK are Heathrow, Gatwick, Manchester, London Stansted, London Luton, Edinburgh and Birmingham. All of these reported in ARP3, as well as East Midlands, Glasgow and Cardiff.

Four of the largest UK ports have reported their climate change risk assessments and adaptation plans in ARP3. Some major UK port operators have not reported.

- **The four largest UK ports have reported their climate change risk assessments and adaptation plans in the latest round of the adaptation reporting power, however, other key strategic port operators have not reported.*** The activities of eleven ports and two lighthouse operators have reported in ARP3, this includes five of the ten busiest UK ports. We assessed most of these reports in our evaluation of ARP3, though some were not available at the time of our assessment.
  - More than half of the reports have assessed risks consistent with a high emissions scenario in the 2050s and 2080s. However, one risk assessment did not differentiate between current and future risk. Some did not discuss different warming scenarios or timescales.
  - All have presented a comprehensive programme of adaptation actions with actions linked to risks.
  - Only a third of reports presented timescales consistently for all adaptation actions and most indicated a monitoring and evaluation framework is in place. However, there was not always enough information presented, for example on the frequency of risk reviews or escalation processes.[17]
- Some major UK ports, including Felixstowe and Milford Haven, are not represented in the latest round. The Committee has recommended since 2016 that reporting under the ARP should be mandatory, to ensure all key port operators are completing climate change risk assessments and adaptation plans.

(f) Outcome 6: Interdependencies identified and managed

Interdependencies are not being consistently assessed in risk assessments and adaptation plans.

There has been some progress in identifying interdependency risks, particularly for rail, strategic roads, ports and airports. However, interdependencies are not being consistently assessed in risk assessments and adaptation plans. Therefore, progress is assessed as **insufficient** but improving. For local roads, we are unable to evaluate progress due to a lack of data.

- **In ARP3, all reporting organisations were invited to report on their interdependency risks.** While almost all reporting organisations commented on their sources of interdependency risk, detailed mapping of specific interdependencies and incorporation into climate risk assessments and adaptation plans is a critical gap. The voluntary nature of ARP means there are gaps in reporting in all the sectors, which limits the value of the reports in presenting a system-wide view of the scale of interdependency risks and the actions being taken by infrastructure operators to manage them. Mandatory reporting and more specific requirements and guidance on interdependencies is needed for ARP4. The scope needs to be broadened, including local roads and key supply chain organisations.

* ABP Harbour Authority Hull, ABP Harbour Authority Humber, ABP Harbour Authority Immingham, ABP Harbour Authority Hull Southampton, Port of Liverpool, Port of Sheerness and Chatham Docks, Dover Harbour Board, Port of London Authority, Mersey Docks and Harbour Company, Port of Sheerness, Northern Lighthouse and Trinity Lighthouse reported in ARP.

Minimum climate resilience standards and consistent remit for regulators would enable more cross-sector collaboration on managing interdependency risks.

- **Regulators in the transport sector and other infrastructure sectors have inconsistent climate remits.** Together with minimum climate resilience standards, consistent remits of regulators would enable more cross-sector collaboration on managing interdependency risks. We discuss this further in Chapter 1.

(g) Recommendations to close policy gaps

Table 8.2 provides a set of targeted recommendations for actions to close key policy gaps to better prepare for climate change in this sector.

Table 8.2
Recommendations

Primary responsibility	Recommendation	Timing
Cabinet Office	Develop pathways to review and implement climate resilience standards to align with timing of regulatory cycles for transport.	2030 latest
DfT	Ensure changes to transport systems, especially electrification of road and rail networks, to deliver Net Zero are resilient to climate impacts.	Ongoing
Defra	Extend the scope of the next round of the Adaptation Reporting Power (ARP4) to cover local authority functions related to road infrastructure and key supply chain organisations.	2023
DfT	Establish and monitor a suite of transport adaptation indicators, in particular for local roads, airports and ports, and infrastructure for active modes such as walking and cycling.	Ongoing
DfT	Designate transport sector regulators with consistent remits for climate resilience.	Ongoing

Endnotes

[1] Department for Transport (2022) *Road conditions in England to March 2022,* https://www.gov.uk/government/statistics/road-conditions-in-england-to-march-2022/road-conditions-in-england-to-march-2022.

[2] Department for Transport (2022) *Port freight annual statistics 2021: Overview of port freight statistics and useful information,* https://www.gov.uk/government/statistics/port-freight-annual-statistics-2021/port-freight-annual-statistics-2021-overview-of-port-freight-statistics-and-useful-information.

[3] Data provided by Network Rail, unpublished.

[4] *Office of Rail and Road annual statistics 2021/22 Tables 140 and 6320*, https://dataportal.orr.gov.uk/statistics/infrastructure-and-emissions/rail-infrastructure-and-assets/, and https://dataportal.orr.gov.uk/statistics/usage/estimates-of-station-usage/.

[5] Data provided by Network Rail, unpublished.

[6] Office of Rail and Road (2022) *Annual Assessment of National Highways' performance 2021-22,* https://www.orr.gov.uk/sites/default/files/2022-07/annual-assessment-of-national-highways-performance-2022-web_0.pdf.

[7] https://constructionmanagement.co.uk/nao-difficult-decisions-on-road-projects-amid-higher-costs/#:~:text=In%202021%2C%20DfT%20reduced%20the%20total%20number%20of,across%20the%20portfolio%20of%20projects%20by%20approximately%20%C2%A33.3bn.

[8] N*etwork Rail Route Weather Resilience Plans*

[9] Control Period 6 WRCCA Plan Progress Report for 2019-March 2021

[10] *DMRB Standard GG103 – Introduction and general requirements for sustainable development and design, July 2019.*

[11] *DMRB Standard LA114 Climate, October 2019.*

[12] *DMRB: LA113 Road Drainage and the Water Environment; DMRB: CG501 Design of Highway Drainage Systems*

[13] UK Road Liaison Group (2016) Well managed highways infrastructure – A Code of Practice

[14] Defra (2023) *Consultation Document Fourth round of climate adaptation reporting*, https://consult.defra.gov.uk/climate-change-adaptation/fourth-round-adaptation-reporting-power/supporting_documents/Consultation%20Document%20%20Fourth%20round%20of%20climate%20adaptation%20reporting.pdf

[15] CCC (2022) Understanding climate risks to UK infrastructure: Evaluation of the third round of the Adaptation Reporting Power, https://www.theccc.org.uk/publication/understanding-climate-risks-to-uk-infrastructure-evaluation-of-the-third-round-of-the-adaptation-reporting-power/

[16] *Ibid.*

[17] *Ibid.*

Chapter 9

Towns and cities

Table 9.1
Progress summary – Towns and cities

	Delivery and implementation	Policies and plans	Summary
Outcome 1: Towns and cities are prepared for and resilient to river and coastal flooding	Mixed progress	Credible policies and plans	• Current flood and coastal erosion risk management policy and current levels of funding represents significant progress in adaptation, allowing the Environment Agency and other risk management actors to deliver adaptation actions. • The updated Environment Agency strategy is integrated across all sources of flooding, which is positive progress. • It is too early to assess the effectiveness of implementation of many of the policies and plans.
Outcome 2: Towns and cities are prepared for and resilient to surface water and groundwater flooding	Mixed progress	Limited policies and plans	• Recent policy progress has included local surface water management planning and commitments to better model surface water flood risk. The implementation of Schedule 3 and engagement with water and sewerage companies through drainage and wastewater plans are also key positive policy progresses. • However, more buildings are at risk of surface water flooding and trends suggest urban impermeable surfaces are increasing. Schedule 3 does not provide mechanisms for slowing increase in unplanned impermeable urban surfaces. Risk mapping of urban surface water and groundwater flooding still lags other flood risk sources. • It is too early to evaluate progress towards delivering new policies and current plans lack consistent monitoring frameworks to ensure future climate change is considered.
Outcome 3: Sustainable and long-term coastal erosion management plans	Mixed progress	Partial policies and plans	• Plans for coastal erosion management exist but remain non-statutory and are not adaptation focused. • Recent increased funding and more ambitious, innovative adaptation planning represents good progress – but plans and delivery has typically been limited to areas with strong cost-benefit rationale for protection, meaning evidence of wider delivery is lacking.
Outcome 4: Urban heat risks to Towns and Cities are mitigated	Unable to fully evaluate	Limited policies and plans	• Urban heat risk management at the settlement scale lacks overarching vision within policy. • National planning policy, combined with emerging policies for biodiversity net gain and management of green and blue space, could enable urban design which promotes cooling measures, but these policies are currently inconsistently applied. • Monitoring delivery of adaptation measures, such as green infrastructure, is lacking, resulting in limited evidence to evaluate.

Outcome 5: A planning system which prioritises future climate resilience	Mixed progress	Insufficient policies and plans	• Recent updates to guidance on floodplain planning is limiting new development at risk of flooding, although some development is still occurring against advice. New guidance for green infrastructure is also progress, but overall, climate resilience is not embedded nor sufficiently enforceable within spatial planning policy. • Climate resilience measures are largely considered as guidance, resulting in inconsistent implementation and delivery. There is potential for planning and environmental improvement policies to enable planning decisions to consider adaptation, but clear mechanisms are currently lacking. • Planning policy lacks standards and mechanisms for monitoring the inclusion and maintenance of climate resilience measures.
Relevant risks from CCRA3: Risks to health and wellbeing from high temperatures (H1); Risks to people, communities and buildings from flooding (H3); Risks to viability of coastal communities from sea level rise (H4); Aspects of Risks to infrastructure services from river, surface water and groundwater flooding (I2) and Risks to infrastructure services from coastal flooding and erosion (I3) are also covered less explicitly in this system.			

Around 83% of England's population live in urban areas.[1] This number is increasing – the population in towns in England has risen by 12% and the population in cities in England and Wales outside of London by 16% between 2001 and 2019.[2] As such, towns and cities represent areas where exposure to the risks from climate change is high, due to higher densities of people, buildings, infrastructure, and businesses.

Furthermore, in 2011, around 17% of the UK population lived in coastal communities and in 2020 over 5.3 million people live in coastal towns in England and Wales.[3,4] These communities may be at increased risk of flooding and erosion due to climate change. Recent research suggests that there are around 2,200 properties, worth around £584 million, in the 21 highest erosion risk coastal communities.[5]

People, buildings and land in towns, cities, and smaller settlements will be exposed to more severe and frequent hazards associated with climate change, such as heatwaves, flooding, and erosion.

Towns and cities will face several risks from changes in the UK's climate over the coming decades:

- **Heatwaves:** Urban land surfaces, such as pavements and buildings, absorb and retain heat. This means that towns and cities are usually warmer – particularly at night – than surrounding rural areas and experience increased risk, and potential harmful impacts, of overheating during hot temperatures.

- **River and surface water flooding:** Increased flood risk is expected from more high intensity rainfall events predicted under future climate scenarios. Additionally, even in the absence of climate change induced flooding, there are more people and buildings at risk of flooding due to the development of land on flood plains and the use of more impermeable surfaces (e.g. roads and paving).

Population growth, particularly in urban areas, exposes more people to climate risks.

- **Sea-level rise:** Sea level rise means that coastal towns and settlements are at higher risk of coastal flooding during storms or high tides. In addition, around 1,800 km of open coastal areas are also at risk of erosion, with 28% of the coastline of England and Wales experiencing erosion greater than 10 cm per year.[6,7] Erosion rates are expected to increase with the greater nearshore water depths which result from sea level rise.

Adaptation actions in and around towns, cities and other smaller settlements can reduce the harmful impacts of climate change risks.

Flood and coastal erosion risk management and spatial planning are the key areas of policy which can influence adaptation to climate change in the urban and rural built environment. Both are devolved. Some flood risk management plans cross catchments into Wales and Scotland so managing flooding and coastal risk requires cooperation across these administrations.

While these areas are driven by national policy in England, local authorities and risk management authorities have a key role in delivery through, for example, town planning, surface water, and groundwater flood risk management. Local context is therefore important. The distribution of risks, harmful impacts of climate change, and the most suitable adaptation interventions will be different in different towns and cities. Adaptation requires collaboration across a range of key local actors (Box 9.1).

Adaptation policy in towns and cities must align with other policy goals for reducing emissions, and creating pleasant and efficient spaces, with sufficient housing and infrastructure.

There are several other policy goals for towns and cities which may have co-benefits or trade-offs with climate change adaptation. These include:

- Meeting housing and infrastructure demands
- Reducing greenhouse gas emissions towards Net Zero
- Making urban environments safer and more pleasant places to live, including through improved air quality and greater access to (and quality of) nature

Box 9.1
Key actors for climate adaptation in towns and cities

- **Local government bodies –** particularly **Local Planning Authorities** - are key actors for local planning development. **Local Planning Authorities** carry out urban planning functions, such as preparing Local Plans and determining planning applications.
- County councils, unitary authorities and Metropolitan Borough councils are **Lead Local Flood Authorities** and are responsible for managing risk of flooding from surface water. Coastal erosion responsibilities lie with **Coastal Protection Authorities**.
- **The Environment Agency** manage risk of flooding from main rivers and the sea, including defence maintenance.
- **Planners and developers** influence the design and location of new developments.
- **Water and sewerage companies** manage the risk of flooding to water supply and sewerage facilities and flood risk from the failure of their infrastructure.
- **Adaptation planning by other infrastructure providers** (such as power, transport and highways) also contributes to the overall resilience of the system through their capability to maintain key services and enable effective response.

There are multiple actors for climate adaptation in towns and cities, which is strongly linked to plans at the local scale.

This chapter excludes risks and policies related to large-scale infrastructure and individual buildings. Community response and preparedness is a key part of resilience in towns and cities. This is covered in the community preparedness and response chapter (Chapter 12). Climate resilience in towns and cities is also strongly linked to resilience across several other sectors. Some of the key risks, such as flooding and overheating, are overlapping – and delivery of adaptation and response to hazards is interdependent.

Key interactions include:

- **Power, telecoms and transport infrastructure:** Adaptation actions to reduce risk to infrastructure systems must also protect nearby settlements and not result in increased risks to surrounding areas. Spatial planning must therefore consider the resilience of infrastructure systems and the additional pressures they may place on an urban environment, such as heat generation and reduction in drainage capacity. Infrastructure networks are also critical for helping towns and cities respond to hazard event, by enabling warning systems and emergency coordination – as also discussed in the community preparedness and response chapter (Chapter 12).

- **Water supply:** Well-adapted drainage and sewerage infrastructure can increase resilience to flooding, while poorly maintained infrastructure can exacerbate the impacts of climate events.

Policies and actions for preparing urban developments to climate change are linked with those in other chapters.

- **Buildings:** Adaptation of individual buildings can contribute to overall resilience in well-adapted towns, cities, and smaller settlements. Buildings, and their contents and occupants, will be impacted by urban heat and flooding hazards.

- **Nature:** Risks to urban and rural nature and their capacity to build resilience will impact built-up areas. Nature-based solutions (NbS) can be adopted in adaptation plans to manage climate risks to infrastructure and urban environments. For example, riverine tree planting and ponds can increase infiltration of water, facilitate urban cooling and reduce surface water run-off, making downstream flooding less likely.

1. Monitoring progress towards well-adapted towns and cities

Well-adapted towns and cities should be prepared for and resilient to the harmful impacts of climate and weather extremes.

Well-adapted towns and cities are places which are adequately equipped for climate and weather extremes, such as flood events and high temperatures. Built environments should be designed in ways which minimise the negative impacts of future climate hazards.*

In this chapter we propose a monitoring map (Figure 9.1) of the key outcomes, enablers and policy actions that are needed to ensure that fewer buildings, people and activities in towns and cities are at risk from the harmful impacts of climate change. This can be achieved through good planning, design, and preparedness.

The key adaptation outcomes that are required are:

- **River and coastal flood risks to people, land and buildings are minimised.** New flood defences will be required to protect settlements from increased river and coastal flood risk. Existing and new flood defences need to be well-maintained to continue to function well. In addition to defences, flood risk management requires a suite of broader actions to increase resilience, such as improved risk mapping, flood warnings and the ability to recover quickly (see Chapter 12). Effective flood risk management requires a catchment-based approach. A combination of upstream (rural) and downstream (urban) interventions allows for better management of overall risk.

Towns and cities should be prepared for future flooding from rivers, the sea and rainfall events.

- **Surface water and groundwater flood risks to people, land and buildings are minimised.**† This requires effective management and mapping of water flows above and below ground in urban areas. This is achieved through well-maintained drainage infrastructure – including sewers, drains and sustainable nature-based options. Managing the extent of impermeable surfaces and delivering appropriate property level protection are also key to managing surface water flood risk. Groundwater flood risks can be managed through drainage and pumping, as well as property level protection measures.

Policy should ensure coastal settlements are protected from erosion or supported to adapt or relocate where this is not sustainable.

- **Areas at risk of coastal erosion are supported in a sustainable coastal transition**. This requires long-term planning which considers the scale of future risk. Some coastal areas will need to be defended by structures. In some areas, coastal defence may not be a sustainable option, and communities should be supported to relocate. The whole coastline should be considered as connected using a combination of approaches, including nature-based solutions. Long-term planning, particularly for coastal erosion, is required to ensure decisions made now are sustainable in the future.

* While this Chapter is named 'Towns and cities', the climate risks, policy goals, and enablers for adaptation are similar for smaller settlements.

† Surface water flooding is considered separately from river and coastal flooding because different policies, plans and actors are required for adaptation. However, there are significant overlaps between the different sources of flooding (all sources are covered in the FCERM Policy and Strategy and have some of the same climate drivers) and this should be considered in managing the risk.

- **Urban heat island risks are minimised.** Urban heat island effects can be minimised through careful urban design. Policies which encourage more shading (trees) and water in street design can act to reduce urban outdoor temperatures, as can maximising green and blue spaces, and reducing surfaces that absorb heat (such as creating green or reflective roofs).

Adaptation to urban heat must be addressed by urban planning.

- **Climate resilience is fully integrated into, and enforced by, the planning system.** Sufficient legislation, regulation and enforcement is required to ensure that new developments are built in locations and designed in a way that reduces vulnerability to flooding, coastal erosion and urban overheating now and in the future. Policies should enforce and support sustainable planning decisions in new developments and adaptation retrofitting in existing developments. This will allow more proactive risk management.

Climate resilience should be embedded in policy and decisions which influence the location, spatial layout and design of settlements.

Enabling factors that need to be in place to deliver these outcomes are:

- **Funding.** Building and maintaining flood defences and green infrastructure requires sufficient and well-targeted public capital (new investment) and resource (maintenance) funding, including for local authority spending. In addition to defences and interventions, monitoring, warning systems, community engagement and further research all require funding. Planning decisions should be properly funded to allow for a thorough consultation and assessment process. Additional funding from the private sector is likely to be required to meet the scale of ambition required for well-adapted towns and cities.

- **Governance**. A proactive planning system which considers future climate risks needs to be supported by joined-up risk management plans, which have clear responsibilities for decision makers and stakeholders. This allows for collaboration across catchments and between urban and rural regions. It also promotes the sharing of data necessary for effective adaptation. Ambition and resource in local authorities and risk management authorities are key enablers for this.

- **Engagement and education**. The public should be well-informed about future climate risks to enable household-level decisions about building in adaptation. Clear risk mapping and communication is required to achieve this. In addition, equitable long-term planning requires local stakeholder engagement. Climate-resilient planning and construction requires workers with technical and practical skills to support activities such as modelling, design and installation.

Adaptation in towns and cities will require sufficient funding, clear responsibilities for actors, updated research and buy-in from communities at risk.

- **Research.** Further research can enable improved flood risk mapping. This is particularly an issue in relation to groundwater flooding. An improved understanding of risk, vulnerability indicators and the benefits of climate adaptation actions beyond risk reduction (such as health and well-being) will help their incorporation into decision-making and improve public confidence. This is key for ensuring funding is allocated to locations and projects based on socio-economic factors in addition to where benefits are the highest.

- **Data and monitoring.** More standardised approaches to risk mapping across scales (local to national) and consistent monitoring is crucial for catchment-based approaches which work across rural and urban regions. Good practices of data sharing across sectors, regions and risk management authorities are key to enabling climate resilient planning.

Monitoring changes in risk and the status of adaptation actions, such as the runoff reduction from sustainable drainage systems, will enable better targeting of future actions.

Our monitoring framework highlights policy and planning milestones which must be in place to achieve these required outcomes for well-adapted towns and cities. These fall under the following categories:

- **Legislation and regulation:** National policy must create legislation which enforces sustainable long-term plans for flood risk management, coastal erosion risk management and spatial planning. Legislation should include mandatory, but place-based and adaptable, resilience targets (such as green infrastructure installations or delivery of shoreline management projects) and provide appropriate frameworks for regulation. However, licensing and regulation should be pragmatic. Small-scale natural flood management or sustainable drainage systems (SuDS) should not be subject to the same evidence standards as hard engineered construction projects. Portfolio approaches, where multiple small interventions are considered together, should be enabled. Legislation should also ensure that funding allocation is appropriate to meet adaptation goals. This requires funding policy to value the capacity for adaptation in plans – promoting a wider focus on flexibility and whole-system resilience over a greater number or height of built interventions.

A lack of legislation, regulation and standards for adaptation actions in current policy is limiting delivery at the scale and urgency required.

- **Standards:** Well-adapted towns and cities will require policy to create resilience standards which reflect planning fit for future climate conditions. A nationally consistent approach to setting resilience standards should promote place-based resilience by enhancing plans for protection, response, and recovery to climate hazards. This includes standards for buildings in new developments, as well as quality standards for green infrastructure (such as SuDS) and nature-based solutions. Quality and maintenance standards are also required for flood and coastal defence infrastructure. Standards should be informed by and adaptable to long-term monitoring.

- **Subsides and taxes**: Policies should seek to financially incentivise adaptation actions (such as using gravel or grass verges instead of paved surfaces, or installing green roofs) by actors, including developers, utilities companies and individual home or business owners. Good upstream land management (often not directly within built-up areas at risk) should be supported with public funding.

Policy should enable mechanisms for funding and incentivising adaptation actions by a range of actors.

- **Information and reporting**: National policy must ensure that there are clear responsibilities for key actors (Box 9.1) which result in joined-up risk management. Reporting on some aspects of risk and adaptation planning and delivery should be mandatory. This will improve understanding of the national picture of adaptation in settlements – resulting in improved future modelling and risk assessment, to be used for funding prioritisation and community engagement. Targeted policies may be required to ensure that risk information is reaching the right people and results in actions, for example by funding and enabling community engagement. Improvements in modelling and communication technology create opportunities for early warning systems. Policy should set in place target standards for warning alerts across climate risks which should include spatial coverage, accuracy and speed.

There are other factors outside of policy control which influence the risk levels, such as changes to hazard intensity and frequency, and some aspects of vulnerability of the places at risk.

Progress towards well-adapted towns and cities will be affected by contextual factors (Box 9.2) – depending on changes in magnitude and frequency of the hazards, changes in the places which are exposed to these hazards and changes in factors which influence the vulnerability of those areas.

Box 9.2
Contextual factors in towns and cities

Contextual factors outside of control of the policies covered in this Chapter may influence the risk level and need for adaptation in different towns, cities and smaller settlements. Aspects of these changes to hazard, exposure and vulnerability factors may be useful to track.

Hazard. Sea level rise, in combination with increased storm surge intensity and frequency, will increase the likelihood of coastal flooding. Monitoring of sea levels and tipping points which might have high impacts on flooding, such as sea temperature, are key to understanding this hazard. Evidence currently suggests that warming air will influence rainfall patterns and therefore flooding hazard intensity, particularly the intensity and timing of short-duration precipitation.

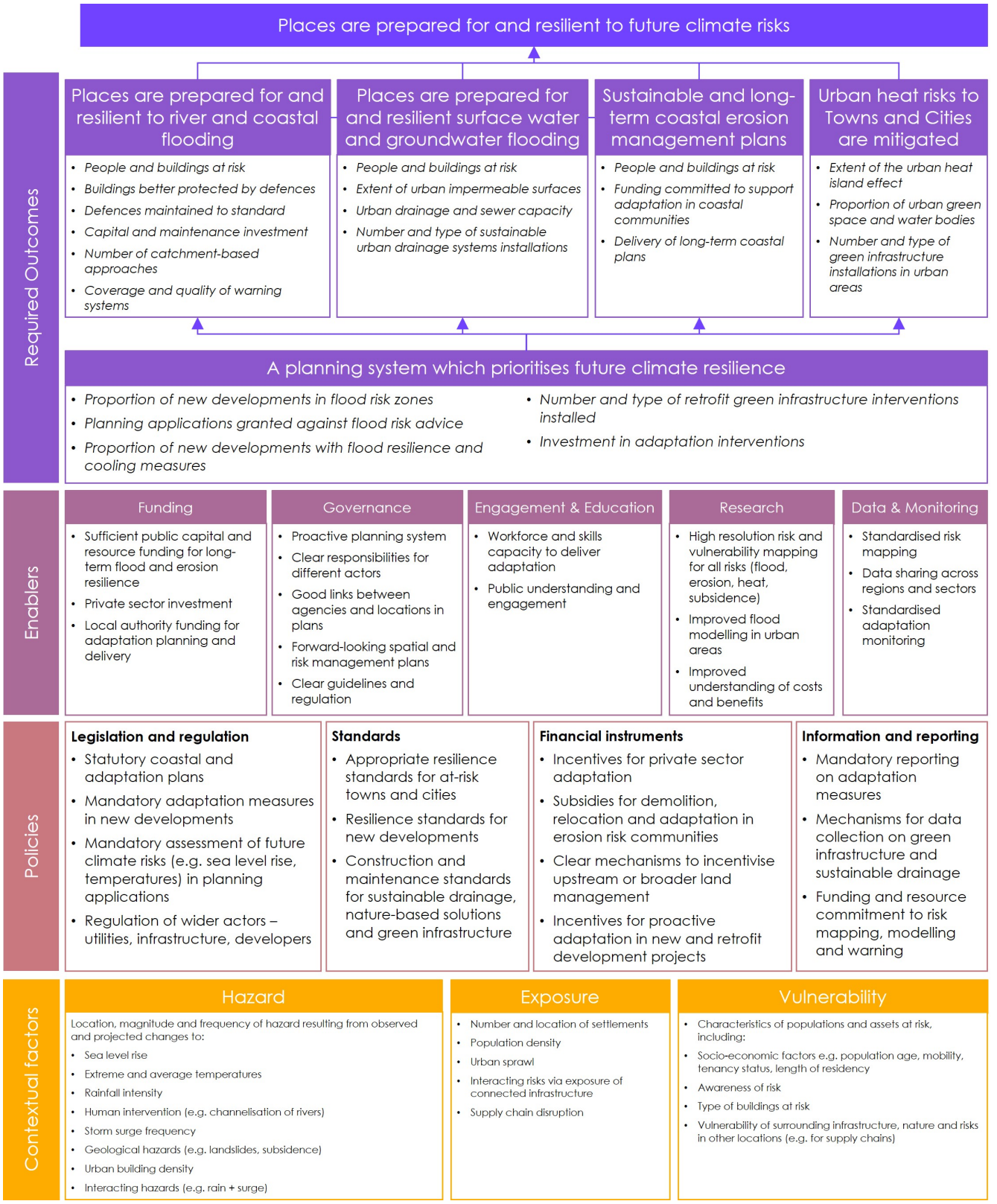
Extreme temperatures are likely to be hotter in urban areas due to the urban heat island effect. Tracking urban temperatures may help to prioritise risk management measures in heatwaves, such as alerts to the public.

The interacting impacts of different types of flooding, such as heavy rainfall combined with high tides, and the risks associated with overheating and drought, such as reduced permeability, should be monitored and modelled.

Exposure. Modelling for the Third Climate Change Risk Assessment indicates that under a low population growth scenario, with the current level of adaptation, around 2.6 million people and 1.4 million residential properties (and 200,000 non-residential properties) are at risk from surface water, coastal and fluvial flooding in England by the 2080s. Under a high population scenario, this rises to 3.3 million people and 1.8 million residential properties.[8] On top of more people living in high-risk areas, increasing urban development raises exposure to surface water flooding through reduction in permeable surface areas.

Vulnerability. The demographic characteristics of the population at risk in urban areas may influence their ability to respond to hazard events. For example, the proportion of the population aged 65 and over in large coastal towns in England and Wales was between 2-6% greater than in large non-coastal towns in 2019.[9] The most recent Environment Agency flood risk maps suggest that around 17% of the total properties at flood risk lie within the top 20% most deprived locations in England.[10] Analysis for this report finds six local authority areas in England (two of which are coastal and all of which are in the East of England), are within the top 20% for properties with the greatest deprivation and at a medium to high flood risk from rivers and the sea. Eleven local authorities are in the top 20% for properties with greatest deprivation and medium to high surface water flood risk.[11] This may impact ability to respond to and recover from flooding, even under well-adapted policies and plans.

Figure 9.1 Monitoring map for towns and cities



Source: CCC analysis.
Notes: Italicised text indicates suggested measures for each outcome.

This section documents available evidence on progress towards delivery and implementation of each of the climate resilience outcomes identified in the previous section.

(a) Outcome 1: Towns and cities are prepared for and resilient to risk of flooding from rivers and the sea

To have confidence that progress is being made towards this outcome, evidence which shows a decreasing exposure of people and buildings to significant current and future flood risk is required. This includes evidence that flood defences are in a good condition, warning systems are of good coverage and quality, and that a catchment-based approach – which recognises connections in water flow and risk levels across the wider landscape – is being implemented across the country.

Indicators of progress should show that fewer people and buildings are at high risk of flooding, with positive trends for defence condition, warning coverage and catchment-based management.

We conclude that there are some positive trends in cumulative protection of homes at high flood risk and delivery of projects. However, there is a slowing in defence maintenance and some unavailable data for assessing delivery of catchment-based schemes. We therefore score delivery and implementation towards this outcome as **mixed progress**.

Our assessment of relevant indicators finds that:

- **The risk of flooding to the built environment from rivers and the sea is rising.**

More people and buildings are at risk from river and sea flooding – but fewer are considered at 'high' risk.

  - **Buildings.** The number of residential properties at risk from river and sea flooding in England has increased by 1.5% since 2021 to reach 2.06 million.[11] Most of this increase comes from residential buildings in the low and very low likelihood risk of flooding categories (Figure 9.2).* The number of dwellings at high likelihood of flooding has fallen by 6,000 (4.5%) to 126,700. The number of dwellings at medium likelihood of flooding has fallen by 11,900 (2.5%) to 461,000 since 2021.[11]

  - **People.** The most recent assessment from 2022 of the number of people at high risk (1 in 30 chance) from flooding from rivers and the sea in England is 291,500 (0.5% of the population). The total at-risk population is around 4.8 million.[12,†] High risk areas remain located in the south-west and around The Wash (Figure 9.3). Data regarding which risk bands homes and people have moved into and out of are not routinely published as a time series. This type of information would improve our ability to track high risk regions and evaluate whether current investment and protection level is sufficient under future conditions, where more people are likely to be at risk. Analysis for the Third Climate Change Risk Assessment found that by the 2050s, under a 2°C scenario, the number of people at a 1 in 75 year or greater flood risk in England rises by around 389,000 from current levels –

* Likelihood of flooding categories reflect those used by the Environment Agency. These are: High risk - greater than or equal to 3.3% chance in any given year (a 1 in 30 chance); Medium risk - less than 3.3% (1 in 30) but greater than or equal to 1% (1 in 100) chance in any given year; Low risk - less than 1% (1 in 100) but greater than or equal to 0.1% (1 in 1,000) chance in any given year; Very Low risk - less than 0.1% chance in any given year (1 in 1,000.)

† The total number of people in areas at risk of flooding from rivers and sea dataset (RoFRS November 2022) calculates the number of people by multiplying residential property numbers in the National Receptor Dataset (2021) by the latest General Lifestyle Survey (2021) average household size of 2.36.

assuming a baseline of no population growth and enhanced adaptation.[13]

  - **Damages.** The average annual damages from river and coastal flooding in England was calculated to be £696 million in 2022, with damage to residential buildings around £222 million.*,[14] Direct Expected Annual Damages (EAD) to residential properties in England is projected to rise by between 5-29% by the 2050s even under enhanced adaptation, depending on the climate and population scenarios.[15] For context, the observed economic losses from flooding between November 2019 and March 2020 were estimated at about £333 million.[16] Actual annual damages are not routinely published and therefore hard to track.

- **Annual targets for defending homes have been missed over the last two years.** In the last two years, targets for number of homes protected by the flood and coastal erosion management scheme from the Environment Agency have been missed (Figure 9.4).[17] The target for the 2021-2027 flood and coastal erosion risk management capital programme (336,000 homes) is higher than in the previous 2015-2021 programme (300,000 homes), which was exceeded.

The number of homes better protected and defences maintained to standard has fallen short of annual targets in recent years.

- **A declining fraction of flood and coastal defence assets are maintained to target standards.** As of the beginning of March 2023, 94.1% of Environment Agency managed assets were at or above their target condition in comparison to 91.8% at the end of March 2021 and 94.5% in at the end of March 2020.[18] The number of high consequence assets below target condition has increased from 1,813 to 2,217 between March 2021 and September 2022.[16,17] This indicator reflects stretched maintenance funding, which is currently lower than required to restore assets to the 98% targets. This is compounded by ageing asset portfolios, an increased number of assets overall, and increasing deterioration from loading due to more frequent and extreme weather events. Resource allocation towards regular asset maintenance activities has increased from £110 million since the 2020-2021 financial year to £121 million for 2022-23.[19,20] The target and actual standards of assets which are not managed by the Environment Agency remains a data gap for this indicator.

- **There is some evidence to suggest that flood risk management approaches are increasingly including land management as part of a catchment approach.** The components of effective delivery of land management will vary depending on the characteristics of individual catchments. At the national scale, the number of farmers engaged in the Catchment Sensitive Farming partnership has followed an increasing trend since 2016 (Figure 9.5). Estimates in uptake (where advice is delivered into actions) of Catchment Sensitive Farming advice over the last eight years range from 55-60%.[21] This demonstrates increased engagement in advice which has the potential to provide long-term catchment resilience, both in water quality and flood risk benefits.

Flood risk and land management is placing increased focus on delivering natural flood management and wider catchment-based approaches.

- **More natural flood management projects are being funded by central government.** All updated draft Flood Risk Management Plans, published in December 2022, contained elements of nature-based solutions and natural flood management (NFM), which indicates a broader and catchment-based approach to planning.[22]

* This figure is expected to change with the release of NaFRA2 in 2024.

The Environment Agency's Flood and Coastal Resilience Innovation programme is also funding a large number of local authority led catchment-based and NFM projects. Risk management authorities enhanced and created more habitat in their flood risk management work in 2020-2021 than in 2019-2020 (1,222 ha enhanced and 507 ha created, an increase of 737 ha and 207 ha respectively).[6,24] A further 30 km of rivers and 392 ha of habitat were enhanced, and 368 ha of habitat created in 2021-2022.[27] In the 2021-2027 FCERM capital investment programme, 162 projects are forecast to implement NFM measures, more than double the 74 in the previous 2015-2021 programme.[14,23] Further NFM, upstream and catchment-based projects will have been implemented by individual landowners and therefore not recorded.

We lack consistent data on buildings and people in areas of high flood risk and catchment storage capacity over time.

- **There are limited timeseries data on efforts to improve catchment storage capacity across England, meaning that it is not possible to adequately assess the effectiveness of these approaches at a national scale.** While there are several projects and platforms which look to track nature-based flood management, such as the Rivers Trust's Catchment Data Explorer and the Environment Agency's Working with Natural Processes Mapping. Tracking NFM projects and their adaptation benefits is difficult. An increasing number or size of projects does not necessarily result in lower risk, however improved monitoring and data collection can help inform catchment-scale risk modelling and improve our understanding of co-benefits.

- **The Environment Agency and other risk management authorities are consistently delivering flood risk management projects, with new plans published in 2022.** As of March 2021, 21% of Flood Risk Management Plan (FRMP) measures for 2015-2021 were complete, with 8% not started.[23] A further 2,000 projects are planned for the FCERM programme between 2021 and 2027. Between April 2021 and March 2022, 120 FCERM projects were completed, including 27 schemes protecting from sea and tidal flooding, 54 schemes protecting from river flooding, 37 from surface water and 6 from coastal erosion.[24] This is a relatively consistent number and a similar spread across flood risk as the previous year (32 sea, 85 rivers, 50 surface water, 9 coastal erosion).[23] The spread of projects may reflect barriers to accessing funding for coastal and surface water risk management projects in comparison to fluvial flooding.

- **More people are covered by flood warning systems.** The percentage of properties at risk* which fall within an Environment Agency Flood Warning Area or a Community Led Alerting Area has increased consistently from 84% at the end of September 2018 to 86% at the end of September 2022.† The number of properties outside the area covered by these flood warnings has decreased by 12% during this period (Figure 9.6).[25]

The Environment Agency's Flood warning coverage and quality is high and increasing.

- **Flood warnings are mostly high in quality.** The average percentage of flood risk warning messages across reporting quarters which meet the quality standard to provide customers with required information has increased by 4.6% since 2018/19, with 78% of warning messages meeting the quality standard in 2022/2023 data so far.[25]

* At risk properties identified by the Environment Agency from OS Address Base Plus, Flood Zone 2 (a medium probability of flooding – a between 0.1% and 1% chance of flooding from rivers in any year, or between 0.1% and 0.5% chance of flooding from the sea in any one year), and the Environment Agency Area Water Management Boundaries.

† The most recent available data is from the Environment Agency's 2022/23 Quarter 2 reporting, which runs from 1 July to 30 September.

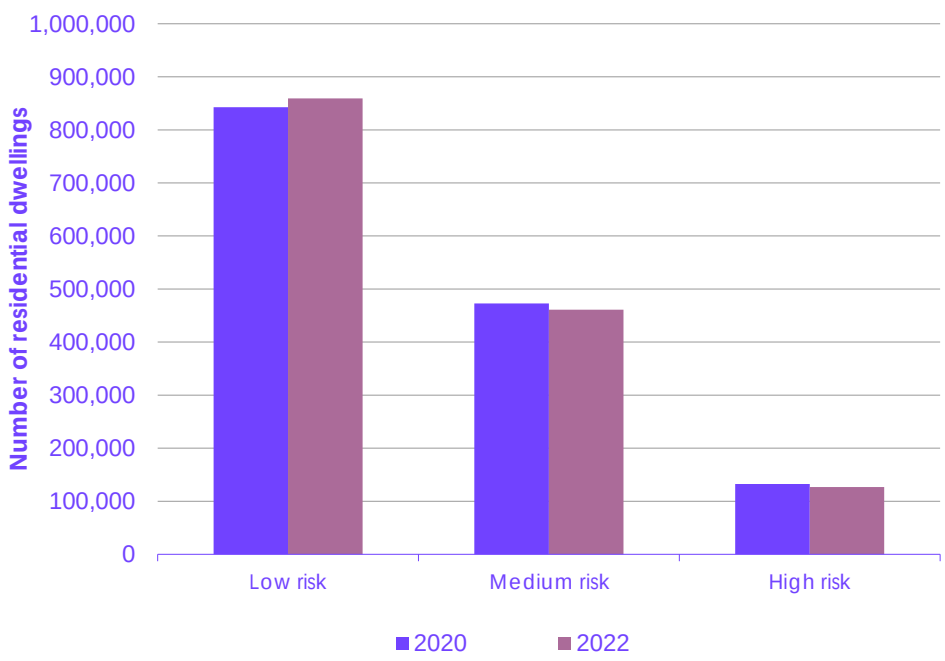
While only a total of five warnings were issued in the first two quarters of 2022/2023, annual averages show a consistent increase in quality (Figure 9.6) – although, as reasonably expected, in years where more warnings are issued, quality drops slightly.[25]

There are many unavailable indicators for this outcome that would improve our ability to assess delivery and implementation. These include consistent time series data of people and buildings moving into different flood risk bands and more detailed monitoring of flood risk management outcomes, particularly at the catchment scale.

Some local data which would be useful to track flood risk management remains unavailable in a centralised format.

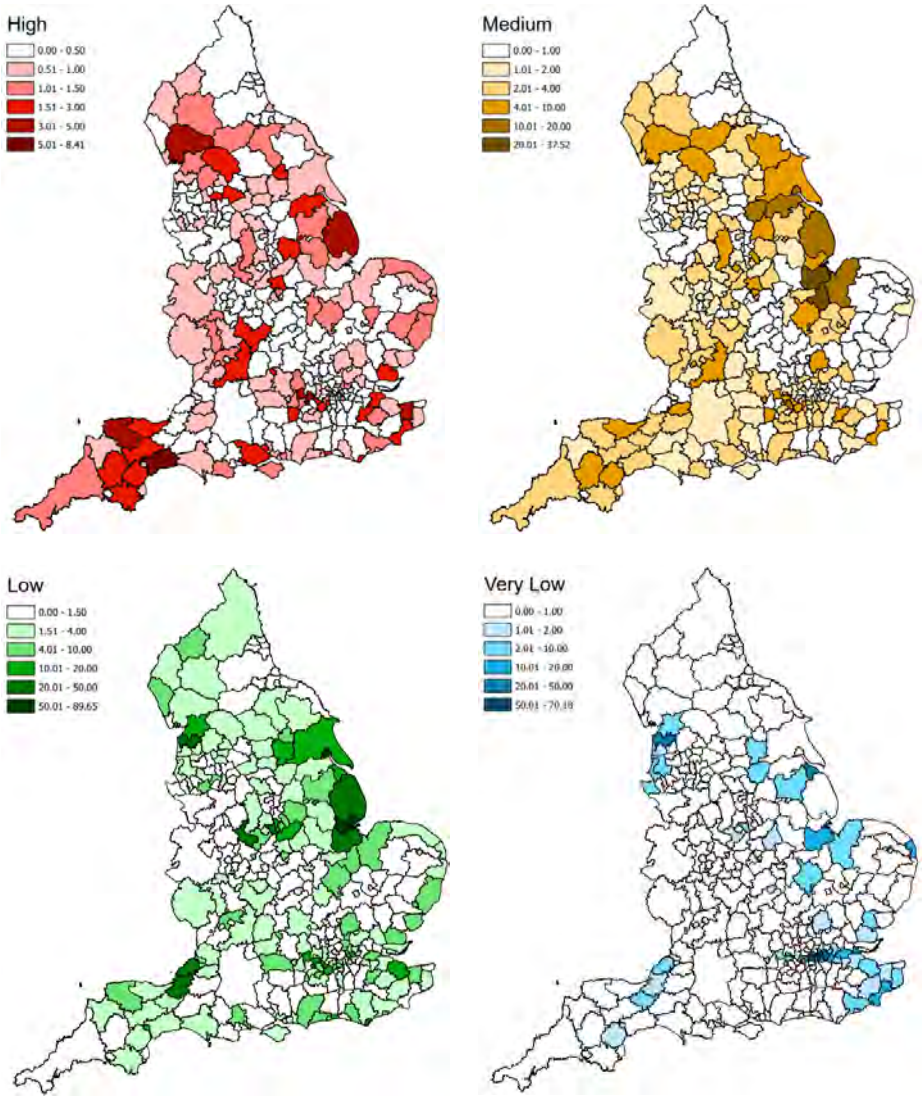
The Environment Agency are developing a suite of long-term flood and coastal resilience indicators which could inform useful tracking across FCERM progress for adaptation, so more relevant indicators should be available for future progress assessments.

Figure 9.2 Number of residential dwellings at low, medium and high likelihood of flooding from rivers and the sea in 2020 and 2022



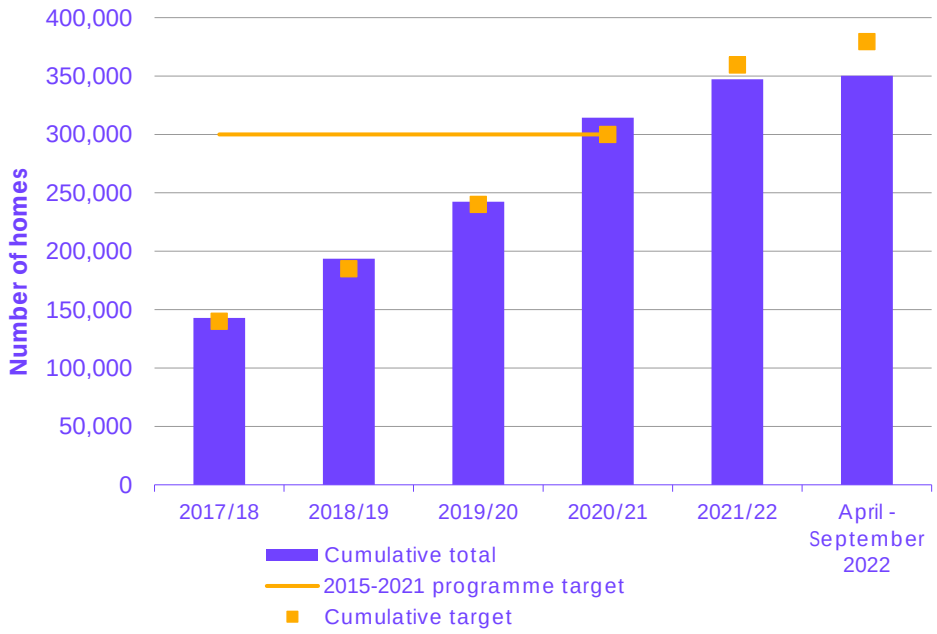
Source: ADAS for the CCC. (2023) *Research to update indicators which monitor progress in adaptation in England*. ADAS report for the Climate Change Committee.

Figure 9.3 Percentage of all properties in each Local Authority at high, medium, low and very low risk of flooding from rivers and the sea in England in 2022.



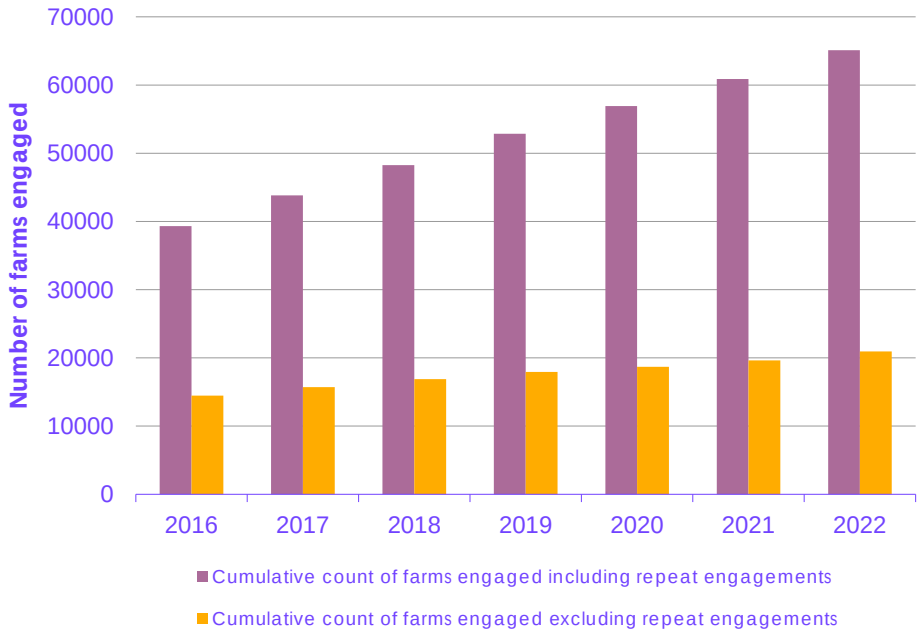
Source: ADAS for the CCC. (2023) *Research to update indicators which monitor progress in adaptation in England*. ADAS report for the Climate Change Committee.
Notes: This data refers to all properties and includes non-residential buildings as well as residential dwellings. Likelihood of flooding categories reflect the risk categories used by the Environment Agency. These are high (properties are at a greater than or equal to 3.3% chance of flooding in any given year, a 1 in 30 chance); medium risk (properties are at a less than 3.3% but greater than or equal to 1% (1 in 100) chance in any given year); low (properties are at a less than 1% but greater than or equal to 0.1% (1 in 1,000) chance in any given year); very low (properties at a less than 0.1% chance in any given year, a 1 in 1,000 chance).

Figure 9.4 Cumulative actual and target numbers of homes better protected through central government flood risk management schemes 2017-2022



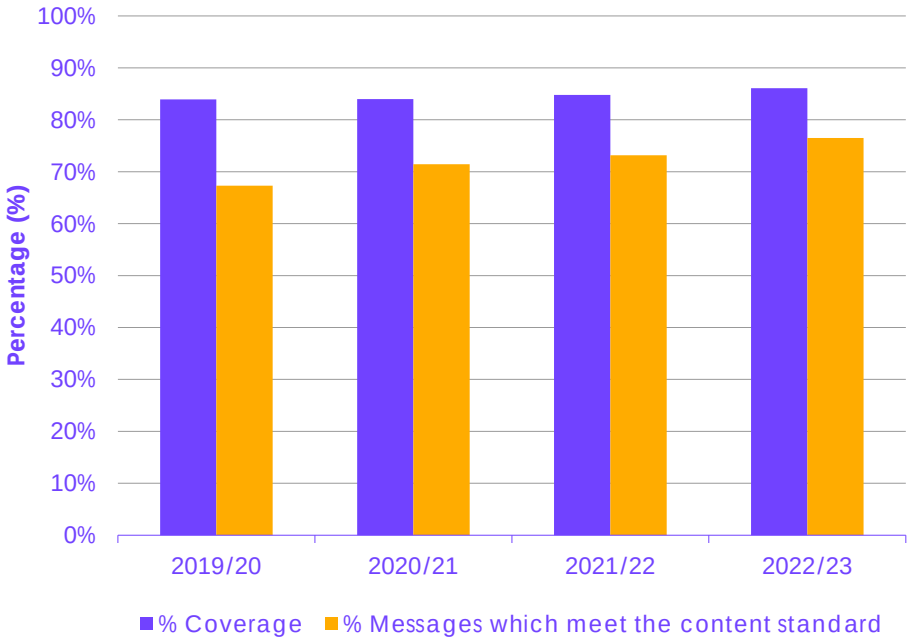
Source: Environment Agency (2023) *Corporate Scorecard Data 2018-2023.*
Notes: The 2022/23 year ends in March 2023. The Environment Agency is forecasting 61,000 houses better protected in total in 2022-2023, against a target of 65,000 (shown by the cumulative annual target). The target for the 2015-2021 capital investment scheme was 300,000 homes. Over the 2021-2027 scheme, the target is an additional 336,000.

Figure 9.5 Cumulative number of farms receiving one-to-one Catchment Sensitive Farming advice



Source: Environment Agency (2023) *Catchment Sensitive Farming Evidence Team.*

Figure 9.6 Percentage of properties at risk which fall within coverage of flood warnings, and the 18-month rolling percentage of flood warning messages meeting content standards



Source: Environment Agency (2023) *Flood Risk Warning Database.*
Notes: % Coverage refers to the number of properties at risk which fall within a Flood Warning Area or a Community Led Alerting Area. The 18-month rolling % of messages meeting the content standard is based on the number of messages providing customers with the required information.

(b) Outcome 2: Towns and Cities are prepared for and resilient to surface water and groundwater flooding

To have confidence that progress is being made towards this outcome, evidence is required that there is a decreasing exposure of people and buildings to significant current (and future) surface water and groundwater flood risk, the extent of impermeable urban surfaces is being managed, the storage capacity of the urban sewer network is maintained and sustainable drainage systems are being consistently implemented in urban developments.

To adapt to surface water flood risk, the increase in impermeable urban surfaces must be managed.

Indicators demonstrate mixed progress towards meeting this required outcome. They show that risk is increasing, and adaptation interventions are currently poorly monitored. We therefore score delivery and implementation towards this outcome as **mixed progress.**

Our assessment of indicators relevant to this outcome find:

- **The number of people and buildings at risk of surface water flooding in England is increasing.** Risk to residential properties from surface water flooding has increased since 2020. Analysis suggests that there has been a 10.7% and 8.4% increase in the number of residential properties at high risk (3.3% chance of happening in any given year) and medium risk (1% chance of flooding in any given year) in England. This equates to around 12,500 more residential properties at high risk, and just under 130,000 in total (Figure 9.7).[11] This number is likely to increase further in the future.

Analysis by the National Infrastructure Commission suggests that future climate change and urbanisation could put an additional 230,000 properties in England at high risk by 2055.[26]

The number of buildings at risk from surface water flooding is increasing – and is predicted to increase further in the future.

- **The extent of impermeable surfaces in urban areas is increasing.** Analysis shows that the total manmade land surface in urban areas in England has increased since 2016.*,[11] There has been a slight increase in total permeable area in urban regions, but also in total developed urban (impermeable) area, so the impermeable fraction has continued to increase since 2016 (Figure 9.8).[11] This dataset is a proxy for adaptation to surface water flood risk. National Infrastructure Commission research found that increases in unplanned impermeable surfaces in urban and suburban areas may put an additional 50,000-65,000 homes in England at risk of surface water flooding.[26]

- **The number of sustainable drainage systems installed in urban areas is not currently monitored at the national scale.** Between April 2021 and March 2022, the Environment Agency worked with other risk management authorities on 37 surface water projects, and two groundwater projects.[24] Only four groundwater projects were carried out in the 2015-2021 FCERM programme, so this represents some delivery progress.[22] While there is no national scale centralised or standardised database of SuDS installations, some progress has been made in inventories in individual cities. For example, the Greater London Authority has been collecting information and mapping retrofit SuDS, as well as SuDS proposed as part of planning applications referred to the authority.[27]

The extent of urban impermeable surface area and installation of sustainable drainage installations are not currently tracked at the national scale.

Overall, indicators for this outcome demonstrate some limited outcome progress in managing surface water flood risks. The number of people and buildings at risk from surface water and groundwater flooding are increasing, and there is a lack of data available to evaluate progress towards mitigating this. Unavailable indicators, which would help to inform our understanding of this outcome include:

- **The storage capacity of urban drainage systems.** Water and sewerage companies are producing Drainage and Wastewater Management Plans (DWMPs), which must assess capacity, pressures and risks to their networks. The plans are currently being produced on a non-statutory basis for 2023. Within the process of creating the draft DWMPs, water and sewerage companies looked at indicators of capacity. There is no national-scale database of these indicators or the indicative capacity.

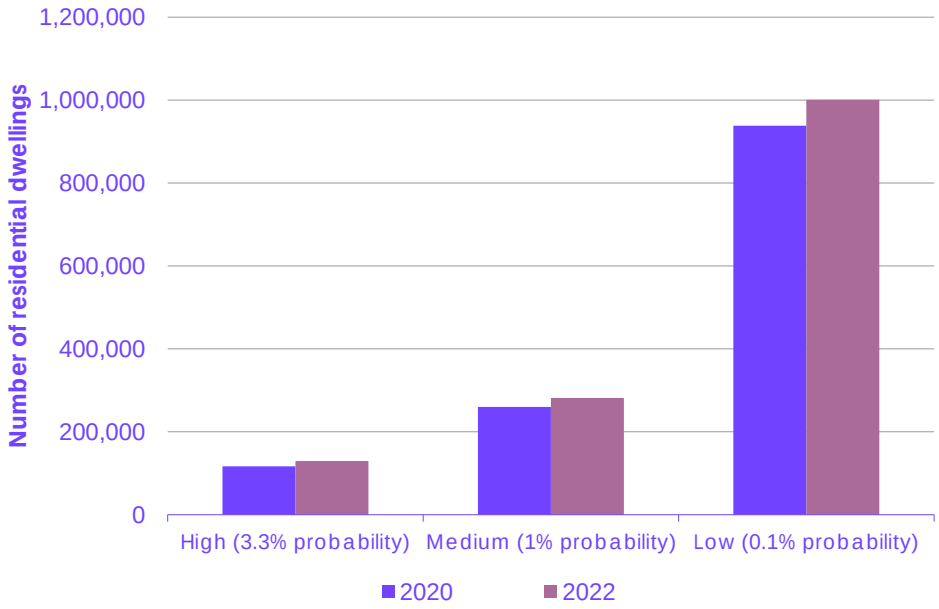
- **The number and characteristics of SuDS installations.** There is no centralised or standardised database of SuDS installations (both new and retrofit). An asset register, including the location, type, maintenance condition and level of protection would be useful for tracking progress in implementation.

Data on the storage capacity of urban drainage systems to cope with flooding are not yet consistently published.

- **The number of buildings at risk of groundwater flooding**. Groundwater flooding occurs when water within the ground (in rock or soil) rises above ground level. The level of the water can change due to long-term and short-term rainfall and water abstraction. There is a lack of monitoring of the incidence of groundwater flooding and its impacts, as well as research to help us understand adaptation options. The risk level and hazards associated with groundwater flooding remain poorly understood and mapped.

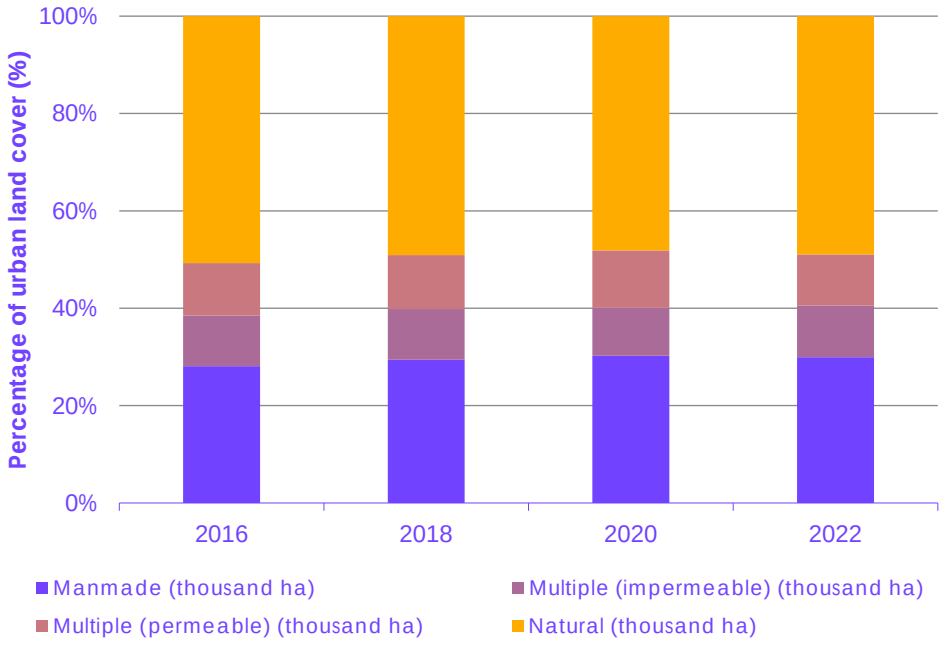
* 'Manmade' land cover category is derived from the Ordnance Survey's MasterMap Topography Layer.[11]

Figure 9.7 Number of residential dwellings at high, medium and low risk from surface water flooding in 2020 and 2022



Source: ADAS for the CCC. (2023) *Research to update indicators which monitor progress in adaptation in England*. ADAS report for the Climate Change Committee.

Figure 9.8 Percentage of urban land coverage split by permeable, impermeable, and man-made land surfaces in 2016-2022



Source: ADAS for the CCC. (2023) *Research to update indicators which monitor progress in adaptation in England*. ADAS report for the Climate Change Committee.
Notes: 'Multiple' category represents domestic gardens, which are assumed to be a mixture of permeable and impermeable surfaces, where 'Multiple (impermeable)'estimates are derived from a method using urban creep rates.

(c) Outcome 3: Long-term and sustainable coastal erosion management plans

To evaluate progress towards this outcome, indicators should suggest that the number of people and buildings at risk of erosion is balanced by investment coastal defence projects and community support. Progress in adaptation to coastal erosion is difficult to assess because there may be some areas where adaptation at site is not possible. Not all settlements will be able to be protected from coastal erosion in the long-term, so indicators should demonstrate progress towards supporting relocation and other schemes.

Adapting to coastal erosion requires a combination of approaches – not all places will be able to be protected from erosion in the long-term.

Overall, indicators demonstrate some progress towards meeting this required outcome. More capital funding has been invested at the coast, but there are sparse data for evaluating adaptation measures. We are unable to evaluate some aspects of progress in adaptation to coastal erosion and change because there is no nationally defined approach or centralised tracking. We therefore score delivery and implementation towards this outcome as **mixed progress.**

Our assessment of relevant indicators finds:

- **There are an increasing number of people and buildings at risk of coastal erosion.** The National Coastal Erosion Risk Maps (NCEREM) currently estimate that about 2,000 properties are at risk of being lost to coastal erosion by 2060, assuming all current shoreline management plan policies are implemented.*,[23] Evidence of the implementation of shoreline management plan policies is unclear. Updated analysis and risk mapping of buildings at risk of coastal erosion is currently being carried out under analysis for NCERM2, expected in December 2023.†

More buildings will be at risk of coastal erosion in the future, and the delivery of plans to protect or move these properties is inconsistent nationally.

- **Shoreline management plans are not consistently considering long-term risk.** Currently, around 53% of England's coastline is designated 'Hold the Line' policy. In the medium term (20-50 years), 17% of published SMP policy will be 'Managed realignment'. However, recent analysis of a 2°C scenario suggests that 33% of policies will be under pressure to move towards realignment, potentially impacting 159,000 (residential and non-residential) by 2050 and 171,000 (residential and non-residential) properties by 2080 under a 2°C warming scenario.[28] In practice, there are multiple contextual factors, such as political pressures and land ownership, which may influence the delivery and adaptation capacity of shoreline management plans.

- **The government has increased capital expenditure for projects focused on coastal defence.** Government investment in schemes to reduce the risk of erosion or flooding from the sea has increased (Figure 9.9). Capital expenditure in 2021-2022 (£249 million) was £50 million greater than in 2020-2021 and covered around 200 schemes.‡,[14] Nine significant schemes focusing on coastal erosion were completed between April 2020 and March 2021. Since the 2015 FCERM programme, 27,000 homes have been

* Shoreline Management Plans in England have four available policies: 'Hold the line' by maintaining or changing the current level of protection; 'Advance the line' by building new defences seaward of existing defences; 'Managed realignment' by allowing the scheme to move backwards; 'No active intervention' where there is no investment in coastal defence or maintenance.

† NCERM (and NCERM2) is designed as a practical tool for future prediction and does not provide an assessment of past losses.

‡ 'Number of Schemes' includes all relevant schemes for which there was Government expenditure in that year. This means there is significant overlap in these numbers between financial years, as most schemes are delivered over several years.

better protected from coastal erosion.[23] A further six projects, better protecting 4,100 properties have been carried out between April 2021 and March 2022.[24]

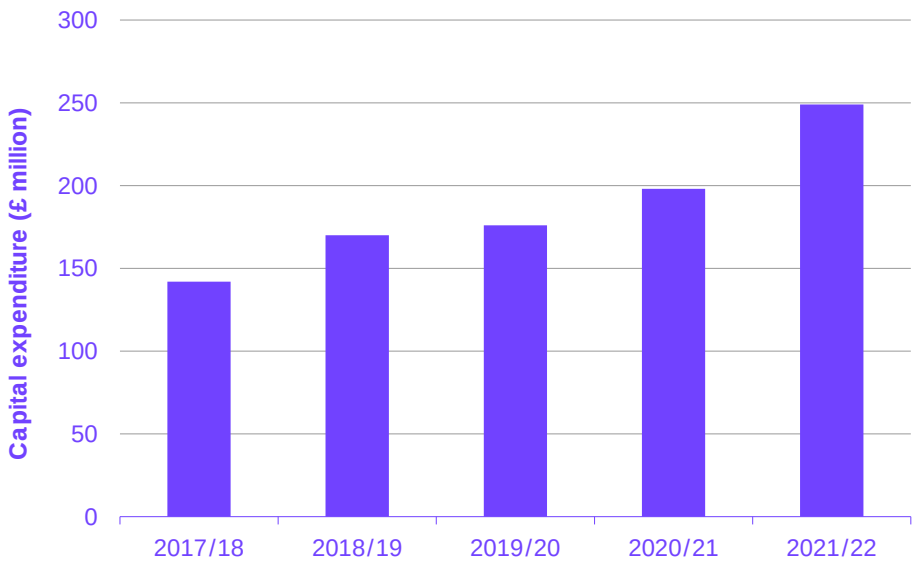
Capital expenditure on coastal defence projects has increased, and there is some central government support for coastal residents for demolition and relocation.

- **Central government is providing some financial support to local authorities with properties at imminent risk of loss due to coastal erosion.** The Environment Agency administered six Coastal Erosion Assistance Grants in 2021-2022. These grants are administered to local authorities to support demolition. Since the scheme began in 2010, 54 grants have been administered (27 of these in 2013-2014).[14] This indicator provides a proxy of losses to coastal erosion – there will be other properties lost where grants were not claimed, and land and infrastructure are not covered by the data. Furthermore, the data does not capture all financial support to coastal communities. Further funding is being made available via the £36 million Coastal Transition Accelerator Programme (CTAP), part of the government's FCERM Strategy (Box 9.3). The initial phase of the project will support 'rolling back', repairs, repurposing and transition in two local authorities – East Riding, Yorkshire, and North Norfolk. These locations contain approximately 84% of all residential properties at risk of erosion in the next 20 years.[29] Individual Coastal Protection Authorities may hold further data of properties and infrastructure losses, as well as funds administered.

Current monitoring of erosion rates, losses and shoreline management plan implementation is not consistent at a national scale.

We lack some key data for tracking the number of properties and land lost to coastal erosion. While there are examples of local monitoring initiatives, there remains no consistent national picture. This data would provide useful context for tracking national-scale risk assessment and targeting funding. The Environment Agency monitors shoreline management plans through an annual report on action plan delivery, although the detailed results have not previously been published. Furthermore, the delivery of shoreline management plans will not necessarily indicate the progress in adapting to coastal change as a whole, which requires a suite of long-term resilience actions beyond defence or realignment.

Figure 9.9 Capital expenditure (in millions) on schemes to reduce the risk of coastal erosion or flooding from the sea and tides



Source: Environment Agency (2023). Unpublished data provided on request by FCRM team.

(d) Outcome 4: Urban heat risks to towns and cities are mitigated

Mitigating urban heat risks requires investment in and delivery of plans which maximise green and blue space in the built environment.

To evaluate progress towards adapting to urban heat island risks, we require evidence that green space in urban areas is increasing and that adaptation interventions (green infrastructure and cooling installations, such as green roofs), are being installed in urban areas. While the cooling impact of these adaptation actions is uncertain, recent evidence suggests that increasing tree coverage by 30% can cool cities by around 0.4°C, suggesting that this is as an appropriate outcome-level target.[30]

Overall, there are a lack of data to evaluate adaptation to urban heat risks and available indicators are not demonstrating positive trends. This means we are **unable to evaluate** this outcome. Indicators for this outcome show that:

Temperatures in major cities are often higher than surrounding rural areas.

- **Urban temperatures are higher than temperatures in surrounding areas.** Recent modelling suggests that major cities in the UK are up to 1.5°C warmer than their surroundings. The models find that both urban and rural temperatures will increase in the future and there is some evidence of greater warming of 0.5°C for central London and Manchester.[31]

- **Urban extent is increasing and spreading into the green belt.** In 2018, 8.3% of land in England was of 'developed' use. This rose to 8.7% in 2022. Urban development in the green belt rose to 6.8% from 6.7% in 2018, indicative of wider spread of urban surface area.[32]

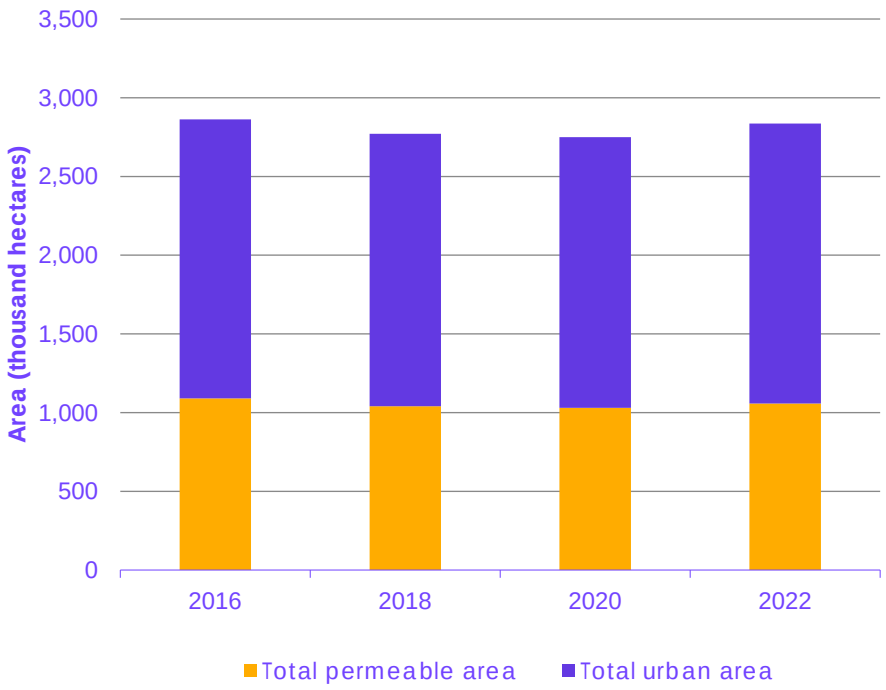
Urban extent is increasing, and the proportion of green and blue space in urban areas shows a decreasing trend.

- **The proportion of urban green and blue space is decreasing.** The percentage of natural urban surfaces has decreased from 61.5% to 59.5% between 2016 and 2022 (Figure 9.10).[11] Analysis by Natural England in 2021 suggests that the average proportion of manmade land surface (not vegetation, water or soils) in regions classed as urban is 21%.[33] This analysis (Natural England's Green Infrastructure mapping) does not have a time series, but can provide a baseline for future assessments. In 2019, the Office of National Statistics estimated the proportion of urban area with blue or natural land cover in England as 31.9%.[34] The asset value (stock) of the urban cooling service of urban natural capital in England has been recently estimated at around £26,600 million for 2021 – an increase from £25,960 million in 2020 (2021 prices).[35]

There are some local data on the number of green roofs and urban canopy cover, but no national-scale monitoring.

- **Green infrastructure installations are increasing but data are sparse.** Between 2016 and 2017, extensive (shallow, 15 cm soil depth) green roofs increased by 17% in the City of London.[36] However, there are a lack of nationally collected data on green infrastructure, including green roof extent and urban tree planting. At a building-scale, there is some baseline data for households owning green infrastructure. Survey data supporting the National Infrastructure Commission's surface water flooding research in England in Autumn 2022 suggests around 15% of surveyed households have installed some form of permeable surfaces and 7% had a green roof. Only 16% said they would consider getting a green roof in the future.[37]

Figure 9.10 Area (thousand hectares) of total built-up area in England with permeable (green space) and urban land cover



Source: ADAS for the CCC. (2023) *Research to update indicators which monitor progress in adaptation in England*. ADAS report for the Climate Change Committee.
Note: 'Permeable' surface cover represents Ordnance Survey's 'Natural' land parcels along with urban greenspace, such as domestic gardens.

There is not enough data to evaluate progress on the delivery of green space and green infrastructure in urban areas in England.

Available indicators for this outcome are either not following the required trends or remain constant. Urban green space is not increasing and there is not enough data to evaluate progress in new and retrofit installations of other green infrastructure, such as green roofs and green walls. Trackable data on green infrastructure assets in urban areas is not readily available. An improved green infrastructure asset registry, which includes data on green infrastructure typology and metrics of quality (such as biodiversity and density), would allow improved future assessment.

(e) Outcome 5: A planning system which prioritises future climate resilience

This outcome is required to ensure that new developments and changes to existing developments are designed to be sustainable in the context of future climate risk. Required trends in indicators for this outcome should show fewer developments in flood risk zones and against Environment Agency advice, as well as increased prevalence of green infrastructure within planned developments. These indicators help to show whether the planning system is considering future risk from flooding and overheating.

New developments should be designed to be prepared for future temperatures, flooding and erosion risks.

This outcome overlaps with outcomes in the Buildings chapter, which require evidence that adaptation measures are fitted into new and existing buildings. Aspects of this outcome are also covered within Outcomes 3 and 4 of this chapter.

Indicators show a mixture of consistent and negative trends, along with a lack of available monitoring data. We therefore score delivery and implementation towards this outcome as **mixed progress.**

Indicators for this outcome suggest that:

Building in flood risk zones has consistently accounted for around 3% the annual total new development for the past decade.

- **The proportion of annual new developments constructed in flood risk zones is constant.** New buildings continue to be constructed in flood risk zones each year. The proportion of new addresses created annually in areas of high river and coastal flood risk (taking account of defences) has remained between 2-4% of all new residential addresses for the last decade, as has the proportion of new development in areas at a 1 in 100 chance of surface water flooding from rainfall in any given year (Figure 9.11). However, the proportion of these new developments which are on non-previously developed land has increased from 34% in 2020-2021 to 47% in 2021-2022. The annual proportion of new residential addresses created in Flood Zone 3 has decreased since a peak of 10% in 2017-2018 but has remained at 7% for 2020/21 and 2021/22.[*,38]

Environment Agency flood risk advice is being followed in more planning applications.

- **A decreasing proportion of residential developments have been granted planning applications against Environment Agency advice.** The percentage of planning applications for all types of development granted against Environment Agency flood risk advice in 2021/22 remained consistent from 2020/21 at around 3%. This is a downward trend since 2019/20 (4.6%). This trend is consistent for residential development only, where Environment Agency advice was followed in 97.2% of cases in 2021/22 (Figure 9.12). The number of residential units granted permission as part of both non-major and major residential developments against advice shows a downward trend since 2019/20 to 28, down from 161 in 2020/21 and 691 in 2019/20.[†] The number of total residential units (including those built as part of mixed-use development) also decreased during this period.[39]

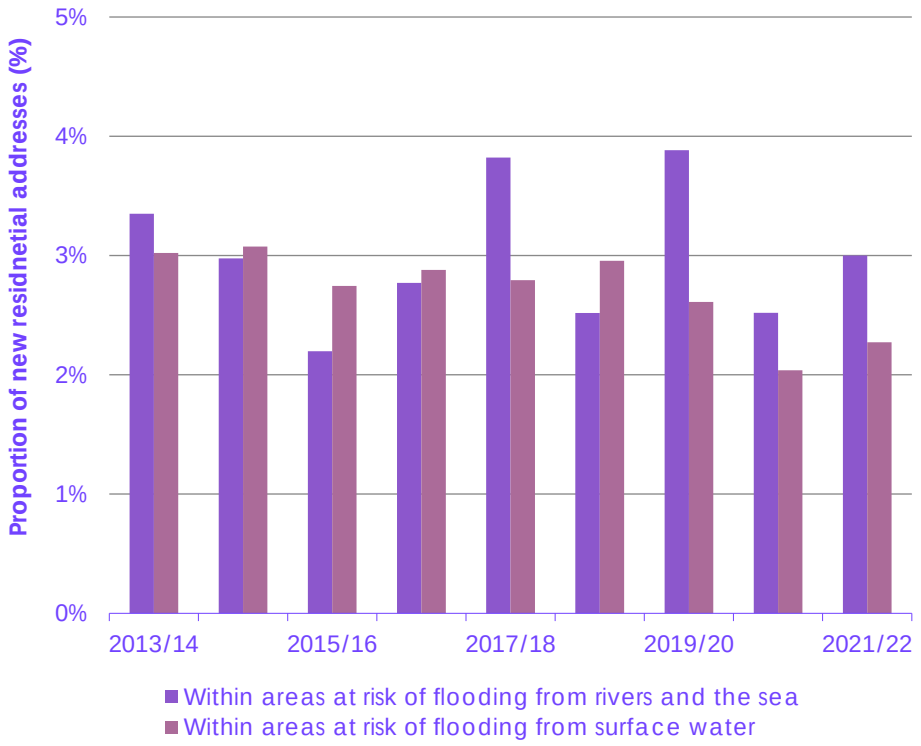
There are a lack of data for monitoring the number of planning applications which include adaptation interventions and the subsequent delivery of these.

- **There are no centralised or national-scale data on the number of new developments built with flood resilience and cooling measures.** While individual local authorities (or developers) may track their investment in blue-green infrastructure for new developments and retrofits, there is no centralised information to evaluate progress at the national scale.

[*] Flood Zone 3 is land assessed as having a 1 in 100 or greater annual probability of river flooding or a 1 in 200 or greater annual probability of flooding from the sea in any year, ignoring the presence of flood defences.

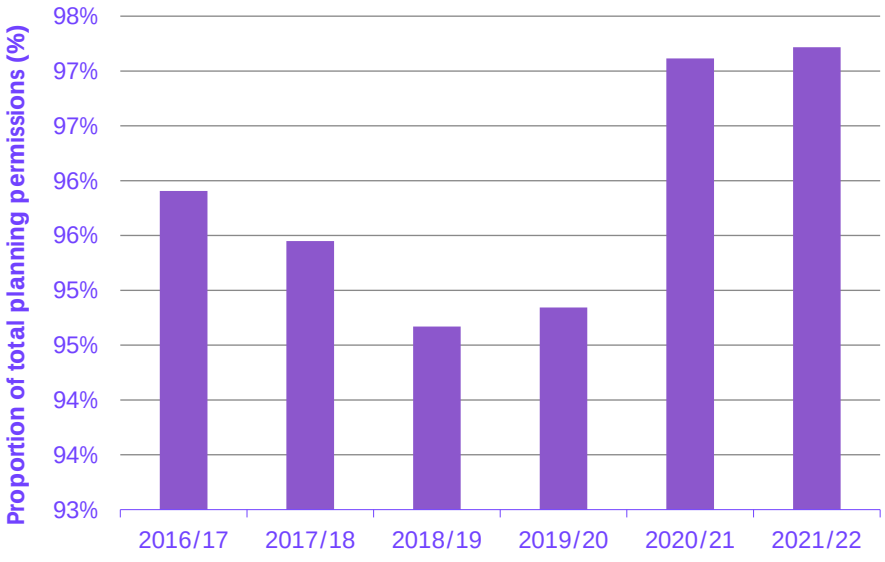
[†] Major residential development refers to developments of 10 or more houses or is to be carried out on a site of greater than 0.5 hectares area.

Figure 9.11 Proportion of new residential addresses created within areas at a risk of flooding from rivers, the sea and surface water



Source: DLUHC (2022). *Land use change statistics – new residential addresses 2021 to 2022 live tables*
Note: Areas are considered at risk if a greater than a 1 in 100 chance of rivers, sea and surface water flooding in any given year

Figure 9.12 Proportion of planning permissions for residential developments where Environment Agency flood risk advice was followed



Source: Environment Agency (2022). *Environment Agency objections to planning applications based on flood risk*
Note: Outcome is currently unknown for 119 residential development planning applications. Residential development does not include residential units may have been approved as part of 'mixed-use' developments.

(f) Progress on enablers

There is some evidence for positive trends in indicators for enabling factors for these outcomes.

To achieve these five outcomes for well-adapted towns and cities, multiple enabling factors must be in place. Enablers should ensure that delivering adaptation to climate change in towns and cities is sufficiently funded and effectively governed. A shortage of workers, skills and raw materials for adaptation interventions can acts as barriers to the outcomes, as can behaviours in communities at risk. Improved datasets through monitoring and research are an important enabler for well-targeted and maintained adaptation.

To evaluate progress in enabling factors, indicators are required which show: sufficient funding and investment, an increasing workforce with the required skills and an increasing public and stakeholder understanding and acceptance of adaptation. Indicators for the enablers show:

- **Central government funding and investment for flood and coastal risk management has been increasing.** Capital investments has increased since 2021 due to the government's commitment of £5.2 billion capital investment for flood and coastal erosion risk management, managed by the Environment Agency. The Environment Agency received £854.3 million in grant-in-aid for flood defence from Defra in 2021-2022, maintaining investment levels from 2020-2021 of £836.1 million. Planned investment until 2027 will exceed recommended minimum levels and capital and revenue sources are due to exceed the level identified by the Environment Agency's Long-Term Investment Scenarios (LTIS) (Figure 9.13).[40]

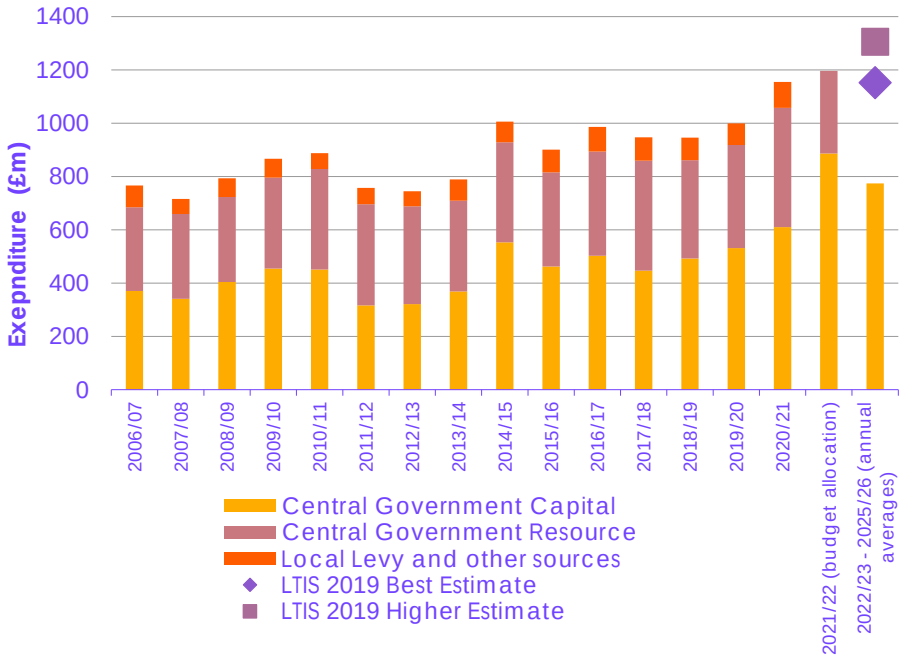
Indicators show increasing government capital and private investment in managing flood risk.

- **Water companies have decreased their investment in managing flood risk.** Water company investment in maintaining the sewer system and property-level protection and mitigation for households has decreased since 2019.[41] However, investment in property flood resilience by water companies to reduce the risk of sewer flooding has increased (Figure 9.14). Furthermore, the new UK Water Industry Research design guidance has increased the climate change uplift to encourage future drainage systems to be designed to cope with more intense rainfall. There may be further adaptation initiatives funded by water companies and other risk management authorities and partners in joint approaches. A more consistent shared dataset across stakeholders would improve our ability to monitor this.

More flood and coastal erosion risk management is being funded by partnerships and money raised from outside central government.

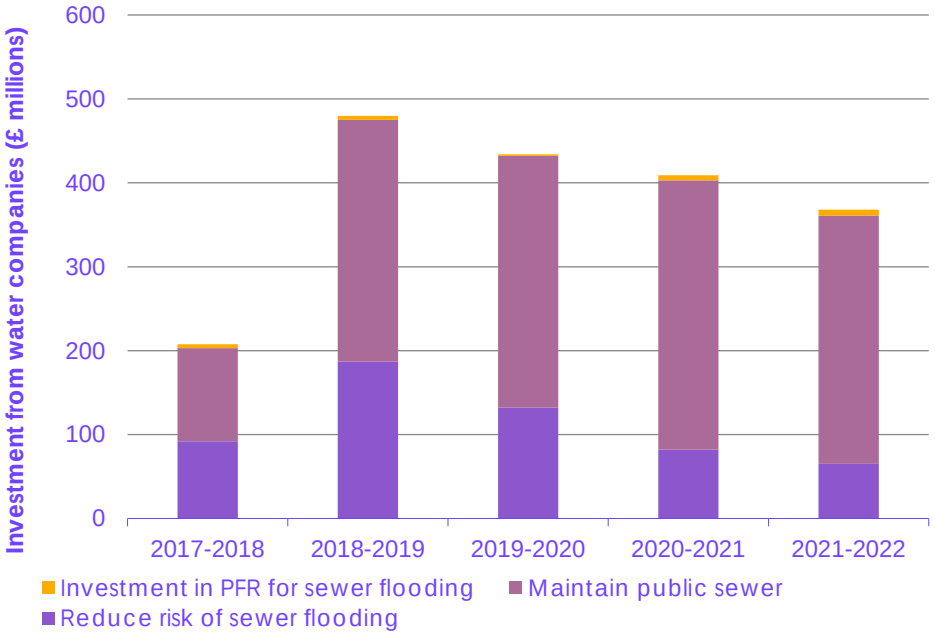
- **Joint funding from other sources increased considerably in 2021.** Expenditure on flood and coastal erosion risk management funded by money raised from outside central government increased considerably to £71 million in 2020/21 from £38 million and £43 million in the two years previously. This total includes Internal Drainage Board precepts, General Drainage Charges, the sale of assets and partnership funding schemes – contributions to the Environment Agency schemes that are only partially funded by Defra. Additional partnership funding raised by other risk management authorities is not included in this total.[42]

Figure 9.13 Spending on flood risk management in England and the optimum identified by LTIS 2019 (real terms, 2021/22 prices)



Source: Defra (2022) *Central Government Funding for Flood and Coastal Erosion Risk Management in England*; Environment Agency (2019) *Long-Term Investment Scenarios (LTIS) 2019*; National Audit Office (2020) *Managing flood risk*; HMT (2022) *GDP deflators at market prices, and money GDP November 2022* (Autumn Statement); CCC analysis.
Note: LTIS optimums shown are corrected to real terms 2021/22 prices.

Figure 9.14 Investment from water companies to reduce the risk of flooding from the public sewer system (in £ millions)



Source: Environment Agency (2018-2023) *Flood and Coastal Risk Management Reports.*

- **Not many local authorities have set targets for green infrastructure.** Target-setting can be an important element of green infrastructure implementation for cities. The IGNITION Project reviewed green infrastructure target setting 18 UK cities and found that while 78% had an assessment of their existing green infrastructure, only 5 cities (28%) referred to monitoring and tracking this.[43]

- **People are becoming more aware and worried about climate change impacts.** As of October 2022, 75% of people think they will be directly affected by rising UK temperature, 36% by rising sea levels and 44% by flooding from rainfall. The percentage of people worried by rising temperature has risen by 13% since the previous survey in May 2022, after the summer heatwave.[44] The percentage worried about sea level rise and flooding from rainfall have also risen in this period by 5% and 4% respectively.[45] 66% of respondents to the Environment Agency's Public Flood survey recognised that climate change would make flooding more likely in their area in the future.[46]

People are increasingly aware of climate change impacts but some evidence suggest risk perception is low.

- **However, a decreasing percentage of people believe their neighbourhood is at risk of flooding.*,†** Just under half of people surveyed by the Environment Agency in 2021-2022 believe they are at flood risk (Figure 9.15) and only 54% of those living in areas classified as high risk. Furthermore, 76% of those surveyed had never looked at long-term flood risk information from the government website, 67% of those who has not looked at long-term risk information felt it was not necessary or irrelevant.[46] First-hand experience is important for driving these perceptions of risk. Residents who live in areas that have previously been flooded are more likely to believe their neighbourhood is at risk (73% in comparison to 23% of never-flooded people, and 87% for people whose current or previous home has been flooded).[46]

- **Most people think that flood risk management is a shared responsibility for homeowners and local and national governments.** In total, 74% of respondents to the Environment Agency's Public flood survey thought responsibility should be shared, with 44% suggesting authorities should have more of this shared responsibility.[46] A 2022 Red Cross survey echoed similar findings with 64% of those surveyed ticking the response that prevention of flooding to people's homes is the responsibility of local councils and 61%the UK government.[47]

Most people continue to view flood risk management and funding as a responsibility for local and national government, not individuals.

- **There are some gaps in public proactivity in preparing for flooding and only some people are willing to pay for surface water flood risk reduction.** There has been a decline in the proportion of people keen to take an active role in community plans to deal with flooding from 60% to 49% between 2020 and 2022.[46] Furthermore, approximately 15% of UK adults (and 22% of those living in high social flood risk areas) do not have buildings or contents insurance.[47] 52% of households in England surveyed in July 2022 as part of the National Infrastructure Commission's surface water flooding report said they were not willing to pay to reduce risk of surface water flooding. However, 20% were willing to pay an additional £25 per year and 7% an additional £50 per year. This was related to cost, risk perception and perception of individual's responsibility and intervention benefits.[37]

* Before the 2020-21 Environment Agency survey, the wording of this question was 'area' not neighbourhood.

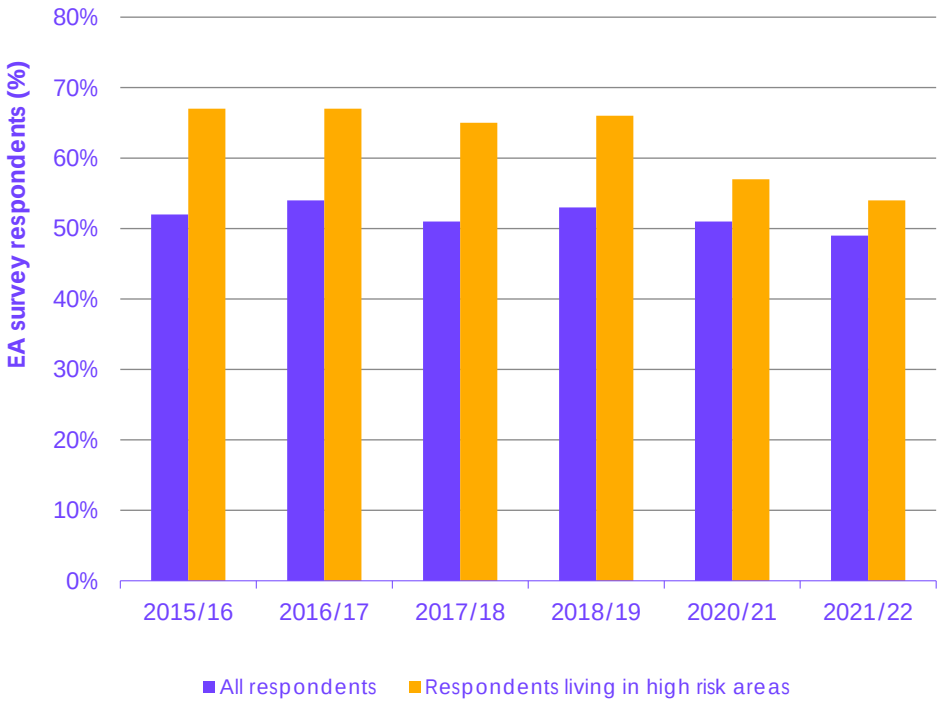
† The Public Flood Survey in 2021 conducted 650 phone interviews with household decision makers in postcodes on the 'at risk' database, plus 100 online surveys with household decision makers aged 18-34. 605 respondents had never been flooded.

- **There are not enough available data on the number of workers and prevalence of key skills in planning, construction and risk management.** Tracking skills such as digital planning and flood risk management, within local authorities and planning and construction industries would help to inform the future role of this factor in enabling progress.

There is no mechanism for monitoring the prevalence of key skills and workforce capacity to enable adaptation in planning and construction.

- **Tracking the provision (i.e. availability and funding) of design and planning guidance would improve understanding of enabling factors.** Currently, non-statutory guidance, such as CIRIA's (the Construction Industry Research and Information Association) SuDS manual and resilient design codes inform many green infrastructure installations. It is important to track the use and accessibility of these guidelines as enablers of good practice.

Figure 9.15 Proportion of Public Flood Survey respondents who believe they live in areas at risk of flooding



Source: Environment Agency (2022) *Public Flood Survey.*

This section documents key policy developments relevant to each of the climate resilience outcomes identified within our monitoring map and the extent to which the key policy and planning milestones are in place.

(a) Outcome 1: Towns and cities are prepared for and resilient to risk of flooding from rivers and the sea

There are ambitious and clear policies and plans in place for preparing towns and cities for river and coastal flooding.

The score for this outcome is **credible policies and plans.** Most of the key policy milestones (see Box 9.3) to minimise risk of harmful impacts from river and coastal flooding on towns and cities are in place. Policy and planning could be further strengthened by clear targets for flood risk reduction and catchment-based management.

Committed capital investment is a key cornerstone in flood risk management but consistent funding for defence maintenance should also be guaranteed.

- **Key aspects of legislation and regulation are in place, but there are some gaps in the allocation of long-term funding.** Updated flood risk management plans (Box 9.4) show progress in considering whole catchments and monitoring projects. Plans should work closely with the new drainage and wastewater management plans and responsibilities across different actors should be more clearly laid out. For example, there are no clear targets for risk reduction by different actors in a catchment. While the £5.2 billion committed capital spending (Box 9.3) is an important cornerstone of flood risk management in England, long-term commitment to maintain (or decommission) existing defences is lacking. Furthermore, current funding allocation is based on cost-benefit analysis and does not fully capture future risk and changes in socio-economic vulnerability.

The Environment Agency's FCERM Strategy Roadmap lays out actions for delivering the flood and coastal erosion policy.

Box 9.3
What is England's Flood Risk and Coastal Management Policy?

In 2020, the Government published a National Policy Statement on flood and coastal erosion risk management. This was supported by a commitment to invest £5.2 billion in capital spending on flood and coastal erosion risk management. The Environment Agency's statutory National Flood and Coastal Erosion Risk Management Strategy was published in 2020.

Since 2021, progress has been made in actioning the statement through the Environment Agency's Flood and Coastal Erosion Risk Management Strategy Roadmap to 2026, published by the Environment Agency in June 2022. The Strategy Roadmap sets out the delivery of actions to manage flood risk and support the implementation of the investment programme.

The Strategy Roadmap contains welcome routes to delivering these ambitions. A further £200 million investment has been committed to testing and developing resilience measures. Many delivery projects are currently ongoing, including:

- A £150 million Flood and Coastal Resilience Innovation Programme (FCRIP), which is enabling 25 place-based resilience schemes, testing practical resilience actions; the £8 million Adaptation Pathway Programme, developing four major estuary-wide projects, and the £36 million coastal transition accelerator programmes (CTAP). These projects are key for proof-of-concept future climate resilience schemes.
- An update to the national coastal erosion risk map (NCERM) and to the assessment of flood risk (NaFRA2), using improved data inputs and higher resolution modelling (including of surface water flood risk) for clearer outputs. NaFRA2 will be available from 2024 and will be used to produce new and updated LTIS scenarios in 2025.

The Strategy Roadmap also includes a commitment to incorporate surface water flood risk into the digital Flood Map for Planning.

- A review of the Shoreline Management Plans and a new online portal for shoreline management information.
- Doubling the number of NFM projects delivered as part of the FCERM programme. Risk management authorities are to work with landowners and Defra to pilot the Environmental Land Management Schemes, and to maximise opportunities for environmental net gain in flood and coastal resilience investment.
- A commitment to work with water companies and water regulators to inform drainage and wastewater management.
- A commitment to ensure that all places at high risk of flooding from rivers and the sea are covered by flood warning services, in addition to the government's Emergency Alerts.

Resilience and maintenance standards of flood and coastal defences are not legislated currently.

- **Overall resilience standards for flooding would improve plans and policies.** A consistent framework for place-based resilience standards and targets for flood risk management, based on long-term monitoring, could result in adaptive plans being more consistently applied in flood risk management. The standard of protection of existing defences does not always map to the areas of highest future risk, and there are no overall resilience standards for flood defences and buildings within flood risk areas or future flood risk areas. Furthermore, maintenance status of defences not maintained by the Environment Agency is inconsistently recorded. Standards (for construction and maintenance) of natural flood management or smaller-scale defences are also lacking. There is no requirement to collect data on these schemes at the local and national scale.

There is potential for land management subsidies to support natural flood management and catchment approaches.

- **Current policy and plans recognise the opportunities for funding to improve resilience.** Current plans recognise the possible role of other land management schemes (such as the Environmental Land Management Schemes (ELMS) and Biodiversity Net Gain) for ensuring catchment-based and nature-based solutions are appropriately funded. Incentives for maintaining flood defence infrastructure across risk management authorities and landowners should also be prioritised. Work to update the Environment Agency's Long-Term Investment Scenarios, with improved flood risk assessment and climate change scenarios present good progress in understanding future funding needs.

There are plans to improve the consistency of monitoring and evaluation across regions and stakeholders.

- **Policies and plans show good progress in ambition to improve risk information access and quality.** Delivery of consistent monitoring and mapping cannot currently be evaluated. The new flood risk management explorer portal is useful for data sharing and should be developed to include real-time updates on projects and monitoring. There remains a lack of requirement for communication and data sharing across catchments and risk management authorities. The ongoing Defra review of governance is important progress in improving clarity in flood risk management responsibilities. Outputs of the review should be incorporated into future plans.

(b) Outcome 2: Towns and cities are prepared for and resilient to surface water and groundwater flooding

The score for this policy and plans outcome is **limited policies and plans**. The implementation of Schedule 3 is welcome progress in moving towards more consistent management of surface water flood risk, although there will be challenges in delivery which must be clearly addressed. The inclusion of surface water risk in national risk mapping and changes to partnership funding rules will enable more surface water flooding projects to be funded. However, additional policy milestones are required to reduce risk of surface water flooding, such as addressing unplanned increases in impermeable surface area.

Recent policy will introduce mandatory sustainable drainage systems in new developments of certain size.

- **There is some mixed progress in the legislation for sustainable drainage and drainage plans.** Mandatory SuDS and their approving bodies are key policy milestones. However, this must be accompanied by effective guidance for stakeholders (including planners and construction) and must be well-regulated to ensure good delivery and maintenance. Drainage and wastewater management plans (DWMPs) will be made statutory through the Environment Act. These could present an opportunity to promote engagement between water companies and other risk management authorities, encouraging collaboration, clear roles and data sharing. However, there are no specific targets for risk reduction from surface water flooding. In addition, there is no clear policy to address unplanned increases in impermeable surfaces, from paving, driveways, and highways in urban areas in the future.

Draft statutory plans for drainage and wastewater management are progress in aligning water companies and other risk management authorities.

- **New policy should support clear standards and regulations for SuDS.** Schedule 3 will support mandatory sustainable drainage in new developments. Sufficient regulation and standards are required to ensure these interventions are installed in the right places, of high quality and well maintained. Furthermore, policy will not cover standards and requirements for all retrofit SuDS. While these solutions are locally specific, there are no national frameworks for targets or monitoring.

Standards for maintenance and installation of SuDS remains a gap – plans must set out a mechanism for recording and monitoring SuDS as a priority.

- **Options for financing and funding surface water flood management infrastructure are lacking.** There remain limited incentives and business models for private sector, water companies and homeowners to install sustainable drainage systems. Furthermore, there is currently no clear pathway for securing funding for long-term operation and management. Government-supported subsidies for water storage or disconnecting from public sewers could be a policy opportunity. Recent progress includes funding and partnerships between schools and utilities companies – such as the SuDS in Schools pilot schemes – involving the Department for Education, Environment Agency and local authorities across England. Funding allocation to manage increases in surface water flood risk due to increasing impermeable urban surface area will be required. This may be in the form of support for building-level measures, such as property-level flood resilience (see Chapter 10).

The updated national flood risk assessment will include better modelling of surface water flood risk – feeding into long-term investment scenarios.

- **Improvements to national-scale mapping and modelling of surface water flooding represent good progress in information and reporting policy.** Monitoring data at local scales is important for understanding surface water flooding and should be closely incorporated into local flood risk management plans. Plans to improve warning systems for surface water flood events must be delivered to improve household awareness and preparedness for surface water flooding events.

Updates to the Environment Agency's National Flood Risk Assessment and Long-Term Investment Scenarios to better model and account for surface water flood depths and flood volumes are welcome progress for plans. Mandatory sustainable drainage systems will require a good data collection policy to ensure that records of location and type of SuDS, as well as other aspects, such as cost and level of protection, are included. This should seek to understand how to quantify some of the multiple benefits.

(c) Outcome 3: Long-term, sustainable, coastal erosion management plans

The score for policies and plans for this outcome is **partial policies and plans.** Policies for ensuring sustainable coastal management are only partially in place. Despite some innovative schemes and committed capital investment, coastal erosion risk management policy still lacks some components of a framework for adaptation which has the required realism and urgency.

Ambitious plans for coastal erosion adaptation are only partially in place, meaning ambition and funding is geographically inconsistent.

- **There is no statutory legislation and regulation for shoreline management.** Shoreline Management Plans (SMPs) are not statutory, which means it is difficult to monitor their progress or guarantee their funding. Statutory plans should consider long-term risk and involve all stakeholders. Coastal groups are currently reviewing the policies and actions in their SMPs, but there is no regulation or tracking of policy implementation, and SMPs do not include mandatory reporting and evaluation. Programmes to ensure funding for coastal defences, transition and adaptation remain currently targeted at a few communities and regions. It will be of key importance to ensure programmes are scalable to other regions under climate change. Coastal Change Management Areas (CCMAs) are the main tool for managing development in erosion-risk locations and are currently defined and mapped by local planning authorities in local plans. These areas are currently not mapped centrally, nor aligned with Environment Agency maps or updated regularly.

Coastal plans are not statutory and planning decisions at the coast are not consistently regulated or evaluated.

- **There are more available guidance documents but no clear frameworks with standards for managed realignment schemes and working with natural processes.** Recently published guidance on restoration and beneficial use of dredged material is good progress, as is the ongoing update to the Working with Natural Processes Evidence Directory. Clear standards for maintenance and monitoring of nature-based solutions are required.

- **There is no strong commitment to provide sufficient resources and support communities at risk of being lost to erosion and flooding.** Where coastal protection cannot be provided, resources and support for coastal communities to carry out relocation, demolition, and adaptation are inconsistent. There is no insurance scheme for homeowners and businesses at erosion-risk. There are limited clear incentives for managed realignment. Environmental Land Management schemes provide an opportunity to subsidise working with natural processes on the coastline.

There is not enough financial support for adaptation plans in local authorities and communities at risk of erosion.

- **Improved coastal erosion mapping and modelling will enable local government and communities to access clearer information on coastal erosion risk.** Updates to the National Coastal Erosion Risk Mapping are good progress (Box 9.4) – these will include projections which take account of future climate and sea level rise scenarios and a digital platform for the risk maps and SMPs will be available at the end of 2023.

Complex geology will continue to pose a challenge for erosion modelling, and continued research and monitoring is required to update models with the latest analysis. Defra's review of historical coastal change will provide an important baseline for future predictions. NCERM2 will feature clarifications to SMPs highlighted in the SMP Refresh process. This process would be improved by an overarching vision for coastal adaptation monitoring, which should consistently track wider adaptation actions (such as those implemented by private landowners), alongside the delivery of SMP policy. Community engagement and co-development of policies will be key to work with communities towards coastal adaptation (see Chapter 12).

(d) Outcome 4: Urban heat risks to towns and cities are mitigated

Policies and plans to manage and mitigate urban heat risks are limited and lack overarching ambition.

The policies and plans in place to minimise urban heat island impacts are currently **limited policies and plans.** While there are promising emerging plans to increase urban greening, these are only partially in place and could be more ambitious. Plans for monitoring and evaluation are currently vague. Furthermore, there remains a gap for joined-up strategy for managing urban heat overall.

Recent guidelines for green infrastructure are progressive but are mostly not enforceable under current and planned legislation.

- **There is no clear legal requirement to protect and enhance public green and blue space.** While there is some progress, like February 2023's Environmental Improvement Plan, there is still no requirement for local authorities to protect or provide green space. The Environmental Improvement Plan includes a commitment that the public should be able to access green space within a 15-minute walk from their home. This should be used as an opportunity to strengthen planning policy. Funding commitments are required to maintain parks and green spaces, without risks of stop-start investment. There is no statutory requirement for local councils to run and manage open spaces. Some national-level targets are in place – the government has committed to planting 30,000 hectares of trees by 2025 – and has set up a £10 million scheme (the Urban Tree Challenge Fund), which provides 80% of published standard costs for the planting and establishment of trees in urban areas.[48,49] Natural England's new Green Infrastructure Framework is a positive step with standards for 40% of residential developments to have green infrastructure (the Urban Greening Factor), standards for urban tree canopy cover in development and standards for accessibility of green space.

Policies and plans do not address resilience standards for future urban heat risks.

- **There are no national-level resilience standards or even an overarching vision for adapting to urban heat risks.** This includes existing urban areas and in new developments. The Green Infrastructure Framework can act to enable better planned and targeted urban greening. However, further progress is required to ensure that interventions are ecologically coherent and of good quality. Furthermore, there are no accompanying standards for building fabric and urban surfaces to minimise urban overheating, or standards for monitoring urban heat risk. Better monitoring of heat islands and cooling interventions is key to targeting future adaptation.

There is potential for green infrastructure to be funded by subsidies, but the wider cost-saving multiple benefits must be incorporated into policies.

- **There is potential to encourage green infrastructure uptake through the provision of funding and other incentives.** Some urban cooling adaptation, such as green roofs, can be installed by individuals, businesses, or communities. Funding and subsidies, particularly in low-income areas, could improve uptake at this scale. To enable this, the varied cost-saving and wider benefits of green spaces and green design should be factored into policies.

Options for financing some of these benefits – including physical and mental health, recreation, education – may provide an opportunity to subsidise green spaces. Community involvement in managing green spaces should be encouraged. This will require more secure resource to local government.

Current policies and plans do not include mandatory monitoring and reporting of green infrastructure.

- **Data collection on urban heat impacts and adaptation uptake is not sufficiently included in current plans.** Mandatory monitoring and reporting of green infrastructure within urban areas would improve our ability to track and understand their effect on heat risks, as well as possible trade-offs, such as increasing drought risks from more trees. Local authorities should be supported in reporting and evaluating urban heat risks and adaptation interventions. This requires co-ordination across sectors and stakeholders, including developers. While the second National Adaptation Programme recognised that people lack awareness and understanding of overheating risks, there is no clear current plan to address this.

(e) Outcome 5: A planning system which prioritises future climate resilience

Policies and plans for embedding climate resilience within spatial planning are currently insufficient to meet adaptation goals.

The score for polices and plans for this outcome is **insufficient policies and plans.** While there has been some progress in policy to reduce development in areas at flood risk, planning policy does not currently promote adaptation in new and existing development. Climate resilience features in the language of current guidelines, but these lack the detail and specificity to ensure that resilient new development is prioritised on-the-ground. Planning reform has the potential to address some of these gaps, but current plans do not sufficiently regulate or address inconsistency and barriers to adaptation at the local planning level.

Planning policy is currently under reform. It is essential that updated legislation creates a framework for well-adapted places.

- **Planning policy is currently under reform. Updated legislation should create a clear framework for sustainable planning.** Current planning guidelines are not sufficient to ensure that new developments are built in appropriate locations or with adequate climate change adaptation. Clear guidelines on adaptation requirements, backed up by regulation and standards for new development would allow local planning authorities to regulate development more consistently. There remain inconsistences in how Flood Zone 3b ('functional floodplain') and Coastal Change Management Areas are defined and mapped.** Neither are mapped nationally in relation to the Environment Agency's risk assessments, meaning development is inconsistently regulated. The implementation of Schedule 3 and the Green Infrastructure Framework are welcome progress. However, both frameworks are targeted at new developments, with a lack of plans for retrofitting existing urban areas and more specific regulation for building in the flood plain. These plans have not yet fully addressed how the maintenance of adaptation actions (such as green walls, water tanks and storage ponds) will be funded.

Resilience standards and adaptation targets for new developments and land use changes could help to enforce sustainable design in planning decisions.

- **Standards of resilience and quality of sustainable development are not guaranteed**. Approving bodies for sustainable drainage and standards such as the Urban Greening Factor should help to ensure targets in sustainable planning. However, there are currently no overall statutory target standards for the quality and continued maintenance of adaptation interventions. Standards for adaptation in new developments should be

** 'Functional floodplain' – areas of land where water has to flow or be stored during a flood event, normally comprising land with a 3.3% or greater annual probability of flooding, or land designed to flood in an extreme flood.

accompanied by standards for retrofits and resilience standards for individual buildings.

- **Incentives for developers to install green infrastructure and plan for future climates lack ambition.** Beyond regulation, there is limited financial incentive for developers to include sustainable drainage and green design. The Green Infrastructure Framework and Green Infrastructure Standard encourage local authorities to develop strategic policies and delivery plans for enhancing green space, but central government subsidies and incentives for cross-sector collaboration will likely be required for delivery. Incentives could focus on the wider benefits of green infrastructure.

Current policies do not enable local authorities to prioritise tracking and delivery of adaptation in towns and cities.

- **Targets and mandatory adaptation installations require good monitoring of progress.** There is a lack of mandatory reporting on adaptation within the planning system and current plans lack a clear approach to monitoring and evaluating the proposed targets. Developers, planners, and other agencies who may be installing adaptation designs should collaborate with local councils. Data sharing is a key part of measuring progress, and further work on who hosts a database and the sort of information it should hold is required. To deliver this, the barriers to digital planning should be investigated, and communities should be enabled to find out about how planning in their area is accounting for future climate risks.

(f) Recommendations to close policy gaps

Box 9.4 highlights policy developments since 2021. Table 9.2 provides a set of targeted recommendations for actions to close key policy gaps to better prepare for climate change in this sector.

Box 9.4
Policy developments since 2021

There have been several key policy delivery developments in flood and coastal erosion risk management since 2021. Developments to spatial planning and local government policy are ongoing. It is largely too early to evaluate the outcomes of many of these policies. Key policy milestones and potential missed opportunities are discussed with reference to the required outcomes below.

Outcomes 1 and 3:

- The delivery of flood and coastal erosion risk management policy is underway via the Environment Agency's Strategy Roadmap (Box 9.3) which contains welcome actions for delivering a relatively high ambition of adaptation. Many delivery projects are currently ongoing.
- In June 2022, the Environment Agency and Ofwat published a joint approach for how water companies should consider flood and coastal resilience and their statutory roles.
- In December 2022, after a public consultation, the Environment Agency published the most recent Flood Risk Management Plans (FRMPs) for 2021-2027 which show some progress in addressing key themes, such as clear objectives for a catchment-based approach. Production was coordinated with the River Basin Management Plans (RBMPs) to improve join-up across catchments, floods and water management.
- Updated FRMPs and Shoreline Management plans are being hosted on interactive mapping tools, which include information such as appraisal guidance, thus reducing time, cost and complexity associated with securing funding.
- The Government have also committed to reforming local flood and coastal erosion risk planning to support long-term local action by 2026.

- However, flood and coastal erosion risk management policy does not specify long-term targets for the reduction in the number of properties at risk of different types of flooding and coastal erosion. There remains a lack of direction for adapting to the risks associated with reservoir and groundwater flooding. Work reviewing groundwater flood risk management published in 2021 found limited guidance, inconsistent implementation and limited evidence of groundwater flooding considered in spatial planning.

Outcome 2:

- The implementation of Schedule 3 of the Floods and Water Management Act in January 2023 is a welcome policy milestone. Schedule 3 provides the policy framework for mandatory SuDS and approving bodies in new developments. The Government accepted the review of the implementation of Schedule 3. The review recommends actions to ensure maintenance and delivery of SuDS, including building and accessing appropriate skills and knowledge for design and construction. Implementation is expected in 2024. Defra will carry out consultations this year to collect views on impact assessment, national standards and statutory processes.
- Publication of draft Drainage and Wastewater Management Plans (DWMPs) in 2022 for each of the wastewater areas served by water companies in England and Wales. These plans are currently in their first five-year cycle. This planning process is included in the Environment Act, meaning it will be statutory for the second cycle.
- It is too early to say whether they will be sufficiently robust to enable the required adaptation to surface water flood risk.

Outcomes 4 and 5:

- Updates to the Planning Practice Guidance on Flood Risk and Coastal Erosion in August 2022 improved the testing for development in the flood plain and strengthened requirements for more thorough flood risk assessments.
- Natural England's Green Infrastructure Framework launched in early 2023 is aimed at local planners and developers. It provides a framework to support access to green space and embedding tree planting and green infrastructure within urban design. It includes 5 standards: for urban recovery, urban greening, urban tree canopy cover, accessible green space, and green infrastructure; and will support mandatory Biodiversity Net Gain requirements.
- Recent consultation on the proposed approach to updating the National Planning Policy Framework (from December 2022 – March 2023) should promote effective delivery of the plan's sustainability aspects, including local design codes, strategic flood risk assessment, nature-based solutions and multi-functional benefits.
- Policies and plans are currently not consistently enforced, meaning adaptation is not considered with the required ambition or urgency in planning policy.

Table 9.2
Recommendations

Primary responsibility	Recommendation	Timing
DLUHC	Planning policy should be reformed to ensure that climate resilience is a priority, with mandatory adaptation interventions on all built-environment project applications.	2024
DLUHC	Planning policy should ensure that assessments for all type and size of built development include, at a minimum, an assessment of current and future flood, erosion, and heat risk under future climate scenarios. This requires tighter controls on Functional Floodplain and Coastal Change Management Area designation, as well as statutory consultees with appropriate skills to assess future climate risks.	2025
Defra	Government should set long-term targets for the number of people and buildings at high to very low risk for all sources of flooding (sea, river, surface water and groundwater).	2025
Defra	Government should guarantee funding for maintaining existing flood and coastal defences at a target standard suitable to future climate risk over the current FCERM policy cycle.	2023
Defra	Policy decisions within shoreline management plans should be statutory.	2025
Defra	Set out mechanisms for funding installation and maintenance of SuDS and green infrastructure.	2023
Defra, DLUHC	Urgently collect data on the location, type and standard of SuDS and green infrastructure interventions.	2023
DLUHC, Defra	Provide a mechanism for setting out place-based targets for urban greenspace and unplanned impermeable urban surfaces in towns and cities.	2024

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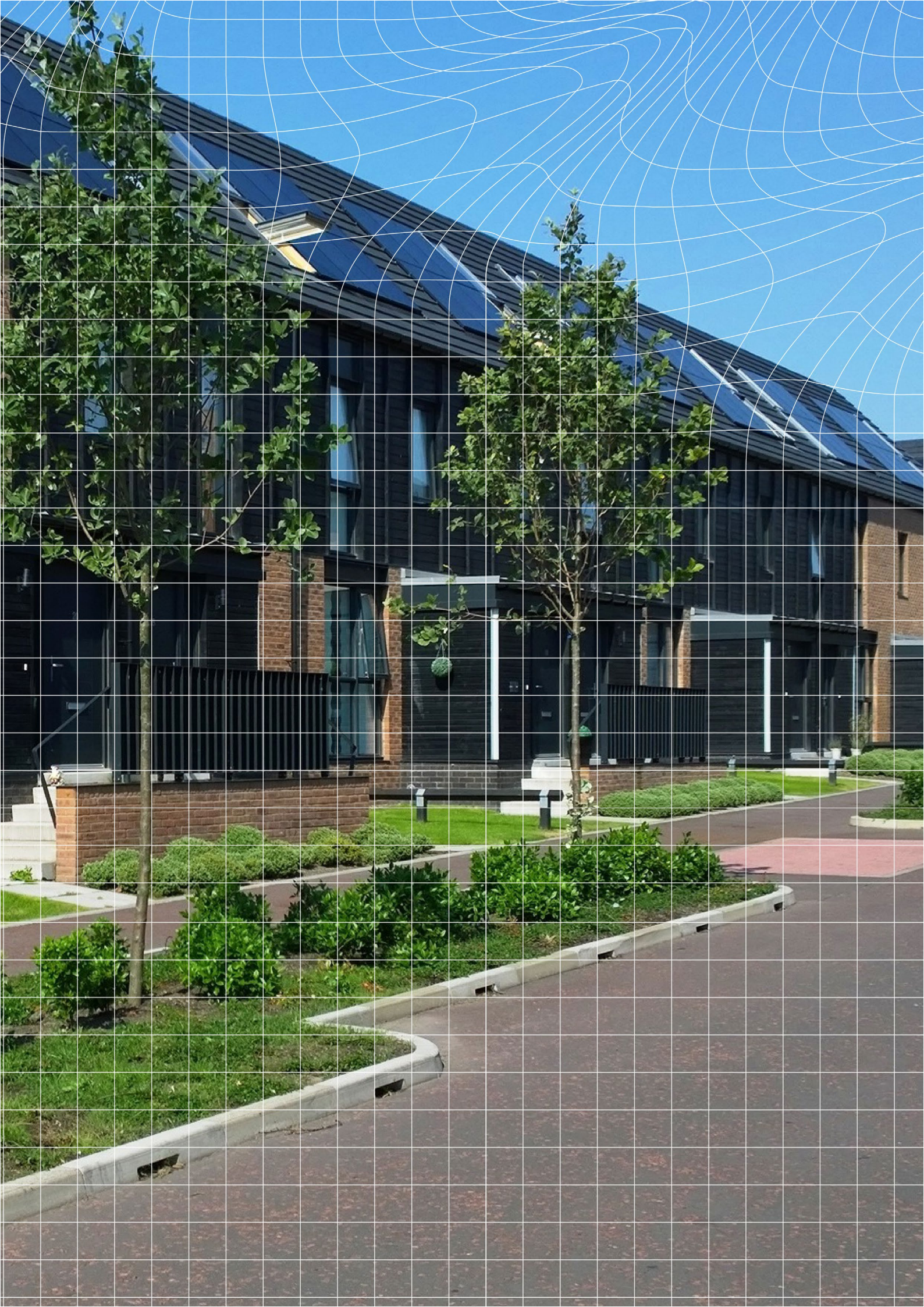


Chapter 10

Buildings

Introduction

Table 10.1
Progress summary – Buildings

	Delivery and implementation	Policies and plans	Summary
Outcome 1: Buildings do not overheat	Unable to evaluate	Limited policies and plans	• There are no regular data to track overheating rates in residential or non-residential buildings. • The update to Part O of the Building Regulations is a significant step forward to address overheating in new build homes. • There remains a lack of policy to address overheating in existing homes and non-residential buildings.
Outcome 2: Buildings are prepared for flooding	Mixed progress	Limited policies and plans	• Plans to improve access to and awareness of Property Flood Resilience (PFR) are a positive step, as are Flood Re's Build Back Better scheme, kitemarked standard property flood resilience products, and the Construction Industry Research and Information Association's Code of Practice. • Data for tracking PFR implementation are lacking and there is fragmented policy to support PFR installations.

Relevant risks from CCRA3:
Risks to health and wellbeing from high temperatures (H1); Risks to people, communities and buildings from flooding (H3); Risks to building fabric (H5); Risks and opportunities from summer and winter household energy demand (H6); Risks to health and social care delivery (H12); Risks to education and prison services (H13).

Buildings should be healthy and comfortable places to spend time in all year round.

This chapter assesses progress in adapting the UK's buildings to a changing climate. Buildings should be healthy and comfortable places to spend time in all year round. This means warm in winter, cool in summer and resilient to climate hazards such as flooding. The building stock includes residential and non-residential buildings, such as commercial buildings (offices and factories) and public buildings (e.g. schools, prisons and hospitals).*

Changes to the UK climate will increase the severity of several important weather hazards that impact on buildings and their occupants.

Changes to the UK climate will increase the severity of several important weather hazards that impact on buildings and their occupants:

- Higher summer temperatures and more intense heatwaves will increase the risk of overheating within residential and non-residential buildings. This can lead to health problems for people in buildings, particularly those who are vulnerable or have underlying health conditions (such as heart and respiratory conditions), and even lead to increased heat-related deaths. Overheating in buildings also leads to impacts on productivity directly (e.g. working from home) and indirectly (e.g. through poor sleep).

* In this progress report, the building chapter does not include adaptation of hospitals and care settings which are covered in the Health Chapter (Chapter 11). Commercial buildings and the impacts to workers are largely captured in the Business Chapter (Chapter 13).

- Periods of more intense rainfall are also associated with warmer air temperatures throughout the year. High intensity rainfall events can result in surface water and river flooding. More frequent and intense flooding events will increase the number of properties at risk of flooding. In addition, sea level rise will increase the risk of flooding from the sea for buildings in coastal communities. Flooding can destroy or damage contents within the building and can also undermine a building's structural integrity.

- Changes in other hazards that can affect buildings – such as wind strength and storminess – remain uncertain. These hazards can have a significant impact on buildings.

- Some hazards impacting buildings and their occupants may become less likely in the future, such as extreme cold and snow. However, the burden of ill-health from cold will remain significant in the UK and is a priority for public health and Government action.

Risks from climate to buildings depend on several other factors.

Risks from climate to buildings depend on the type of building (e.g. single-aspect, mid- and top-floor flats that lack sufficient ventilation are more likely to overheat than houses), the tenure and occupancy, the location of new and existing buildings, the vulnerability of their occupants (such as age and health) and the severity of the changes in hazards.[1] Socioeconomic factors, such as income levels or mobility of building occupants also have a significant impact on risk levels in buildings.

Ensuring that buildings across the country are safe and comfortable in periods of weather extremes will have benefits across society. Buildings that do not overheat (now or in the future) will reduce the health burden of high summertime temperatures and will have benefits for economic productivity. Property-level flood protection will have a significant social and economic benefit due to the level of disruption flooding can cause.* Key policy levers for new (e.g. building regulations, planning and property-level flood resilience policy) and existing buildings are devolved.

The efforts to adapt buildings to climate change have strong overlaps with adaptation actions in other chapters.

This chapter focuses on actions related to the building design and operation that can help address these many climate-related risks. The indirect risks arising from the interaction of building design with other areas are covered elsewhere in this report. The efforts to adapt buildings to climate change have strong overlaps with adaptation actions in other chapters:

- **Towns and cities.** Urban design strongly influences the climate risks faced by buildings and their occupants. Urban areas (such as large towns and cities) can be significantly warmer than surrounding countryside – particularly overnight – meaning the indoor air temperatures are also higher.[2] Water, trees and green space can reduce this urban heat island effect by providing shade, reducing heat absorption by urban surfaces and providing sources of evaporation. Building these measures into urban areas is known as 'green infrastructure'. Green infrastructure can also make urban areas less susceptible to surface water flooding by improving water storage and drainage. Other sustainable drainage schemes, such as permeable paving, also help to reduce flooding at a settlement scale – although building-level protection may also be required. Large-scale defences from

* Property level flood protection, whilst critical, will not by itself offer sufficient protection from flooding hazards. Property level actions will need to be integrated with wider 'settlement' scale flood defences, covered in Chapter 9.

river and sea flooding tend to be planned and implemented at the settlement scale and are designed to protect whole neighbourhoods.

- **Health.** Overheating in buildings can result in increased deaths and increases in the prevalence and severity of some health conditions. Given the large fraction of time people spend indoors (particularly overnight) the overheating experienced in buildings is a large contributor to the overall health impacts of increasing temperatures. Some buildings are also critical to the operation of the health and social care system (e.g. hospitals and care homes) – with overheating in these buildings often impacting on particularly vulnerable people or causing stress to the operation of the health system.

- **Water supply.** Homes and non-residential buildings consume water provided through the public water system. A key action to increase resilience to future drought extremes is reducing water demand within buildings. This means more water-efficient appliances installed within buildings.

- **Business.** Climate change impacts on commercial buildings, such as extreme heat, can make it difficult for staff to conduct their roles. Without adaptation measures, there is a risk of resulting productivity losses.

- **Community preparedness and response.** This chapter (Chapter 12) covers ensuring local heritage, including different types of heritage buildings, is conserved under a changing climate. Recent mapping of hazards found a high increase in exposure to overheating and humidity, relatively low levels of coastal risk and insufficient data to understand exposure to precipitation.[3]

Decarbonisation policy and building safety are two important goals for buildings in addition to adaptation.

There are two additional policy goals for buildings relevant to adaptation efforts:

- **Decarbonisation.** Policy to reduce emissions from buildings focuses on reducing energy demand in buildings through energy efficiency and replacing fossil fuel fired heating systems with low-carbon ones. The decarbonisation of the building stock should be done alongside a consideration for overheating and indoor air quality risk.

- **Building safety**. A key policy objective for buildings relates to building safety. This means, in the context of this chapter, ensuring that buildings do not overheat, have good levels of indoor air quality, meet fire safety standards, and do not have indoor moisture problems such as mould and damp.

1. Monitoring progress towards a well-adapted building stock

In this chapter we propose a monitoring map (Figure 10.1) of the key outcomes, enablers and policy actions needed to ensure that England's buildings are fit for now and the future, including being resilient to future climate extremes.

Buildings should not overheat during heatwaves, should be prepared for flooding and should be resilient to other climate risks.

There are three top-level outcomes that need to be achieved to ensure buildings are resilient to the range of climate impacts that they face:

- **Buildings do not overheat during heatwaves**. This requires that new buildings are built to meet a robust standard on overheating, and existing buildings that are vulnerable to overheating are retrofitted with (primarily passive) cooling and insulation measures where necessary. Beyond the properties of the building, residents and occupants of buildings should understand how to best manage the internal temperature and take appropriate actions during heatwaves.

- **Buildings are prepared for flooding**. New and existing buildings, in areas of flood risk, should have the necessary property-level flood resilience (PFR) and resistance measures installed. Flood-resistant construction, such as flood doors or air brick covers, can prevent water entering buildings up to depths of around 0.6 metres.[4] Flood resilience measures look to minimise damage when a building is flooded. This includes use of resilient building material and raising socket-outlets. These measures increase preparedness to flood events, minimise the damages if flooding was to occur and increase the ability of occupants to recover quickly after flooding.

- **Buildings are resilient to other climate risks.** Beyond overheating and flooding, additional direct and indirect risks to buildings will likely increase over time. These include subsidence due to drought and dry soil, or structural damage due to high winds. At present, little is known about how climate will affect these risks.[5] Further research is required to understand the extent that these risks will change in future climate scenarios, the household costs for damage associated with these climate hazards and the most appropriate policy response. Modelled estimates show that climate change is likely to reduce the burden of cold-related mortality (connected to cold buildings), however the overall burden remains high, even to the end of the century, and population ageing is likely to offset some of the benefits from warmer winters for cold-related mortality. Policies to improve energy efficiency and reduce winter fuel poverty are therefore still required.

Enabling factors that need to be in place to deliver these outcomes are wide-ranging, from ensuring private funding and investment in buildings retrofit, to education and awareness about climate risk and adaptation strategies:

Enabling factors that need to be in place to deliver outcomes are wide-ranging.

- **Governance.** Ensuring policies for buildings decarbonisation include climate adaptation is a key priority, especially given the risk of increased energy efficiency standards potentially exacerbating the risk of overheating and poor indoor air quality. There is also a need for enforcement of the planning system to ensure that any building in areas of flood risk considers appropriate property-level resilience measures. The planning system can help ensure that development at future risk is constructed and designed with adaptation measures, as discussed in Chapter 9 (Towns and Cities).

- **Funding and investment.** Most of the investment in adaptation measures for the building stock will be private. Low-cost finance, which enables households and businesses to install adaptation measures, is needed. Finance can be accessed through instruments such as green mortgages, property-linked finance, and flood insurance.

- **Education and awareness**. High levels of awareness of climate risks and adaptation actions amongst the public would ensure that people know how to prepare buildings for, and behave during, extreme weather events. Occupiers and residents of buildings need to know how to operate and manage building temperatures.

- **Research.** Additional research on heat thresholds, overheating, adaptation options and how to retrofit buildings to achieve co-benefits across energy efficiency, thermal comfort, air quality, and ventilation would help target action and better understand synergies and trade-offs.

- **Data and monitoring**. There is currently a lack of large-scale monitoring of overheating incidences and flood risk across the building stock. Without monitoring, people may be unaware that there is a risk that they should be mitigating.

- **Skills and construction.** The construction and engineering industry are key actors enabling PFR and widespread understanding and skills in this industry are key. Professional standards are important to this. For example, the PFR Code of Practice was developed in a collaborative project by the Construction Industry Research and Information Association (CIRIA), and the Chartered Institute of Water and Environmental Management (CIWEM) is involved with PFR industry training. There is also a need for building control officers to have the skills to check regulations are being met.

We identify a number of policy milestones that would be required to help deliver the climate resilience outcomes and put in place the set of wider enabling factors:

Building regulations and the planning system are the Government's key levers for ensuring that new buildings are built to a high standard and have limited overheating and flooding risks.

- **Legislation and regulation.** Building regulations and the planning system are the Government's key levers for ensuring that new buildings are built to a high standard and have limited overheating risks (including under both current and future climate conditions). Regulations and policy to help adapt existing buildings are also needed. Currently, a series of tests must be carried out by planning authorities before new buildings are developed in areas at flood risk. If building goes ahead, risk should be mitigated through new or improved flood defence infrastructure and property-level resilience measures. The extent of PFR required and the installation of these measures (in both new and retrofit buildings) should be regulated to ensure maintenance and quality, with building-level surveying and recording a regulated part of the installation process. Property flood resilience projects should continue to be funded through flood risk management policy. This should be targeted at the most effective measures and locations. Projects should follow a proactive approach, focusing on installing measures before flooding occurs, to complement post-event grants.

Financial mechanisms should be in place to support building-level adaptation investment.

- **Financial instruments.** Mitigation packages for adapting to overheating risks can come with a high cost, although there are also several low-regret, low-cost options. Financial mechanisms should be in place to support building-level adaptation investment for any buildings; this is particularly important for vulnerable private households. The biggest role for public funding is expected to be supporting reduced overheating risk as a co-benefit of investment in greenhouse gas emissions reductions through energy efficiency improvements to buildings. Access to affordable insurance is required for quick and effective recovery from flooding events. Finance mechanisms should consider socioeconomic and vulnerability characteristics of building stock and building occupants in the allocation of post-event grants.

Access to affordable insurance is required for quick and effective recovery from flooding events.

- **Standards.** There are standards for buildings health and safety (such as the Decent Homes Standard and Housing, Health and Safety Rating System) that should include consideration of overheating. Standards for new and retrofit PFR are key to ensuring a good quality market and installation industry. Standards should consider resilience as well as resistance measures to ensure new buildings are capable of dealing with being flooded should resistance measures fail.

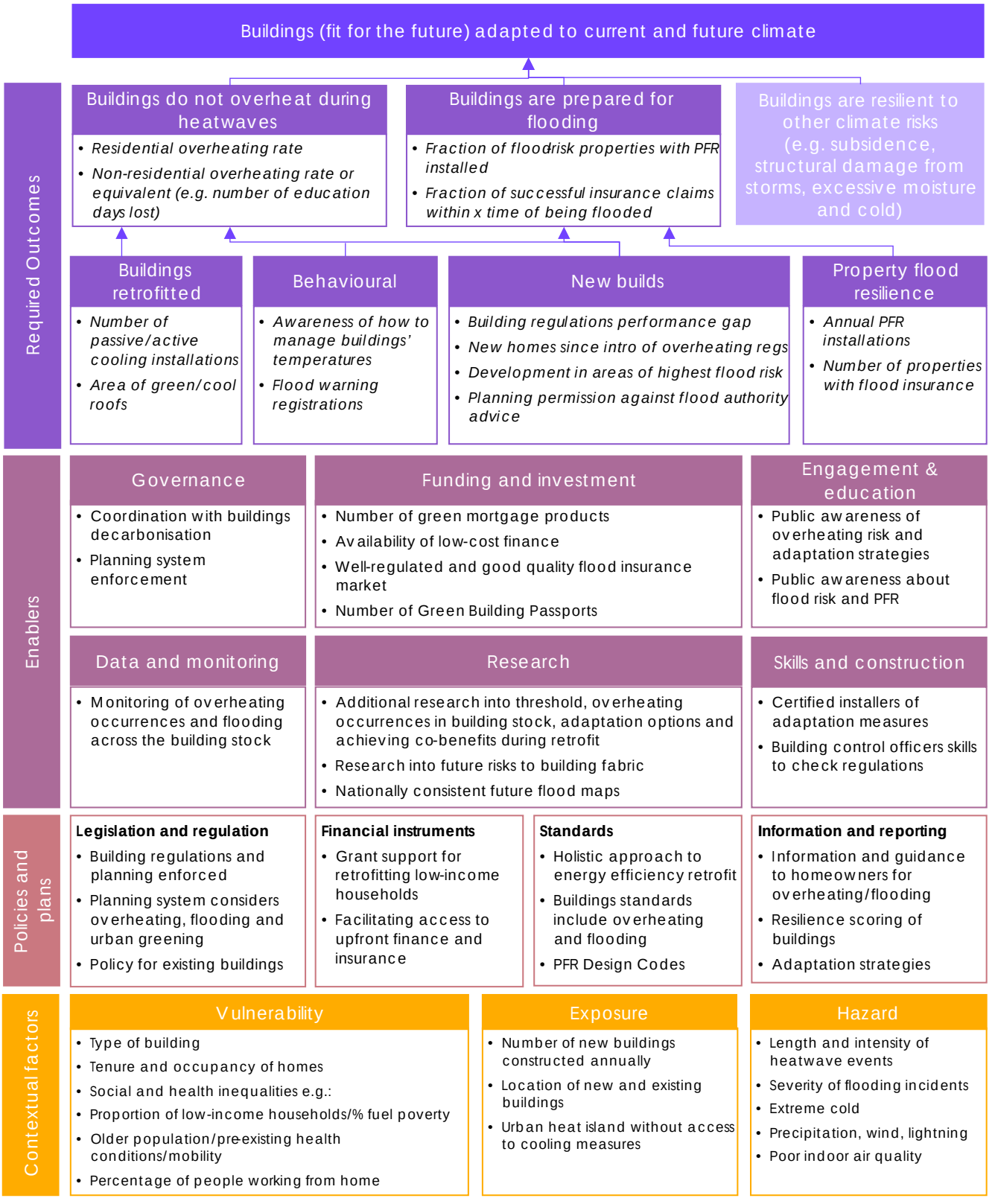
Information and guidance to homeowners and building occupiers for overheating and flood risk is key to enable them to use buildings effectively and reduce risks.

- **Information and reporting.** Information and guidance to homeowners and building occupiers for overheating and flood risk is key to enable them to use buildings effectively and reduce risks. Homeowners should be able to check their flood risk and access information about how to prepare their homes for flooding and other climate risks. This could be via mechanisms similar to EPCs. Organisations should produce adaptation strategies, planning for at least 2ºC global temperature rise, outlining actions to be taken and improving knowledge. Much engagement must be carried out at the local level to trigger behavioural change at the household or building level.

Contextual factors can influence vulnerability to climate hazards, and ability to respond to them.

Contextual factors have a significant impact on adaptation outcomes in the buildings and how they are distributed across society. Factors such as building type and location, age, income level, or even social networks can influence vulnerability to climate hazards, and ability to respond to them (Box 10.1).

Figure 10.1 Monitoring map for buildings



Source: CCC analysis.
Notes: Italicised text indicates suggested measures for each outcome.

Box 10.1
Contextual factors

Contextual factors in buildings – relating to hazard, exposure and vulnerability - have a significant impact on the outcomes and how they are distributed across society. This box presents available data and evidence regarding some important factors for the UK or England.

Type of building. Flats often represent the type of building most at risk of overheating compared to other types of buildings. Modern, urban flats often have high levels of glazing with little shading and limited natural ventilation, are single aspect and many have no easy access to outdoor green space. Multi-tenement flats can also be hard to alter given that the agreement of all households is needed to make changes. There is also the difficulty in attributing costs and benefits of measures to each flat. In 2021, 21.7% of households lived in a flat, maisonette or apartment, up from 21% in 2011.[6]

Other types of buildings, such as schools, prisons, care homes and hospitals are occupied by people that may be more vulnerable to climate risks.

Tenure and occupancy. Tenure is important for considering barriers and incentives to climate change adaptation and mitigation measures. A person in rented accommodation is more likely to be in fuel poverty, which may mean they have limited resources for measures such as energy efficiency and property-level adaptation. A person living alone, especially if they are vulnerable, may also be at greater risk of climate impacts. Since 2011 there has been a decrease in the proportion of households owning their accommodation (62.5% in 2021 compared to 64.3% in 2011) and an increase in people renting (37.3% in 2021, up from 34.3% in 2011).[7] The number of people living alone in the UK has increased by 8.3% between 2011 and 2021.[8]

Proportion of people working from home. There have been increasing numbers of people working from home (from around 5% working exclusively from home each week before the COVID-19 pandemic to around 14% in 2022).[9,10] In 2022, 24% of workers were hybrid working. This may increase the exposure of much of the population to high temperatures during the daytime. One consequence of a shift to people working from home would be a greater productivity impact of summertime overheating.

Income and vulnerability. Income levels are one means of assessing the adaptive capacity of a population to respond to climate hazards such as heatwaves or flooding. People with lower incomes or households in fuel poverty may find it more difficult to adapt their houses. Studies have shown that there are many regions in the UK which have high levels of exposure to climate risks, and where income levels are below average.[11,12] In 2022, there were an estimated 13.4% of households in fuel poverty in England, up from 13.1% in 2021.[13]

Other social and health inequalities. The UK population is growing and growing older, increasing the demand for housing. As well as age, underlying health conditions and mobility can impact a person's risk level. These are discussed in more detail in Chapter 11.

(a) Outcome 1: Buildings do not overheat during heatwaves

There is a lack of data to fully assess whether progress is being made to ensure buildings do not overheat.

There is a lack of direct or proxy datasets to assess how the proportion of the building stock which is overheating has been changing over time. This means we are **unable to evaluate** overall progress towards adapting the building stock in England for current and future climate.

- **Data for residential overheating is sparse or not available.** There remains no regular data collection to monitor overheating rates in residential buildings nor data on the amount of passive cooling measures installed. One-off studies provide an indication of the proportion of buildings in the UK which are overheating, but we are unable to assess whether this proportion is changing over time.
  - The 2021 Energy Follow Up Survey (EFUS), found that nearly a fifth of English houses were currently overheating during summer months.[14]

A fifth of English houses currently overheat during summer months.

  - Recent research carried out by Arup for the CCC provided further modelled evidence that a significant proportion (55%) of the residential building stock is currently overheating, although this was based on the CIBSE TM59 criteria for bedrooms which is difficult to pass. The proportion overheating was estimated to rise to 90% in a 2ºC scenario and 100% with 4ºC of warming (Figure 10.2).[15]
  - It is too early to tell the impact of Part O regulations on the new building stock. The number of new homes built since the regulations came into force will be useful to track when the data becomes available.
- **Annual data on non-residential overheating is not yet available.** There are some planned and ongoing data collection efforts regarding overheating in other buildings such as schools and prisons, but at present no regular annual monitoring is in place.

Pilot studies are taking place in schools and prisons but at present there is no regular annual monitoring of temperature.

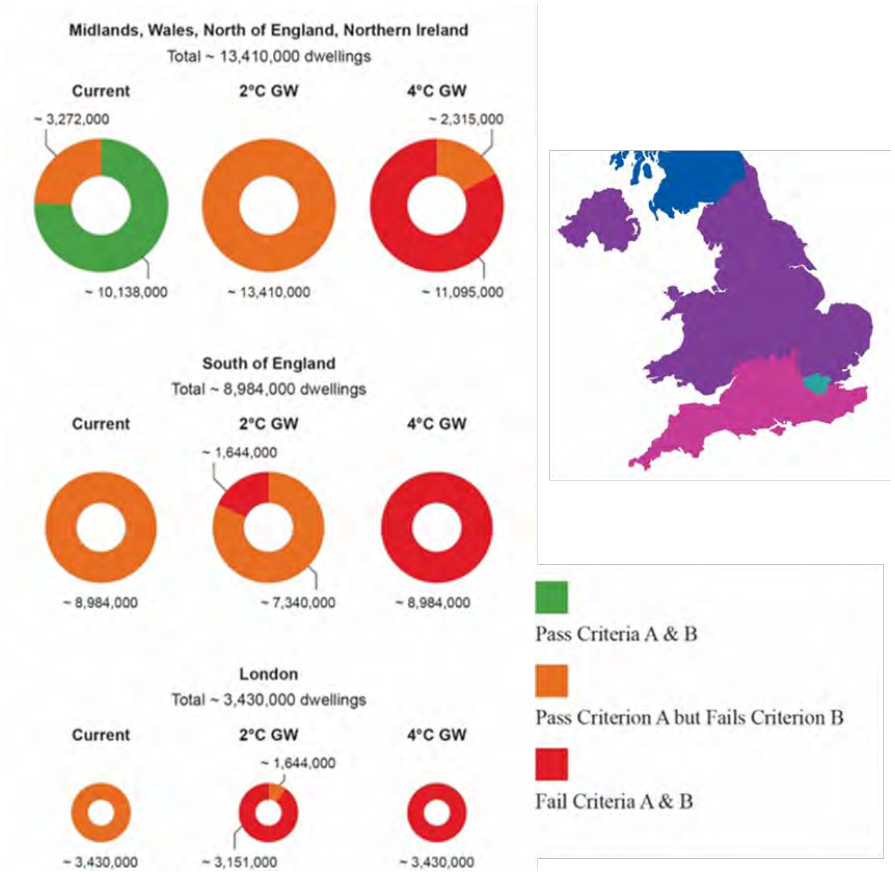
  - The Department for Education (DfE) has completed several wide-ranging pilot studies to help improve evidence. These include monitoring ventilation and temperature in a sample of new and existing schools that had been identified as being at risk of overheating.[16]
  - The DfE is currently developing an approach to quantifying overheating risk to education services. Developing an indicator on lost education days each year due to extreme weather would be useful.
  - The Ministry of Justice (MoJ) is currently monitoring temperature, humidity and carbon dioxide levels in a sample of prisons of varying building archetypes (age, condition, building fabric).[17] There are plans to extend the project to other locations and types of prisons in 2023 to better understand the extent of overheating and assess possible interventions.

There are no data available for additional indicators.

Additional key indicators for this outcome sit in the third row of the monitoring map: the annual number of cooling measures installed in homes, area of green roofs, awareness amongst the public about how to manage internal temperatures, and the in-use performance of new build homes passing Part O of building regulations, as well as those for enabling factors such as the number of green mortgage products and Green Building Passports. There are no nationwide datasets for most of these indicators.

There would also be value in tracking the rollout of active cooling over time, which currently isn't collected. BEIS estimates that annual cooling energy consumption could be around 12.0 TWh and 6.3 TWh for high and low emissions scenarios respectively by 2100, if there is no intervention (although these values can be significantly reduced through policy intervention).[18] This indicator would serve two purposes: in addition to the benefit of knowing the number of buildings with cooling installed, tracking the rollout of active cooling would help estimate the potential future power demand for air conditioning in summer.

Figure 10.2 Overheating risk across existing homes in England and Northern Ireland according to CIBSE TM59 criteria



Source: Arup, for the CCC (2022) *Addressing overheating risk in existing UK homes.*
Notes: Data is also available for Scotland. The TM59 methodology from the Chartered Institute of Building Services Engineers (CIBSE, 2017) was selected as the most suitable method of determining the overheating risk in homes at present. TM59 presents two criteria to assess the risk in homes that are 'predominantly naturally ventilated'. Criterion A (for living rooms, kitchen and bedrooms) assesses overheating during all summer occupied hours using an adaptive approach that defines the maximum acceptable temperature based on the external temperature; Criterion B (for bedrooms only) assesses night-time overheating based on a fixed temperature threshold of 26°C.

(b) Outcome 2: Buildings are prepared for flooding

To evaluate progress towards this outcome, we require evidence that more existing buildings at flood risk are installing resistance and resilience measures; more new buildings in flood risk areas are being designed and built with these measures; and more properties and buildings can access funds to repair damages from flooding.

Indicators for this outcome demonstrate **mixed progress** for buildings adapting to flooding. It is too early to evaluate the outcomes of several ongoing initiatives. Data collection on property-level protection installation, and the effectiveness of different types of measures under different flood scenarios, is not nationally consistent.

There is no baseline or current national-scale monitoring for property flood resilience measures in the building stock.

- **There is no consistent national dataset on the percentage of flood risk properties with flood resilience and resistance measures.** The Environment Agency track properties better protected by schemes delivered in their flood and coastal erosion risk management programme which focus on property level protection. In the 2015-2021 capital programme, 92 of the 854 delivered projects are tagged as focusing on property level protection – better protecting a total of around 2,250 homes. In the first year (April 2021 to March 2022) of the 2021-2027 programme, 271 homes were better protected by 16 property-level focused schemes (Figure 10.3).[19] While this is an imperfect indicator – because property-level protection may also have been delivered in wider schemes within the programme – it indicates a consistent and slightly increasing focus on government funded property-level schemes. Property-level schemes can also be funded and delivered outside of Environment Agency schemes – by water companies, local councils, or by individual property owners – so there are likely to be many more than observed in this dataset. Annual water company investment in property flood resilience in 2020-2021 of £6 million was substantially higher than in previous years (£2 million in 2019-20 and £4.7 million in 2018-2019).[20]

Funding and investment from public and private sources for property flood resilience projects has increased over recent years.

- **Trends in the uptake of government grants for property flood resilience over time are unclear from available data.** In the two most recent PFR Repair Grant schemes, after flooding in November 2019 and February 2020, Defra awarded 2,600 PFR grants – resulting in a total spend of £10.7 million.[21] Average grant per property was £3,800 in February 2020 (£4,600 in 2019). Uptake of grants was lower in 2020 (29% compared to 40%) but total spend was higher – reflecting more severe flooding over more local authorities (34 to 18).[22]

- **Consistent monitoring of property-level flood measure uptake is lacking, meaning that indicators for this outcome are incomplete.** There is no nationally consistent data collection on installation. It would be useful to know the number and type of property-level protection measures being installed, and the level of protection they provide. Different products will be more suited to different situations and installation doesn't necessarily equate to protection because many installations require maintenance or active intervention, such as manually putting up barriers before a flood event.

There is no framework for consistent monitoring of the uptake and upkeep of property-level flood protection, and thus, our understanding of their efficacy, costs and benefits has substantial gaps.

- **There are some local examples of studies of PFR uptake, but the national picture is hard to evaluate**. For example, research after the November 2019 floods in Doncaster, South Yorkshire, found that 18% of the 338 households surveyed and 22% of the 178 affected households had installed flood defences around their properties. 37% of affected properties had applied for a PFR grant from the Government.[23]

- **The Environment Agency, Defra and Flood Re are all engaging in trying to collect these data.** The Flood Resilience Pathfinders project, funded by Defra, finished in 2021 and aimed to increase awareness around PFR installation. The project has resulted in a prototype 'PFR Assured Database' which enables local authorities and other partners to collect and map household-level data. The database and community engagement aspects of the Pathfinder projects are being developed as part of one of the Environment Agency's Resilience Innovation Programmes.*

There are several ongoing Government and non-Government projects which are looking to create a database of property flood resilience installations.

- **Property owners can also invest in measures to reduce the risk of surface water flooding. There are little data on uptake of these measures at a buildings scale, but uptake is low.** Research for the National Infrastructure Commission's Surface Water Flooding report found that water butts were the most owned measure of flood intervention (42%) to reduce surface water flooding amongst surveyed households in July 2022, followed by rain gardens (22%) and soakaways (17%).[24,†]

- **More households at risk of flooding can access multiple insurance quotes.** The proportion of at-risk households with recent flood claims (in the last 5 years) able to obtain more than 10 different quotes for insurance has steadily increased since the introduction of Flood Re (Box 10.2), from 1% in early 2016 to a high of 98% in November 2021, declining to 93% in June 2022, where it has remained steady since (Figure 10.4).[25] It could also be beneficial to track successful insurance renewals and claims: for example, 87% of households in Doncaster were successful in renewing their insurance including flood cover after the November 2019 floods.[26]

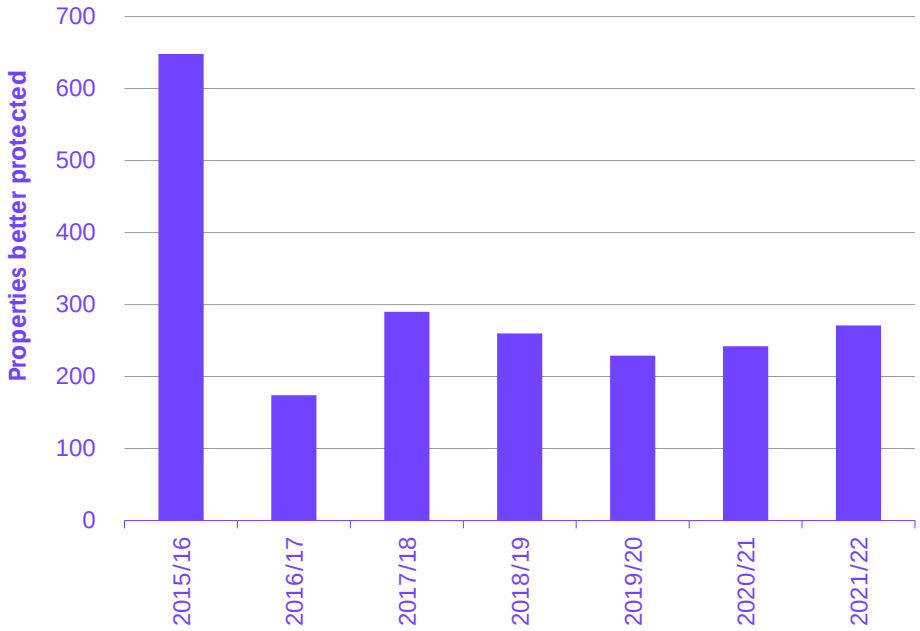
Nearly all of households at risk of flooding can access insurance quotes from more than five different providers – this has been a steadily increasing trend since the introduction of Flood Re.

- **There are no available data about the fraction of successful insurance claims and the time taken for pay-outs.** Data from insurance providers could enable better tracking of the preparedness and risk assessment of buildings**.** For example, data from the Association of British Insurers suggests that the average domestic flood insurance claim value in 2021 was £20,094. This is in comparison to £2,771 for other domestic weather-related claims.[27]

* The PFR Assured database was developed by the Yorkshire Integrated Catchment Solutions Programme as part of the PFR Pathfinders scheme. The database includes a mapping tool. The Pathfinders scheme also developed the 'Be Flood Ready' website portal. Both products are now being developed in the RAIN (Resilience and Innovation Northants) FCRIP project.

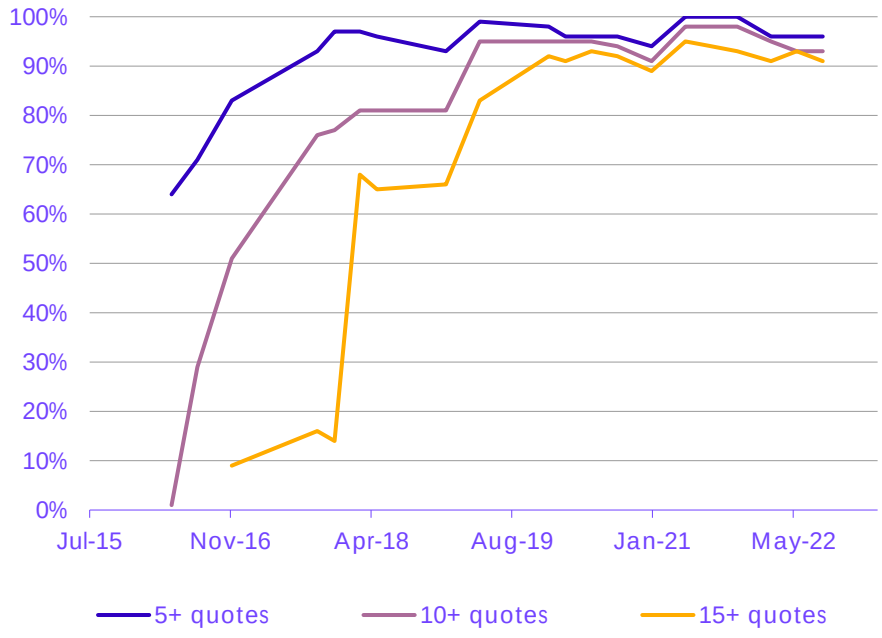
† Survey carried out by BMG on behalf of the National Infrastructure Commission, involving 2,002 participants of a nationally representative demographic of England aged 18+.

Figure 10.3 Homes protected by property-level resilience focused schemes delivered within the Environment Agency's FCERM programme



Source: Environment Agency (2023). Data provided on request.
Note: Schemes may run over multiple years before completion. An additional nine schemes were identified in the capital programme, but the year of completion is not known.

Figure 10.4 Proportion of households with recent flood claims able to obtain multiple insurance quotes



Source: Flood Re (2023). Data provided on request.
Note: Prices fell throughout 2022, which appears to be a direct result of the General Insurance Pricing Practices reforms by the FCA, which means companies have to offer the same price to everyone. Households with recent flood claims are those who have made claims in the last five years. Quotes were analysed across two price comparison websites.

(i) Enablers

To achieve these outcomes for well-adapted and resilient buildings will require enabling factors to be in place. Enabling factors for building adaptation include sufficient funding mechanisms, resilient supply chains for construction and retrofit, improved homeowner awareness and sufficient training of skilled construction and planning professionals. Indicators relating to enabling factors demonstrate some positive trends, but there are limited data available to assess overall extent to which the enablers are in place. For example, while some government funding is available at the household-level and can be tracked, there is limited accessible data on funding from private investment.

Indicators for the enablers show:

Households with insurance can now access funding for installing resilience measures after flooding above the cost of flood repairs.

- **Properties with insurance can now access grants for installing resilience measures repairs after a flood event.** In April 2022, Flood Re (Box 10.2) announced the introduction of 'Build Back Better', which allows participating insurers to offer reimbursement costs of up to £10,000 for installing property-level protection, over and above the cost of flood repairs.* In future, data on the number Build Back Better claims processed for PFR could be used to track property-level protection installed by homeowners. However, funding must support a more sustainable and consistent market - the PFR industry is mainly based on small businesses and currently highly reliant on one-off sales after a flood.

More funding is required to support individuals, businesses and risk management authorities to install and maintain adequate property-level resilience measures.

Box 10.2
Flood Re and flood insurance accessibility

Flood Re is a reinsurance company. It allows other insurance companies to insure themselves against losses because of flooding. This means that people who own and live in properties at flood risk areas are more able to access affordable home insurance.

Flood Re was established by Government legislation in 2016, to replace previous agreements between government and insurance companies to provide flood insurance coverage to domestic properties at risk of flooding. It is a not-for-profit, publicly accountable fund. The set-up costs were covered by the insurance industry, and the pool of money to cover claims comes from a charge for each policy which is passed to Flood Re and an additional £135 million annual levy from all home insurers in the UK.[28]

Customers do not deal directly with Flood Re – their insurer will place the flood risk part of their policy with Flood Re when it rises above a certain level. The insurer is then charged a fixed sum based on council tax bands. When a customer makes a claim, the insurer can then recover the costs of the claim and repair works from Flood Re.

Most homes in high flood risk areas are eligible – although properties built after January 2009 and flats in leasehold blocks containing four or more homes are not. Businesses are not covered. Flood Re can cover contents insurance for tenants if the property qualifies.[29]

Source: ABI (2023) *Flood Re Explained*; Flood Re (2023).

- **There is currently no way of regulating effective and well-maintained property-level flood protection.** Tracking the effectiveness of property-level installations and how well they have worked in a flood event will help regulate for good installation and improve the evidence-base to understand what kind of interventions work best.

* Build Back Better is funded from the same pool of money which covers claims (see Box 10.2).

Effective use of property flood resilience products and their installation requires good regulation and enforcement of standards, as well as skilled construction workers.

- **There is poor awareness of household-level flood risk and the adaptation measures that can be taken to address this.** Property-level adaptation requires engagement and education. A study of more than 2,000 UK adults in Autumn 2022 found that only 14% know what to do to prepare for a flood and 19% said they knew where to access information about what to do before, during and after a flood.[30] The proportion of people surveyed in the Environment Agency's public flood survey who have investigated flood protection products such as flood boards, air brick covers and sandbags has remained between 22% and 29% since 2016 – with 24% the most recent result of the 2021-2022 survey.[31] However, the 2021-2022 survey showed 67% of people who had been flooded recently had deployed property protection products before or after flooding, and 55% of people who had not been flooded in the past few years would deploy flood protection products if they believed their homes were at risk.[32] This suggests that awareness amongst those who have never been flooded is greater than engagement with installing the products themselves, indicating some opportunity for encouraging behavioural change at the household level.

Public awareness of flood insurance and flood resilience measures is low, resulting in less uptake.

- **Improved data collection and outcome monitoring is required to work out which solutions work best in different locations and scenarios.** Improved monitoring of PFR installations and their risk reduction benefits is key to creating a sustainable and high quality PFR market.

- **There are some baseline data which indicate the number of skilled workers.** The construction, engineering, planning and risk management industry require sufficient workers and skills to fit quality PFR installations. CIWEM launched an online PFR training course in 2022 - 277 individuals have enrolled or attended all PFR courses; 175 of these attendances were for the 'PFR Foundation Training'. Nearly half of these places (46%) were EA funded, with the remaining self-funded places predominantly surveyors or installers.[33] This data should be tracked in future to indicate industry readiness to upscale PFR installation.

(c) Outcome 3: Buildings are resilient to other climate risks

We do not fully understand the impacts of other climate risks such as subsidence, moisture and high winds.

In addition to overheating and flooding, there are other climate change risks to both new and existing buildings in the UK. Climate hazards which can damage building fabric include subsidence caused by drought and dry soil, excessive moisture due to flooding and heavy rain, and structural damage due to high winds. The impact of climate change on these specific hazards is not currently well understood. As a result, we do not yet have indicators to assess progress against this outcome.

Further research is required to understand how risks to building fabric will vary over time, and to form a policy response.

Further research is required to understand how risks to building fabric will vary over time, and to form a policy response. Given the lack of clear outcome, and uncertainty on an appropriate adaptation response to the risks, this outcome is not scored. However, the third UK Climate Change Risk Assessment summary for England stated that despite the uncertainty, "there is high confidence that current building regulations are inadequate for addressing moisture and damp in buildings".[34]

(a) Outcome 1: Buildings do not overheat during heatwaves

There are currently only **limited plans and policies** in place to ensure that buildings do not overheat during heatwaves.

The update to Part O of the Building Regulations is a significant step forward.

- **Legislation and regulation.** The update to Part O of the Building Regulations, published in June 2022, is a significant step forward for ensuring that new residential buildings are resilient to summertime overheating, although it does not include refurbishments, prisons and conversions from non-residential to residential. There remains no policy in place to incentivise adaptation in the existing building stock. The UK Green Building Council states that 80% of those homes that will exist in 2050 are already built.[35]

There remains no policy in place to incentivise adaptation in the existing building stock.

  The Health and Safety Executive were appointed as the new Buildings Safety Regulator in June 2022. There is no explicit mention of overheating in the regulator's remit, although the regulator is responsible for general building safety (such as overseeing standards, improving build competence and implementing a new regulatory framework), particularly in high-rise flats.

- **Financial instruments.** There are currently no financial mechanisms in place to support building-level adaptation investment for any buildings. This is particularly important for vulnerable private households.

- **Standards.** The Government is currently reviewing the Decent Homes Standard (DHS) and considering applying it to the private rented sector.[36] The current DHS does not explicitly mention overheating. The Housing health and safety rating system (HHSRS) does explicitly include a requirement to establish if tenants are experiencing excess heat.

Energy efficiency, overheating and ventilation should be considered together during building retrofit.

- **Information and reporting.** The Government should ensure that advice offered through the recent energy advice service considers that retrofit programmes takes a holistic approach to improving dwellings' thermal and indoor air quality performance throughout the whole year. Green Building Passports or home retrofit plans could provide holistic guidance and help to unlock green finance. These are not currently being done.

  – The MoJ is updating their adaptation strategy, due to be published in 2023. It is also doing post-occupancy evaluations of new-build prisons.

  – The DfE is collaborating with a range of partners to develop a climate risk assessment methodology for both flooding and overheating, which will model hazard, exposure and vulnerability specific to education services.[37]

In addition to the above, the Government has taken some steps to improve the governance for summertime overheating. The establishment of a new cross-government working group on overheating has created a forum to develop a coherent approach to this risk across the building stock.

(b) Outcome 2: Buildings are prepared for flooding

Some elements of policies and plans to prepare England's building stock for flooding are in place. These require clarity to address some missing milestones, particularly around the monitoring and evaluation necessary to ensure quality and effective use of property level resilience measures. The score for this outcome is therefore **limited policies and plans.**

While there are regulations for planning, there are a lack of enforceable resilience standards to ensure buildings are built or fitted with appropriate property-level flood measures.

- **Legislation and regulation.** The Planning Practice Guidance on Flood Risk and Coastal Erosion was updated in August 2022 to align with National Planning Policy. This sets out tests, designed to favour sustainable development, that all local planning authorities are expected to follow for new buildings. It should ensure that if proposed development cannot be made safe in its lifetime (considered 100 years for residential buildings) or plans do not demonstrate how flood risk will be managed, it should not be permitted. Building-level resistance and resilience measures may be considered as part of these tests. However, there is currently no legislation which enforces standards or regulates property flood resilience in building design, with the only benchmark guidance provided by the CIRIA PFR Code of Practice. Changes to existing buildings at flood risk also require assessment of floor levels and plans for property-level measures, which should protect the property to at least 30 cm above the estimated flood level. However, the quality of flood risk assessments for buildings and their influence on decision-making is inconsistent.

There is a lack of clear financial subsidy or incentives for adapting new and current building stock to flood risk.

- **Financial instruments.** Flood Re's 'Build Back Better' scheme will support homeowners to install PFR of up to £10,000 above insurance claims. This is funded from the same pool of funds used to cover claims. However, further incentives for PFR installation for homeowners and new build developers are required to ensure properties are sufficiently protected. The Government did not take forward proposals for reduced insurance premiums for households with PFR. There are currently no subsidies or taxes to incentivise PFR in non-residential buildings, and limited support for vulnerable households. Water and sewerage companies can also provide a source of funding for PFR grants – and help with project delivery – in addition to government schemes.

- **Standards.** The current National Planning Policy Framework includes guidance for Design Codes for buildings, but these do not specifically include standards for quality of and protection from PFR. Building Regulations in Part P set the minimum and maximum heights for electrical infrastructure. There are British Standards for installation and retrofit materials and design, as well as protecting basements. There is a new British Standard (with no equivalence) coming into place for all new framework installations, based on leakage rates. Design codes and standards for PFR in new buildings can help to ensure that PFR installations are of high quality. There are no standard resilience levels for post-event PFR retrofits. To ensure the quality of PFR installations, CIWEM are establishing a 'Certified Competent PFR Practitioner Schemes' and the Environment Agency are due to launch a new framework of tested PFR suppliers. Standards and quality assurance on building surveys are required alongside installations.

Policy to improve the uptake of property flood resilience must include community engagement, public awareness, and some form of mandatory monitoring.

- **Information and reporting.** Policies to encourage property flood resilience uptake must address awareness. This requires effective and concerted efforts for community engagement. Mandatory resilience scores for buildings could improve homeowner awareness and help to stimulate a market for PFR and other adaptation retrofits.

Policies should encourage data sharing between water companies, insurers, the PFR industry, local authorities, and the Environment Agency. This will improve our assessment of properties at risk and highlight areas where PFR funding and awareness campaigns should be targeted. Improved reporting, combined with proactive PFR installation, will help to improve the evidence base for what a good solution looks like.

(c) Outcome 3: Buildings are resilient to other climate risks

Given the uncertainty related to the climate risks to building fabric, regarding how the risks will vary over time and what an appropriate adaptation response should be, we are not providing a policy score for this outcome.

Our next assessment of progress reducing emissions in buildings will be published later in 2023. The energy price crisis has highlighted the poor levels of energy efficiency across the UK's building stock. The Government response has primarily focused on financial support to offset the impact of rising energy bills during a cost-of-living crisis. There has been less focus on improving the fabric efficiency of buildings, and this was a major policy gap which we highlighted in our 2022 mitigation progress report. The Government urgently needs to develop a coherent set of policies to drive and guide efficiency improvements in buildings across the UK. These policies should articulate a unified approach to building retrofits which ensures that both adaptation and mitigation goals are met, while minimising costs and disruption to building owners.

(d) Recommendations to address policy gaps

The Government urgently needs to develop a coherent set of policies to drive and guide efficiency improvements in buildings across the UK.

Despite some important progress since our last assessment in 2021 (for example, Part O of the buildings regulations coming into force) – there have also been several missed opportunities to close key policy gaps (Box 10.3). We provide a set of recommendations for targeted actions to help put in place critical outstanding policy milestones (Table 10.2).

Box 10.3
Policy developments since 2021

Policy developments

- The most significant policy development related to buildings is the update to the Building Regulations in July 2022, which introduced the overheating standard Part O.
- The Health and Safety Executive were appointed as the new Buildings Safety Regulator June 2022.
- Establishment of a new cross-government working group on overheating has created a forum to develop a coherent approach to this risk across the building stock.
- Following the Flood Reinsurance (Amendment) Regulations in April 2022, a new scheme document allows Flood Re to pay claims from participating insurers which include a resilient repair amount up to £10,000 above the cost of like-for-like reinstatement of flood damage – known as 'Build Back Better'. These regulations extend to England, Wales, Scotland and Northern Ireland.[38]
- There is a new British Standard for PFR products coming into implementation and the Environment Agency's Framework for PFR is going live in 2023. Improvements to the National Flood Risk Assessment and investment scenario modelling (due in 2024 and 2025) are considering the impact of PFR. This builds on recommendations laid out in the 2021 Progress Report.

Missed Opportunities

- Whilst the update to Part O is a significant step forward, it should also have been extended to include refurbishments to existing buildings, conversions from non-residential to residential and prisons.
- There is currently a significant focus on installing energy efficiency measures in response to the current cost-of-living crisis. Energy efficiency measures, if installed with adequate ventilation and shading, can also keep buildings cool during summer. The Government should ensure that retrofit strategies take a holistic approach to improve dwellings' thermal and indoor air quality performance throughout the whole year.
- While 'Build Back Better' is important progress, policy to encourage proactive installation of property-level resistance and resilience (i.e. before a flood event) is key to managing long-term costs and would help to maintain consistency within the PFR industry.
- Defra are currently reviewing the PFR repair scheme. The review outcomes should consider how to deliver improved awareness of preparedness and response measures, as well as barriers to access to grants and insurance.
- The framework for PFR needs to enable the PFR industry to install good quality products to high standards. Funding (including from private investment), reporting and training should be key aspects of an integrated approach.
- The PFR Pathfinders schemes have developed a prototype engagement portal and database mapping tool. This could provide a useful starting point for combining better data collection and community engagement but requires funding and infrastructure for upscaling.

Table 10.2
Recommendations

Primary responsibility	Recommendation	Timing
DLUHC	Expand the Part O Building Regulation requirement to cover refurbishments of existing buildings, conversions of non-domestic buildings to residential and prisons.	2023
DLUHC	Undertake post occupancy evaluations of new build homes to monitor summer temperatures to ensure homes meet Part O when built.	From 2024
DESNZ	Increase understanding of overheating risk in existing buildings by making use of annual empirical studies of overheating. For example, the Energy Follow Up Survey would be a useful tool to track overheating in homes if it were to be conducted each year. The Government should also assess other innovative ways to monitor temperatures in buildings, for example by using smart data.	Ongoing
DESNZ	Through the cross-government working group on overheating ensure the Government is actively addressing the need to mitigate overheating risks when installing measures to increase the energy efficiency of buildings.	2023
DLUHC	Track the resilience of the building stock through mandatory resilience reporting or Green Building Passports.	2023
Defra	Work with the Environment Agency and other risk management authorities, such as water and sewerage companies, to set clear targets for the uptake of property-level flood resilience and set out standards for quality and maintenance.	2023
Defra	Create a framework for data collection and monitoring property flood resilience installations.	2023
DESNZ, DLUHC, Defra	Make finance available to install proactive adaptation measures for overheating and flood resilience. This should be via grant schemes or green finance for private owners, with public funding targeted at low-income or vulnerable households, alongside energy efficiency retrofit.	2023

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Chapter 11

Health

Table 11.1
Progress summary – Health

	Delivery and implementation	Policies and plans	Summary
Outcome 1: Protect population health from the impacts of climate change and utilise potential benefits	Insufficient progress	Limited policies and plans	• Heat-related mortality was estimated at an all-time high in 2022. Data on flood related mortality and flood and heat related morbidity and disruption is not always regularly recorded. There is also little evidence of monitoring of indoor air quality. • A new Centre for Climate and Health Security within the UKs Health and Security Agency (UKHSA) has been created to leads efforts to protect health in the context of a changing climate. UKHSA has introduced enhanced testing and surveillance of invasive mosquitos. • The current Heatwave and Cold Weather Plans do not constitute long-term adaptation plans to reduce the risk of heat and cold related mortality and illness. UKHSA are due to publish a single adverse weather plan in 2023.
Outcome 2: Quality and accessible healthcare delivery during extreme weather	Insufficient progress	Limited policies and plans	• Indicators for this outcome demonstrate unclear progress. Overheating incidences are occurring in hospitals. There is no recording of overheating incidences in other healthcare settings such as care homes, domiciliary care or GP surgeries. • The update to Part O of the Building Regulations is a step forward for new residential care homes. The 2023 NHS Net Zero Building Standard requires an assessment of thermal comfort to minimise overheating risk. • There remains a lack of policy and funding to address climate change impacts in existing healthcare buildings and to incentivise uptake of adaptation interventions. • All NHS Trusts have Green Plans in place. Long-term adaptation should be included in Green Plans going forward, for all Trusts and Integrated Care Systems (ICSs). • There remains a need for a long-term adaptation plan that spans the care sector, including domiciliary care.

Relevant risks from CCRA3:
H1 Risks to health and wellbeing from high temperatures; H2 Opportunities for health and wellbeing from higher temperatures; H3 Risks to people, communities and buildings from flooding; H7 Risks to health and wellbeing from changes in air quality; H8 Risks to health from vector-borne diseases; H12 Risks to health and social care delivery.

This chapter covers the need for adaptation to ensure that the effects of climate change on population health are minimised. To be well-adapted to climate change, the population should be healthy under current and future climate scenarios, and the health and social care system should continue to operate during extreme weather events.

Population health, both physical and mental, may be affected by a range of climate hazards:

Extreme heat will increase risk of heat-related mortality and create stress on the functioning of the health and social care system.

- Increased frequency and intensity of extreme heat will increase exposure to heat stress and increase risks of heat-related mortality (death) and morbidity (disease and illness). Periods of extreme heat can also create significant stress on the functioning of the health and social care system.

- Warmer temperatures may lead to changing suitability for vectors of infectious diseases and increasing the potential exposure of people. Projected changes in UK climate indicate that climate suitability for ticks and mosquitoes will increase in the UK.[1]

- Decreased frequency and intensity of cold weather will help to reduce the mortality and morbidity impacts of cold weather to some extent. However, an aging population will offset this somewhat. Cold related deaths per year are projected to remain around three times higher than those related to heat by the end of the century.[2]

- Other hazards such as flooding can also result in mortality, morbidity and impacts on mental health.

- There may also be some benefits to physical and mental health from spending more time outdoors.

Risks to people's health from climate change are not only affected by the severity of the changes in hazards, but also by vulnerability and exposure.

The risks to people's health from climate change are not only affected by the severity of the changes in hazards (Box 11.1), but also by vulnerability and exposure, such as socio-economic factors leading to health inequalities, equitable access to green and blue space, and levels of existing resilience.

Box 11.1
Climate hazards that impact health

People in the UK are already at risk of illness and death from high temperatures, particularly those with existing heart and respiratory conditions. Changes to the UK climate will increase the severity of the weather hazards that will affect the health of people across the UK. The UK is likely to experience around an additional 0.5°C increase in annual average temperature by 2050, even under ambitious global scenarios for cutting greenhouse gas emissions.

The general pattern of change in the UK is towards warmer and wetter winters, and hotter and drier summers, with high variability. These changes will increase exposure to weather-related hazards, such as:

- The latest UK Climate Projections show a hot summer like 2018 is likely to occur every other year by 2050. Updated projections for average annual heat-related deaths estimate that deaths could rise from around 1,400 per year in the near past to around 2,500, 3,700, 8,200 and > 18,500 at 1.5°C, 2°C, 3°C and 4°C respectively (assuming a high population growth).
  - These latest projections estimate that under 1.5°C and 2°C levels of warming adaptation actions and natural acclimatisation overtime would be able to reduce death rates.

– However, even with assumptions of adaptation action, for 3°C and 4°C global warming levels heat-related mortality is projected to increase from the near-past given changes to population exposure.

- Changes to rainfall patterns, resulting in more frequent and intense flooding events at some times, and water scarcity in others. Flooding can have a direct impact on people's health through injury or even death, as well as impacting mental health.

Source: CCC (2021) *Independent Assessment of UK Climate Risk.* Jenkins, K., et al (2022) *Updated projections of UK heat-related mortality using policy-relevant global warming levels and socio-economic scenarios,* Environ. Res. Lett. 17 114036.

The key policy levers for adapting the health system are devolved. In England, health policy is the responsibility of the Department of Health and Social Care which entrusts delivery to several key bodies: NHS England (responsible for primary and secondary care and bringing together Integrated Care Systems and Boards*); local authorities (responsible for local social care); UK Health Security Agency (UKHSA - responsible for public health protection); Care Quality Commission (CQC - responsible for regulating health and social care services).

Since 2020 the healthcare system in the UK has been under increasing pressures. These pressures may affect the ability of health agencies to make progress in other areas of work including climate change.

There are strong overlaps between health and other chapters, especially buildings.

The impacts of climate change to health will be somewhat determined by how well the built environment is adapted to the future climate. There are therefore strong overlaps with the Buildings Chapter (Chapter 10). There are also other important overlapping areas in other Chapters:

- **Food.** Continued food security and safety from climate-sensitive food-borne diseases under future climate change.
- **Towns and cities.** Urban design, new developments, planning and reducing the urban heat island effect.
- **Communities.** At local levels, communities are prepared for and can respond to climate shocks helping to minimise knock-on impacts on public health.
- **Business.** Productivity losses due to the impacts from overheating on workers, both arising directly in the workplace and indirectly from disrupted sleep.

* Integrated Care System (ICSs) are partnerships that bring together NHS organisations, local authorities and others to take collective responsibility for planning services, improving health and reducing inequalities across geographical areas. There are 42 ICSs across England, covering populations of around 0.5-3 million people.

Being well-adapted to climate change means that the direct impacts of changes in the UK's climate on people's health are minimised and that health system delivery is not disrupted by weather extremes.

We identify several key outcomes that need to be delivered to achieve a healthy population under current and future climate (Figure 11.1):

The impact of climate change on population health should be minimised and potential benefits realised.

- **Protect population health from the impacts of climate change and utilise potential benefits**. The impact of summertime overheating and flood events on mortality and morbidity, including mental health impacts, should be limited.
  - Surveillance mechanisms should be properly implemented to understand any changes in the prevalence of infectious diseases that may become more widespread or established due to changes in the climate.
  - Ambient and indoor air quality levels should be improved by any actions taken to reduce greenhouse gas emissions. Actions to decarbonise and improve air quality should be aligned with adaptation objectives.
  - The single adverse weather plan should be implemented, and climate change included in local risk registers.

Inequalities in health that would help reduce the burden of climate change should be addressed.

  - Explicit attention should also be given to address inequalities in health that would help reduce the burden of climate change on the population and ensure that health co-benefits of adaptation actions across other sectors (such as adapting the built environment) are maximised.
  - As well as adapting to the potential adverse effects of a warming climate, policy should also encourage increased use of outdoor greenspaces during warm weather which can have a positive impact on population health.

The health system should be able to provide quality accessible healthcare during and after extreme weather.

- **Quality and accessible health and social care delivery during extreme weather.** Health and social care delivery must be able to continue during extreme weather events. Primary and secondary care facilities, social care and other health settings will need to be adapted to ensure they do not overheat during heatwaves, are at significant flood risk, or vulnerable to climate-related failures of dependent infrastructure systems.

Enabling factors that need to be in place to deliver these outcomes are wide ranging, from ensuring agency coordination, providing funding and investment in buildings, to training, education and awareness about climate risks and adaptation strategies.

- **Governance.** Appropriate cross-sectoral governance arrangements between different health and social care agencies are essential to adapt to risks. Clear coordination and leadership on public health responses to extreme weather events and adaptation is required.

- **Funding and investment.** Protected public and private funding in place to adapt health and care settings, as well as funding for nationwide vector and disease surveillance and provision of local greenspace are needed. Adaptation options, focusing on health and social care organisations, can offer a targeted approach for reducing heat-related mortality in vulnerable groups. Low-regret options include better forecasting of events, better information and monitoring of risks, enhanced risk preparedness and enhanced risk response. These should be actioned alongside a wider set of adaptation actions for reducing heat exposure in buildings in general and the urban environment.

Enabling factors that need to be in place to deliver outcomes are wide ranging.

- **Engagement and education.** Awareness levels amongst the general population, health and social care staff, and workers across local government organisations is essential. Among clinicians and healthcare staff educational needs vary depending on impact. Education and engagement should cover risks to health, the costs and benefits of adaptation and opportunities (e.g. from spending more time outside in nature). This can be achieved through training, risk communication, education and guidance provision.

- **Research.** A better understanding of costs, benefits and effectiveness of interventions to reduce overheating in health and social care facilities would help to target action. There is also a need for better understanding of the interactions between heat and air pollution, and extreme events on vector breeding and disease transmission.

- **Data and monitoring**. Regular monitoring of overheating, flooding incidences and air quality levels in health and social care settings is needed, which could be built into pre-existing reporting requirements. In addition, continued and widened monitoring of those vectors and infectious disease prevalence impacted by climate change is required.

- **Skills.** Public health professionals and staff able to plan for and respond to extreme weather events.

Funding, regulations, standards, adaptation planning, and guidance are some of the policy milestones required.

We have identified the following roles for policy as key to help deliver the identified outcomes and help put in place enabling factors.

- **Funding and investment.** Public funding for UK-wide surveillance of vectors and vector-borne diseases is needed to ensure knowledge of this risk remains up to date. Long term and protected funding, at sufficient levels, is required to adapt hospitals, care homes and other healthcare buildings to the impacts of climate change.

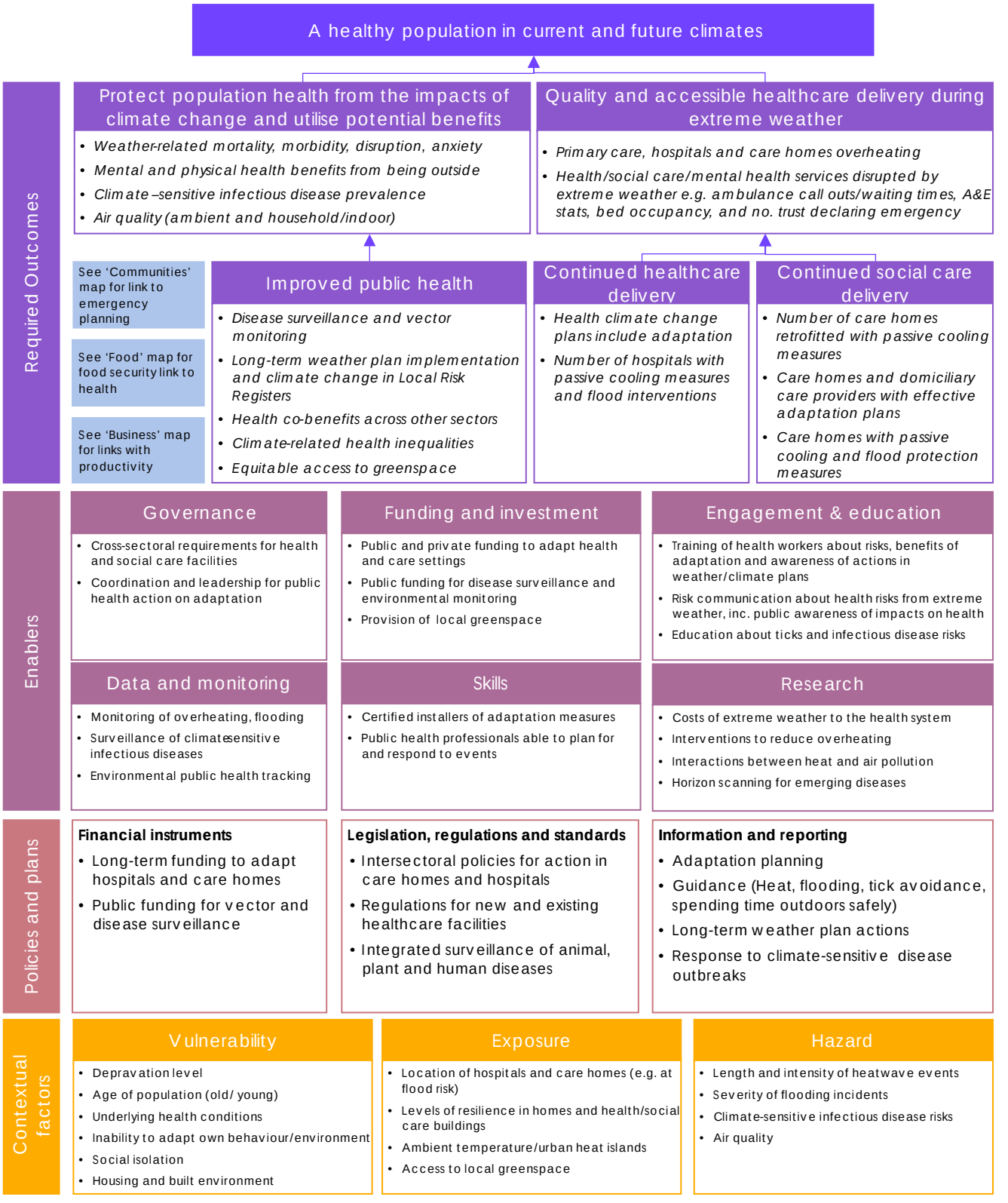
- **Legislation, regulation and standards.** Building regulations and standards for healthcare buildings that address overheating risk would ensure that new and refurbished buildings do not overheat. The readiness of health and care providers to manage overheating and other extreme weather should be regularly inspected by the sector regulator.

- **Information and reporting.** Adaptation plans for all NHS Trusts, ICSs and care home providers should be required. An integrated and coordinated plan that takes account of future climate change impacts of health from pathogens would also be beneficial.

The Government should ensure that the public, health workers and local authorities have appropriate guidance on heat avoidance, spending time outdoors safely, flood risks and tick safety, as well as publishing a single adverse weather plan to take account of both long term and emergency planning. Guidance should be available on how to ensure that overheating and air quality risks are considered alongside energy efficiency installations.

The risks to people's health from climate change are also affected by vulnerability and exposure such as through socio-economic factors leading to health inequalities, the location of healthcare buildings, equitable access to greenspace and levels of existing resilience (Box 11.2). Health risks will continue to be distributed inequitably with vulnerable populations and regions differentially affected unless these are considered across all policies to improve resilience to climate change.

Figure 11.1 Monitoring map for health



Source: CCC analysis.
Notes: Italicised text indicates suggested measures for each outcome.

The over 65 population is most vulnerable to health impacts from heat. People with cardiovascular and respiratory conditions also have a higher risk of adverse health outcomes, including to extreme heat and cold.

Box 11.2
Contextual factors

Contextual factors in health – relating to hazard, exposure and vulnerability - have a significant impact on the outcomes and how they are distributed across society. This box presents data and evidence regarding some of the important factors affecting vulnerability.

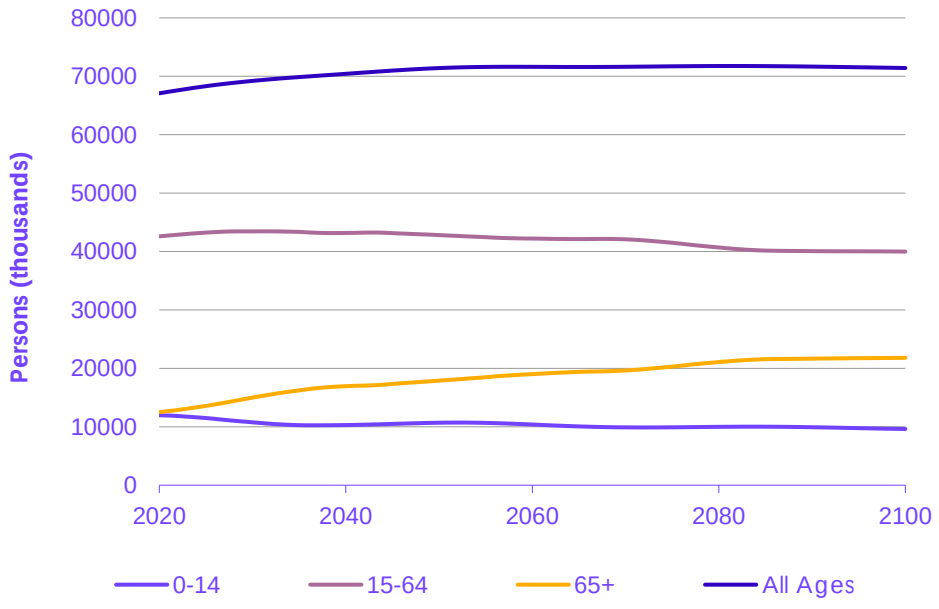
Poor quality housing particularly impacts the health of people and can exacerbate health inequality (see Chapter 10).

Deprivation level. Areas of higher deprivation have less access to high quality green and blue space contributing to differing disease burdens and life expectancy.[3] Deprivation is dispersed across England, with 61% of local authority districts containing at least one of the most deprived neighbourhoods in England.[4] Seven of the 10 local authority districts with the highest levels of income deprivation among older people are in London.

Ageing population. It is widely agreed that the over 65 population is most vulnerable to health impacts from heat. The ONS' population projections show that the proportion of the population aged over 65 is estimated to grow faster than other age groups out to 2100 (Figure B11.2). Population change from migration is uncertain.[5]

Underlying health conditions. People with cardiovascular and respiratory conditions have a higher risk of adverse health outcomes, including to extreme heat and cold. In March 2021, 6.6 million people (12.1%) had either a cardiovascular or respiratory condition in England.[6] Out of 10.8 million people (20.1%) living in private households who were estimated to be living in poverty, 1.3 million people had a cardiovascular or respiratory condition, representing 2.5% of the total population living in private homes.

Figure B11.2 Population projections for United Kingdom, by age group



Source: Based on data from ONS (2022) *Principal projection – UK population in age groups.*

(a) Outcome 1: Protect population health from the impacts of climate change and utilise potential benefits

There is insufficient progress towards ensuring good population health under current and future climate.

Indicators for this outcome demonstrate **insufficient progress** towards ensuring good population health under current and future climate.

- **Record heat-related mortality was experienced in 2022.** With 2,803 deaths (in England) (Figure 11.3), summer 2022 was characterised by the highest rate of heat-related excess mortality that England has ever seen.[7] This corresponded to the record-breaking heatwave experienced in the UK, leading to UKHSA issuing its first level four heat health warning in July 2022 (indicating a national emergency) and some locations exceeding 40°C for the first time.[8] ONS also produced heat related mortality statistics for the first time in 2022 (Box 11.3).

Summer 2022 was characterised by the highest rate of heat-related excess mortality that England has ever seen.

- **Data to track other impacts on mortality and morbidity is patchy and not always regularly recorded.**
  - There are no robust data, such as hospital admissions or GP appointments, available to monitor impacts to health from weather events.
  - Climate change impacts, as well as the concern of climate change itself, are negatively affecting mental health and emotional wellbeing.[9] One of the greatest burdens of ill health from flooding is likely to be due to the impacts on mental health, however there is no regular monitoring of impacts. One study has shown that three years after being flooded, mental health impacts still existed, although were reduced.[10] Evacuation and displacement, particularly without warning, increases the risk of anxiety and post-traumatic stress disorder.

- **There is no regular data collection to assess how mental and physical health from being outside is changing over time.** There is also limited evidence on the extent to which a warmer climate will increase these activities.[11]

Warmer weather is contributing to increasing vector abundance and therefore the risk of exposure to vector-borne diseases.

- **Vector abundance is increasing.** Warmer weather is contributing to increases in tick abundance and activity and the potential exposure of people to tick-borne diseases (such as Lyme disease and Tick Borne Encephalitis).[12] Vector abundance of some mosquito species (such as *Aedes albopictus*) is also increasing and spreading through Europe due to warmer temperatures.[13] There have been 65 cases of dengue fever reported in France in 2022 which represents a step change in risk,[14] although there is no recent evidence of this mosquito in the UK.

- **Vulnerability to air quality has stayed constant.** The benefits of additional adaptation to target climate induced changes in outdoor air quality are likely to be low, although more evidence is needed on the interactions between heat and air pollution. Vulnerability to outdoor air pollution, measured by the total number of people living with chronic respiratory conditions (those with chronic obstructive pulmonary disease and asthma),

has stayed relatively constant over recent years. There is little evidence of monitoring of indoor air quality occurring in existing homes as a regular programme of measurement.

Across England 88% of properties have access to private outdoor space, however this varies between social groups, ethnicity and type of property.

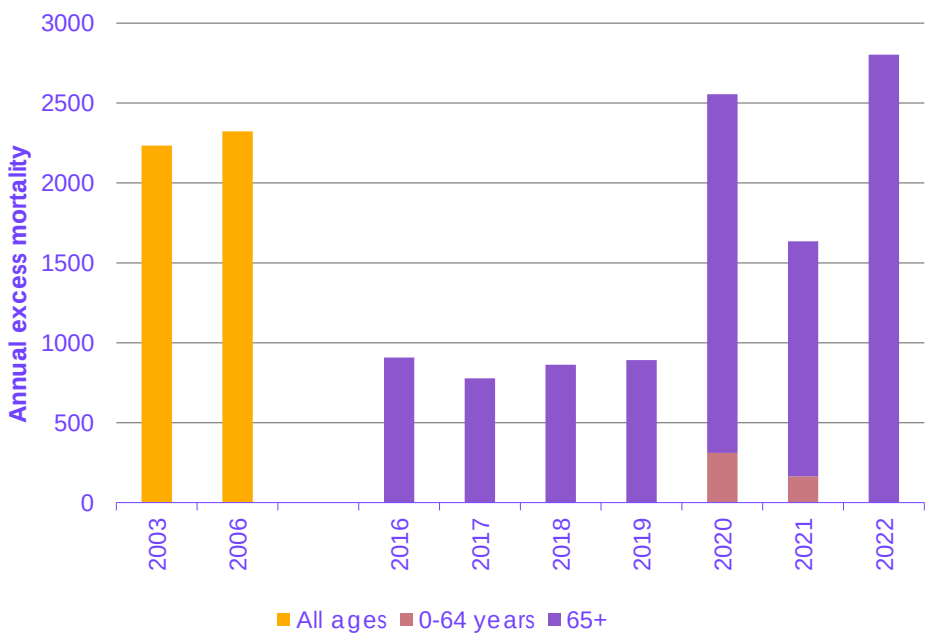
- **Access to greenspace varies.** Access to greenspace can provide important benefits including urban cooling in heatwaves, as well improvements to air quality and mental and physical health. Across England 88% of properties have access to private outdoor space, however this varies between social groups, ethnicity and type of property, it's also not clear whether this is a good quality greenspace.[15] For example, 63% of black, African, Caribbean and black British people have access to private outdoor space and 65% of people living in flats have access to private outdoor space, compared to 97% of houses. The average distance to a public park or public garden in England is ~ 986 metres. It is not clear how this has changed over time.

Better data is needed to track flood-related mortality, and heat and flood related morbidity and disruption. There would also be value in data to track the mental and physical health opportunities from being outside.

Better data is needed to track flood-related mortality, and heat and flood related morbidity and disruption. There would also be value in data to track the mental and physical health opportunities from being outside.

There is limited data available to assess progress in achieving enablers for this outcome.

Figure 11.3 Excess heat deaths during heatwaves



Source: PHE (2020) *Heatwave mortality monitoring reports 2016-2020*, UKHSA (2022) *Heatwave mortality monitoring report.*
Notes: Data split by age range is not available for 2003 and 2006. 2020-2022 data does not include COVID-19 related deaths. 2022 analysis only estimated deaths in over 65s.

Most heat related excess deaths in 2022 occurred in people aged 70 years or older. Deaths occurred in hospitals, care homes and in private homes.

Box 11.3
Heat mortality studies by ONS and UKHSA

Every year, the UKHSA publishes 'heat-mortality monitoring reports.' This year both UKHSA and ONS produced analyses of excess mortality, which went into more detail than usual on summertime excess mortality and broader health impacts.[16] The ONS analysis shows that there were 3,271 (including all cause) excess deaths during periods of heat in England and Wales, whilst the UKHSA analysis estimates there to be 2,803 excess deaths (excluding COVID-19) in England in the over 65s during periods of heat based on a statistical model (to account for registration delays).

A consistent view of annual heat and cold-related mortality, broken down by region would be beneficial. If methodologies are changed, analysis should be backdated to ensure a continuous time series of data for monitoring.

The ONS analysis provided further breakdowns of the excess mortality analysis against other factors such as age, place of death and underlying cause of death.

Age. Unsurprisingly, there was a significantly greater number of excess deaths in people aged 70 years or older, relative to the younger population.

Place of death. Deaths in hospitals were 5.8% and care homes were 9.2% above average on heat-period days followed by below average on non-heat period days, indicating a short-term mortality displacement, where deaths among vulnerable individuals are 'brought forward' to within the heat-periods. Deaths in private homes were average throughout the summer, which has been a consistent trend throughout the COVID-19 pandemic.

Underlying cause of deaths. The causes of death with the greatest increase on heat-period days varied. Cardiac arrhythmias and Parkinson's had the greatest relative increase in mortality during heat-periods.

Source: ONS and UKHSA (2022) *Excess mortality during heat-periods: 1 June to 31 August 2022.*

(b) Outcome 2: Quality and accessible healthcare delivery during extreme weather

Indicators for this outcome demonstrate **insufficient progress** towards achieving continued health and social care delivery during extreme weather events.

There is insufficient progress towards achieving continued health and social care delivery during extreme weather.

- **2021/22 has the highest recorded incidence (5,554) of overheating triggering a risk assessment in NHS Trusts**.[17] This corresponded to the record-breaking heatwaves experienced in the UK in 2022. There isn't equivalent data for care homes, domiciliary care, GP surgeries or other healthcare buildings.

There is no data available to show the extent to which health and social care services have been disrupted by heatwaves or flooding. However, impacts are being seen.

- **Disruption to health and social care services by heatwaves or flooding is unknown**. There is no data available to show the extent to which health and social care services have been disrupted by heatwaves or flooding. Data is available on several factors such as A&E attendance and ambulance call out statistics, but these cannot be attributed to extreme weather. However, impacts are occurring. In July 2021 Whipps Cross Hospital declared a major incident after heavy rain caused flooding in areas of the hospital, damaging buildings and the electrical system.[18] The hospital was forced to cancel planned surgeries and outpatient appointments for several days and move about 100 patients to different facilities following loss of power.

100% of NHS Trusts now have Green Plans in place, but these need to include specific adaptation planning.

- **100% (212) of NHS Trusts have had Green Plans in place since June 2022**.[19] This includes more than 1,000 hospitals and healthcare facilities. However, the plans are mostly focussed on decarbonisation.

- **96% of residential care providers have Business Continuity Plans in place**, although these are not the same as long-term adaptation plans and actions.[20]

Further unavailable indicators include:

- Health and social care facilities with passive cooling measures* or flood protection measures, heat management plans, or effective adaptation plans in care homes.

There is limited data available to assess progress in achieving enablers for this outcome.

* CCRA3 notes that "there is some evidence that care homes and hospitals are already being affected by overheating, with some care homes installing air conditioning." But there is not yet a central database for this type of information.

(a) Outcome 1: Protect population health from the impacts of climate change and utilise potential benefits

There are **limited policies and plans** in place from those needed to ensure population health is adequately protected from impacts of climate change.

Mixed progress towards meeting the key policy milestones required to ensure our population health is protected from impacts of climate change.

- **Funding and investment.** The Government does directly fund surveillance of vectors and vector-borne disease. The UKHSA currently monitor invasive and endemic mosquitoes and tests endemic mosquitoes for viruses. They also have a tick surveillance scheme, with ticks being tested for pathogens through research programmes. However, surveillance is currently constrained and would benefit from additional resources.

- **Legislation, regulation and standards.** The UKHSA and Human Animal Infections and Risk Surveillance (HAIRS) have responsibility for the UK's public health surveillance for infectious diseases. Having an integrated and coordinated plan in place that takes account of future climate change impacts on health from pathogens would be beneficial but does not currently exist. To help improve outdoor air quality, the Environment Act includes legally binding targets to protect our environment, including cutting exposure to PM2.5.

Heatwave and Cold Weather Plans do not constitute long-term adaptation plans to reduce the risk of heat and cold related mortality and illness under future climate change.

- **Information and reporting.** The Heatwave and Cold Weather Plans for England provide guidance to health, social care and community practitioners and the public to protect vulnerable people in hot and cold weather respectively. However, they do not constitute a comprehensive long-term adaptation plan to reduce the risk of heat- and cold-related mortality and illness under future climate change. This year, the Government will publish the delayed Single Adverse Weather and Health Plan (SAWHP) which combines the heatwave and cold weather plans.

  The NHS is starting to develop tailored training materials to educate all NHS staff, including leadership roles, on both mitigation and adaptation.[21] Risk assessments and guidance have been produced for tick-borne encephalitis, West Nile virus, Chikungunya virus, and Zika virus since 2017. UKHSA trains local authorities on vector surveillance and has produced guidance on how to ensure wetland creation, management and expansion does not increase pathogen risk. A tick awareness toolkit for local authorities was updated in March 2022.[22]

(b) Outcome 2: Quality and accessible healthcare during extreme weather

There has been mixed progress towards meeting the key policy milestones required to ensure quality and accessible healthcare delivery during extreme weather.

There are limited policies and plans to help meet the key milestones required to ensure quality and accessible healthcare delivery during extreme weather.

- **Funding and investment.** Long-term funding to adapt hospitals, care homes and other healthcare buildings to the impacts of climate change is not currently available from Government. It is therefore difficult for the health and social care sector to make long-term decisions and take action on adaptation.

The NHS published a Net Zero Building Standard in 2023 which requires a thermal comfort assessment to be carried out to ensure the indoor environment maintains thermal comfort and avoids overheating.

- **Legislation, regulation and standards.** The NHS published a Net Zero Building Standard in 2023 which provides technical guidance to develop sustainable, resilient and energy efficient buildings that support better healthcare environments for patients and staff. It requires a thermal comfort assessment to be carried out for all highly serviced and occupied spaces, to ensure the indoor environment maintains thermal comfort and avoids overheating. It suggests that mechanical cooling be minimised, and passive approaches should be used to reduce overheating risk.

  Building regulations are in place for new care homes that take account of overheating risk, however there are no regulations available for other new or refurbished healthcare buildings and no policy to manage overheating risks in existing health and social care buildings. The CQC has recently simplified the framework it uses to assess all health and social care services, into one Single Assessment Framework. It's not clear whether this will include a consideration of the readiness of staff and buildings to manage extreme weather events when implemented.

Long term adaptation plans should be included within NHS Green Plans.

- **Information and reporting.** Health providers are required to have a Green Plan in place that includes some actions on adaptation. 100% of NHS Trusts now have a Green Plan which is a positive step forward. However, the level of adaptation action within the plans must be strengthened. The NHS Adaptation Reporting Power report includes an action for all Integrated Care Systems to build long-term adaptation planning into their Green Plans by 2025.[23] Appropriate guidance and support, for example through an adaptation policy framework would help Trusts and ICSs to deliver this.

Adaptation planning is needed across the social care sector, including domiciliary care.

  Governance in social care is unique, as provision sits under the DHSC and DLUHC, with all services audited by the CQC.[24] However, commissioning and contract management responsibilities generally lie with local authorities. The Care Provider Alliance published national guidance on business continuity planning (BCP) for social care providers which includes planning for severe weather, however the BCPs do not constitute a long-term adaptation plan.[25,26] There remains a need for an intersectoral plan to address the risks of overheating and other climate risks in care homes and care facilities, including a consideration of domiciliary care, as well as individual effective adaptation plans for care homes and domiciliary care providers.

(c) Policy developments and recommendations

Despite some progress since our last assessment in 2021 (for example, the NHS Net Zero Standard and Green Plan creation, enhanced surveillance and testing of vectors, and Part O of the buildings regulations coming into force) – there have also been missed opportunities to close key policy gaps (Box 11.4). We provide a set of recommendations for targeted actions to help put in place critical outstanding policy milestones (Table 11.2).

Box 11.4
Policy developments since 2021

Policy developments

- Creation of the UKHSA's new Centre for Climate and Health Security to lead efforts to protect health in the context of a changing climate and provide a focus for partnerships and collaborations with academia, local authorities and other public sector organisations.

  - Since 2020 the UKHSA has introduced enhanced testing and surveillance of native mosquitoes for arboviruses in areas at risk of arbovirus emergence. UKHSA also now conduct regular testing of ticks for pathogens.
  - UKHSA published updated guidance on staying safe in hot weather in July 2022.
- Publication of an NHS Net Zero Building Standard. The standard includes a requirement to assess thermal comfort and reduce overheating risk.
- Every NHS Trust in England now has a Green Plan in place.
- The update to Part O of the Building Regulations, published in June 2022, is a significant step forward for ensuring that new residential care buildings are resilient to summertime overheating.
- DHSC are at the early stages of coordinating the adult social care sector to better understand the risks of climate change to care homes. This is a positive step forward, beginning to close a known gap and hopefully leading to a cross-sectoral plan and actions to address risks.

Missed opportunities

- Whilst it's a positive step that Green Plans are in place for every Trust in England, adaptation within the plans is light. Adaptation plans should be included for all NHS Trusts and ICSs. These should take a long-term outlook, include actions and ensure adaptation is considered strategically across the health system. An appropriate policy framework or guidance for adaptation would help Trusts and ICSs to deliver this.
- There remains no policy in place to incentivise adaptation of the existing healthcare building stock. Part O of the Building Regulations should have included refurbishments to existing buildings.

Table 11.2
Recommendations

Primary responsibility	Recommendation	Timing
NHS	Build on NHS Green Plans to ensure long-term adaptation planning is included. Ensure that NHS Trusts and Integrated Care Systems have the support and guidance needed to do this.	2024
DHSC	DHSC must work with DLUHC and local authorities to develop a long-term cross-sector approach to address risks in the social care sector, including using appropriate levers to accelerate adaptation action and ensuring that monitoring of overheating occurrences and air quality in care homes is undertaken frequently.	2024
DHSC	Make available long-term, protected funding to adapt hospitals, care homes and other healthcare buildings to the impacts of climate change.	2023
CQC	The CQC must include the readiness of health and care providers to manage overheating and other extreme weather within the new Single Assessment Framework inspections.	2023

Endnotes

[1] Kovats, S. and Brisley, R. (2021) Health, communities and the built environment. In: *The Third UK Climate Change Risk Assessment Technical Report* [Betts, R.A., Haward, A.B., Pearson, K.V. (eds.)]. Prepared for the Climate Change Committee, London.

[2] CCC (2019) *Progress in preparing for climate change. 2019 Report to Parliament.*

[3] Environment Agency (2023) *State of the environment: health, people and the environment.*

[4] MHCLG (2019) *The English Indices of Deprivation 2019 (IoD2019).*

[5] ONS (2022) *Principal projection – UK population in age groups.*

[6] ONS (2022) *Estimating the number of people with cardiovascular or respiratory conditions living in poverty, England: 2021.*

[7] UKHSA (2022) *Excess mortality during heat-periods: 1 June to 31 August 2022.*

[8] Met Office Press Office (2022). See: https://www.metoffice.gov.uk/about-us/press-office/news/weather-and-climate/2022/2022-provisionally-warmest-year-on-record-for-uk

[9] Lawrance, E., Thompson, R., Fontana, G., Jennings, N., (2021) Grantham Institute Briefing Paper No 36 *The impact of climate change on mental and emotional wellbeing: current evidence and implications for policy and practice.*

[10] BMC Public Health (2020) *The English National Cohort Study of Flooding & Health: psychological morbidity at three years of follow up.*

[11] Kovats, S. and Brisley, R. (2021) Health, communities and the built environment. In: *The Third UK Climate Change Risk Assessment Technical Report* [Betts, R.A., Haward, A.B., Pearson, K.V. (eds.)]. Prepared for the Climate Change Committee, London.

[12] Gandy, S., Hansford, K., Medlock, J., (2022) *Possible expansion of Ixodes Ricinus in the United Kingdom identified through the Tick Surveillance Scheme between 2013 and 2020.*

[13] European Centre for Disease Prevention and Control (2022), *Mosquito maps.*

[14] See: https://www.ecdc.europa.eu/en/dengue-monthly

[15] ONS (2020) *Access to gardens and public green space in Great Britain.*

[16] ONS, UKHSA (2022) *Excess mortality during heat-periods*.

[17] NHS (2022) *Estates return information collection*.

[18] See: https://www.bbc.co.uk/news/uk-england-london-57964769

[19] See: https://www.england.nhs.uk/greenernhs/2022/06/blog-signed-sealed-and-212-steps-towards-delivering-the-worlds-first-net-zero-health-service/

[20] NHS (2021) *Third Health and Care Adaptation Report.*

[21] NHS (2021) *Third Health and Care Adaptation Report.*

[22] Defra update on NAP2.

[23] NHS (2021) *Third Health and Care Adaptation Report.*

[24] NHS (2021) *Third Health and Care Adaptation Report.*

[25] Care Provider Alliance (2021) *Business Continuity Planning: Guidance and Template.*

[26] NHS (2021) *Third Health and Care Adaptation Report.*

Chapter 12

Community preparedness and response

Table 12.1
Progress summary – Community preparedness and response

	Delivery and implementation	Policies and plans	Summary
Outcome 1: Communities are prepared for climate shocks	Mixed progress	Limited policies and plans	• The level of planning for adaptation is low within local councils but public awareness of climate impacts appears relatively high. • More people are now covered by flood warning systems but household preparedness is low. • Mandatory reporting by local authorities, public information and engagement and support for vulnerable groups are not yet in place. There are warning systems in place for flooding and heat waves. Annual resilience reports to Parliament are a positive development.
Outcome 2: Communities can respond to climate shocks	Mixed progress	Partial policies and plans	• Indicator data for this outcome is mostly available for flood events; data for other extreme weather events are very limited. Most people act after receiving a flood warning. • Some of the key policy milestones are in place, but consideration of vulnerable groups is missing and resilience standards could be strengthened. • The UK Government Resilience Framework was a positive step forwards since 2021 to improve local level resilience.
Outcome 3: Cultural heritage is sustained	Unable to evaluate	Limited policies and plans	• Outcome-level evidence is very limited. • The new UK Government Resilience Framework has suggested several potential steps forward for local-level adaptation which would be positive if implemented. • Mandatory reporting from key organisations is missing.

Relevant risks from CCRA3:
H1 Risks to health and wellbeing from high temperatures; H2 Opportunity for health and wellbeing from warmer summers and winters; H3 Risks to people, communities and buildings from flooding; H4 Risks to viability of coastal communities from sea level rise; H11 Risks to cultural heritage; N18 Risks and opportunities from climate change to landscape character.

This chapter covers local-level awareness, planning and response to weather and climate impacts. Ensuring the protection of cultural heritage (which is run by a mixture of local and national organisation) from the effects of climate change is also considered in this chapter.

Local communities and services will be affected by all climate hazards for the UK. However, the majority of local emergency response work will focus on the effects of extreme heat, flooding and sea level rise. Community-level adaptation is fully devolved and, in many cases, relies on local government. Guidance and standards may be provided from national government but planning and actions typically take place at local authority level, often in collaboration with other national or local actors. The Civil Contingencies Act (2004) is the legislative basis for the UK's resilience frameworks, setting out the basis for emergency preparedness and local arrangements for civil protection, including roles and responsibilities for local responders.

1. Monitoring progress towards community-level adaptation

Well-adapted communities are those that are adequately prepared for climate and weather extremes and can respond to weather and climate emergencies when they do occur to minimise their impacts. Maintaining thriving communities also requires conservation of key cultural heritage under future climate change conditions.

Our monitoring map for assessing adaptation progress in community preparedness and response is shown in Figure 12.1.

We identify several key outcomes that need to be climate-resilient in this area:

We have identified three adaptation outcomes for community preparedness and response.

- **Communities are prepared for climate shocks.** Preparing for climate shocks requires good adaptation planning at local authority level, in coordination with other actors in the event of extreme weather. The potential for increased frequency and intensity of extreme weather events should be factored into relevant local plans.

- **Communities can respond to climate shocks.** Responding to climate shocks when they occur requires strong local-level coordination during an extreme weather event to minimise damage and provide ongoing support for recovery after the event. Targeted recovery support may be required for vulnerable communities, and the mental health impacts of suffering damages should also be considered.

- **Cultural heritage is conserved.** Protecting cultural heritage requires an understanding of climate risks and a plan for the most appropriate way to conserve different types of heritage, such as archaeological sites, buildings and structures, historic landscapes, wrecks, museum collections and archives, and their associated communities. We must also consider intangible heritage such as folklore, traditional language, knowledge and practices. Heritage conservation is the process of maintaining and managing change in a way that sustains and, in some cases, enhances the significance of a heritage asset.[1] Given the threat faced by cultural heritage from the impacts of climate change, it may not always be possible to conserve in every situation.

Enabling factors that need to be in place to deliver these outcomes will include:

Targeted support for vulnerable communities will be needed at local level to support them in preparing for and recovering from extreme weather events.

- **Funding and investment.** Targeted support will be needed at local level to support communities which are particularly vulnerable to climate risks to prepare for and recover from extreme weather events. Psychosocial support will also be needed as part of recovery from events such as flooding. Funding for adaptation should be ring-fenced at local level; irregular funding cycles and mechanisms prevent authorities from blending funding streams into coherent projects that can deliver wider benefits for health and nature.

- **Engagement and education.** The public should be well-informed about future climate risks to enable household-level decisions about building in adaptation. Clear risk mapping and communication is required to achieve this. Equitable long-term planning also requires local stakeholder engagement.

An understanding of and skills in managing climate risks will be needed at local authority level. Targeted engagement and long-term relationship building with communities at risk from different hazards is needed to increase effectiveness of early warning systems.

- **Research.** Further research is needed to understand local impacts of climate change, including social vulnerability mapping to different hazards in order to better understand distributional effects of climate change. Research is also needed on the effectiveness of different types of behaviour change for adaptation.

- **Data and monitoring.** Data is needed on local-level adaptation actions and discussions which may already be happening. Data sharing on climate risks between organisations and early warning systems for climate hazards will also be important for local action. For conserving local cultural heritage, community-led heritage asset surveys can provide useful data on heritage assets and their potential exposure to climate change.

Local authorities have an important role to play in community preparedness and response efforts.

- **Governance.** Local authorities have an important role to play in national adaptation efforts. Their roles and responsibilities should be clearly defined to reduce duplication and encourage bottom-up action towards national adaptation programmes. Local public services and institutions can be stress-tested for climate impacts, including responding to cascading climate impacts. Local resilience groups (e.g. Local Resilience Forums in England) should facilitate strong relationships between incident responders to ensure coordinated responses to extreme weather events.

Our monitoring framework highlights policy mechanisms which must be in place to achieve these required outcomes for well-adapted Towns and Cities. These fall under the following categories:

- **Legislation and regulation.** National legislation should enable local preparedness and response to extreme weather events, with clear roles and responsibilities for responder organisations. Regulations should also support protection and appropriate conservation of heritage assets.

- **Standards.** National resilience standards should support best practice among responder organisations, and national guidance should be provided on local community response to extreme weather events. Building standards for heritage assets should support the appropriate restoration or management of heritage assets affected by climate change.

- **Financial instruments.** Sufficient and stable funding is required for local resilience groups (e.g. Local Resilience Forums in England) to ensure long-term planning, relationship building and preparedness. Funding should also be provided to support vulnerable groups implementing local or household adaptation measures.

Local authorities and organisations responsible for heritage should be required to report on their adaptation actions.

- **Information and reporting.** Local authorities should be required to report on local adaptation actions, including adaptation actions relating to cultural heritage. Similarly, organisations responsible for heritage should be required to report. Responder organisation should be required to report on their activities to provide accountability, and community risk registers should include consideration of vulnerable groups. Public engagement and deliberation are critical for adaptation actions, particularly for irreversible and contentious adaptation policies, such as managed retreat from low-lying coastal settlements (see Box 12.1).

Community preparedness and response is included as the focus of a standalone chapter for the first time in this report. The Committee expects this chapter and its monitoring map to continue to develop as further evidence becomes available of climate impacts and the effectiveness of adaptation action at local level across the UK.

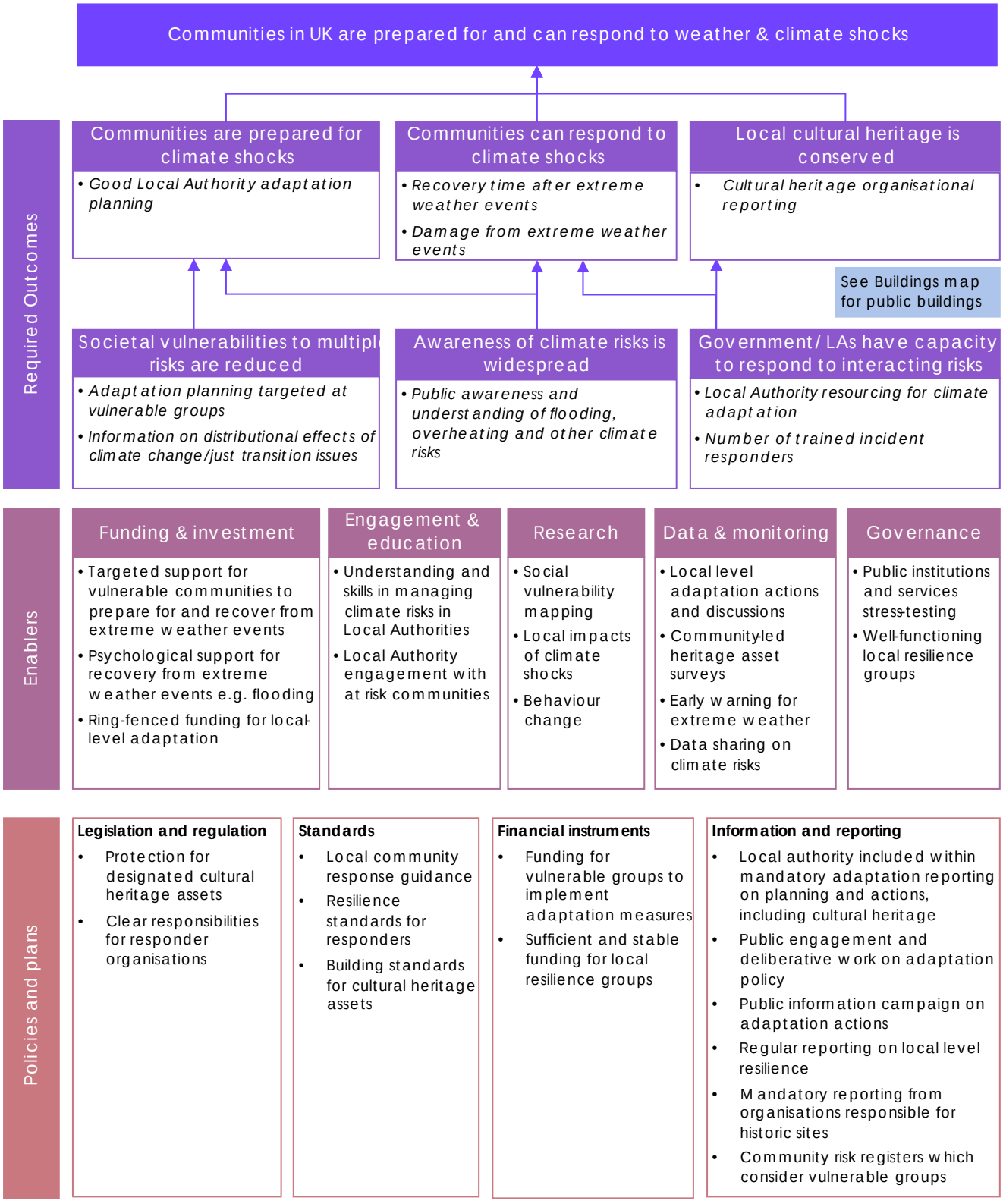
Box 12.1
Community engagement and deliberation in adaptation planning

In recent years there has been growing interest in engaging communities to be part of climate change planning and strategy, for example, through the Climate Assembly UK in 2020 and citizens' juries facilitated by local councils. Community engagement and deliberation around climate change is equally important for adaptation:

- Adaptation interventions should be tailored to the specifics of their local geographical and social context to be effective in reducing risks for the most vulnerable. This means that inclusive consultation and co-design are necessary through the policy design, implementation, and evaluation phases.
- It is important that both individuals or groups who could be negatively impacted by climate change impacts and those by adaptation actions are adequately included in this process.
- For irreversible and contentious adaptation policies, such as managed retreat from low-lying coastal settlements, this process will need to be extensive, highly transparent and allow sufficient time for a thorough public deliberation on the options and their likely costs and benefits, as well as the anticipated costs and impacts without adaptation.

Source: CCC (2022) *The Just Transition and Climate Change Adaptation*; University of Lancaster (2022) *The role of deliberative public engagement in climate policy development.*

Figure 12.1 Monitoring map for community preparedness and response



Source: CCC analysis
Notes: Italicised text indicates suggested measures for each outcome.

(a) Outcome 1: Communities are prepared for climate shocks

Relevant indicators for this outcome focus on local authority-level planning and resourcing and public awareness of climate risks. This outcome is scored **mixed progress.** The level of planning for adaptation is low within local councils but public awareness of climate impacts appears relatively high. Although more people are now covered by flood warning systems, household awareness of how to prepare for flooding is low.

- **Only around one quarter of English councils consider the impacts of extreme weather within their climate actions plans.** 93 out of 344 (27%) councils across England set out how they will help residents prepare for changes in climate and extreme weather in their climate action plans.[2] Adaptation is currently a secondary priority to greenhouse gas emissions reduction in these plans, with a lot lower focus. Climate Emergency UK is currently scoring the actions taken in these plans, with data to be released in 2023.[3]

After the heatwaves in 2022, more people said they felt rising temperatures from climate change are likely to affect them in future.

- **Public awareness of climate change increases after extreme weather events.** Opinion surveys from the Office for National Statistics (ONS) found the percentage of adults who feel that rising temperatures will affect them increased from 62% in April 2022, to 75% in Sept-Oct 2022 after the summer heatwaves. 85% of people who were worried about climate change expected to be impacted by rising temperatures. 53% of people worried about climate change expect to be affected by other extreme weather events in the future (see Figure 12.2).[4]

- **People are worried about the health and wellbeing impacts from flooding and erosion risk.** Most respondents to the Environment Agency's Public Floods Survey recognised the personal impact on mental health (53%) and loss of possessions (42%) from flooding, more than the impact on physical health and illness (16%).[5] Flooding can have severe long-term consequences on mental health in affected populations. Data collected after the 2013-14 winter storms show the prevalence of depression (10.6%), anxiety (13.6%) and PTSD (24.5%) remained high two years after the events.[6]

The number of properties not covered by flood warnings has decreased since 2018.

- **More people are covered by flood warning systems and they are mostly high quality.** The percentage of properties at risk* which fall within an Environment Agency Flood Warning Area or a Community Led Alerting Area has increased consistently – from 84% in September 2018 to 86% in September 2022. The number of properties outside the area covered by flood warnings has decreased by 12% during this period. The percentage of flood risk warning messages which meet the quality standard to provide customers with required information increased by 3% to 78% in the January to March reporting periods of 2019 (137 warnings issued) and 2021(382 warnings issued).[7]

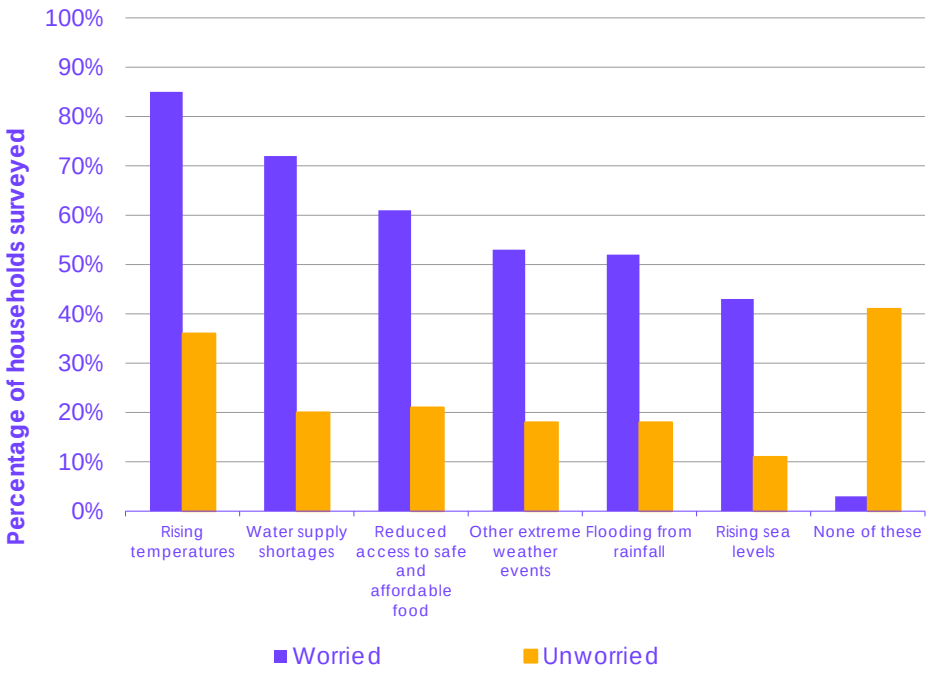
* At risk properties identified from OS Address Base Plus, Flood Zone 2 and the Environment Agency Area Water Management Boundaries.

- **The uptake of flood warnings by at risk households has remained consistent at just below 80%.** The uptake of flood warning systems has remained within 1% of the 2020 number (Figure 12.4). Fewer at-risk properties have not registered or engaged with flood warning alerts. When properties who have cancelled or registered as 'services not required' are included, the total percentage of engaged households is the highest on the Environment Agency's records (83%).

Less than one third of adults in the UK said they had a good understanding of their flood risk. Less than one fifth said they acted in response to advice from the Environment Agency.

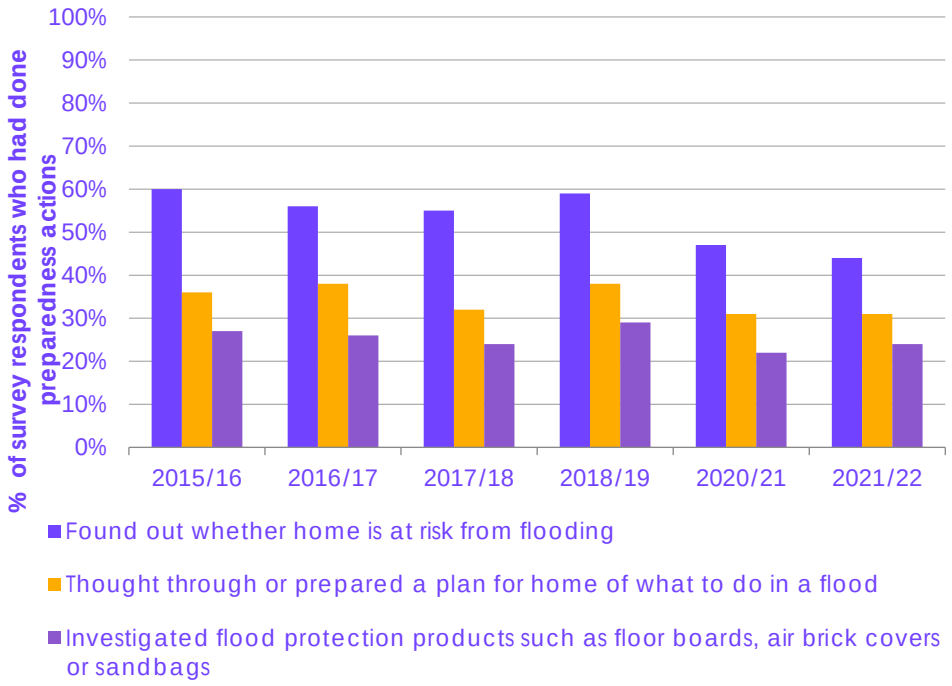
- **However, awareness of flood risk and how to prepare for flooding is low and showing a negative trend.** 17% of respondents to the Environment Agency's 2021-2022 Public Flood Survey said they did not have a good understanding of how to protect their home from flooding (comparable to 18% in 2020-2021).[8] A study in summer 2022 found only 27% of UK adults said they had a good understanding of their flood risk, and only 14% knew what to do to prepare for a flood. Homeowners were slightly more aware about preparedness (16%) than renters (10%).[9] 54% of respondents who acted had been previously affected by flooding. Only 18% and 12% were responding to advice from the Environment Agency and their local council.[10] This decreasing trend in people finding out about flooding and looking into preparedness measures (Figure 12.3) is concerning.

Figure 12.2 Survey evidence on worries about the impact of climate change



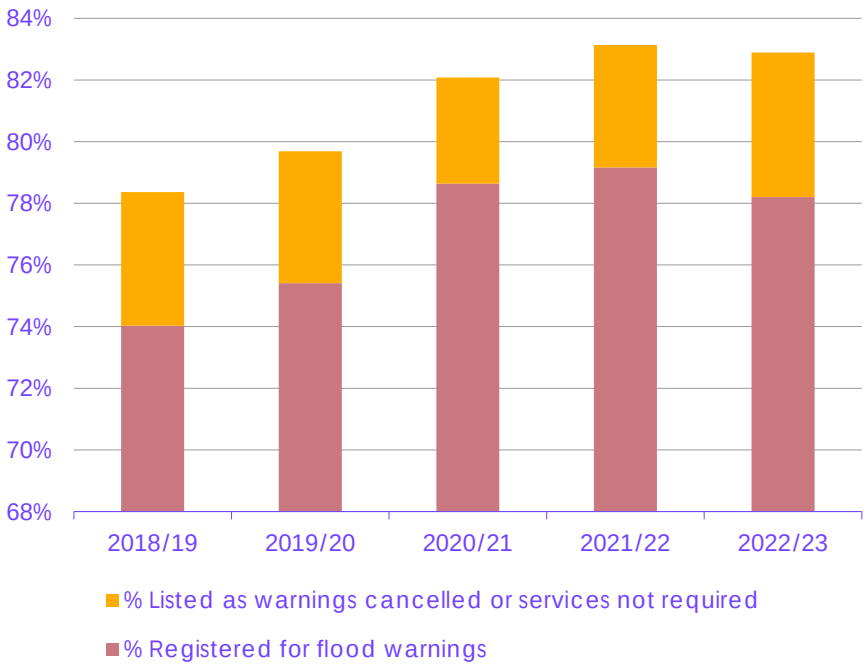
Source: ONS (2022) *Worries about climate change, September-October 2022.*
Notes: Survey data for Great Britain only. Question: "Thinking about climate change, which of these, if any, do you think will directly affect you by 2030?". Respondents were able to choose more than one option. Percentage group of worried about climate change includes those who were very worried or somewhat worried. Percentage of group not worried about climate change includes those who were not at all worried or somewhat unworried.

Figure 12.3 Percentage of Environment Agency survey respondents who had done preparedness actions



Source: Environment Agency (2022) *Public Flood Survey. Base – all respondents (flooded and not flooded).*

Figure 12.4 Percentage of at-risk properties registered for flood warnings and at-risk properties who have cancelled registrations



Source: Environment Agency (2023) *Flood Risk Warning Database, provided on request.*
Notes: At risk properties identified from OS Address Base Plus, Flood Zone 2 and the Environment Agency Area Water Management Boundaries.

(b) Outcome 2: Communities can respond to climate shocks

This outcome is scored as **mixed progress.** Indicator data for this outcome is only available for flood events. Data for other extreme weather events are very limited. There are no data for recovery time from extreme weather events or publicly available year on year comparative data for damage from extreme weather events.

91% of survey respondents acted after receiving a flood warning.

- **Most people take some action after receiving a flood warning.** The Environment Agency's 2021-2022 Public Flood Survey found that 91% of respondents took some action after receiving a flood warning: 62% ensured they knew how to turn off gas, water, and electricity; 26% moved possessions upstairs or to a safe place; 25% deployed sandbags or other flood protection; 23% moved a car to safety; and 10% evacuated their homes.[11]

- **The number of Environment Agency staff trained as incident responders has decreased slightly.** The number of Environment Agency incident staff trained and capable of responding to incidents in September 2022 was 4,426. This has decreased slightly (by 3%, 128 staff) since April 2021.*

There is a lack of national-scale data on the impact of flooding for commercial and public services, such as average business and school days lost, damages to public buildings, and commercial insurance claims. There is also a gap in data on extreme weather events other than flooding, such as heat waves.

(c) Outcome 3: Local cultural heritage is conserved

Evidence for this outcome is very limited so it was **unable to evaluate**.

Organisations responsible for managing heritage are invited to report on their climate risks and adaptation actions, but in the most recent reporting round not all organisations submitted reports.

- **Cultural heritage organisational reporting is incomplete.** Evidence for this outcome relies on reporting from organisations responsible for managing cultural heritage, such as Historic England, English Heritage Trust, Church of England and the National Trust. Under the Adaptation Reporting Power (ARP), organisations responsible for historic sites are invited to submit reports on the current and projected effects of climate change on their organisation; their proposals for adapting to climate change; and progress made towards their implementation. Only Historic England and English Heritage Trust submitted a combined report in the most recent round of the ARP.[12] The report included climate hazard mapping which found a high increase in exposure to overheating and humidity for all categories of heritage, relatively low level of coastal risk to cultural heritage and insufficient data to understand the exposure to precipitation. Vulnerability mapping was reported as ongoing at the time of publication so the full level of climate risk to heritage assets managed by the organisations is still not well known. More work is needed to develop robust methodologies for understanding the long-term risk to all cultural heritage asset types at a national scale.

* The Environment Agency has changed the way it measures incident responders. Since April 2021, staff capable to respond to 'core' incident roles is recorded, rather than the total number of 'staff trained and capable to respond to incidents' previously recorded. Core roles are those required to respond to most incidents – mainly roles which are available and operational 24 hrs, rather than specialists with technical skills or geographical responsibility.

(d) Enablers

Indicators for the enablers are currently limited. Where data is available, there is evidence of improved flood risk mapping and communication. However local-level planning for adaptation does not currently sufficiently consider communities vulnerable to climate change or provide focused funding for these vulnerable groups.

Only around one in five councils in England had climate plans which committed to targeting resources to support the communities most vulnerable to climate change.

- **Only 1 in 5 councils in England have committed to targeting resources to support communities vulnerable to climate change.** 73 out of 344 councils (21%) in England had plans to focus resources to support vulnerable communities. Not all types of support covered by the data were for climate adaptation. Support to vulnerable communities could include adaptation actions such as flood risk and recovery and public green spaces, but also mitigation actions such as energy and fuel poverty, job skills improvement and retraining. Fewer councils – just 28 in 344 (8%) – had plans specifically identifying which groups will be affected most by climate change.[13]

- **Current policy shows clear progress in trying to improve flood risk mapping and risk communication.** Investment into research and online tools for flood risk assessment is showing good progress, for example through the Environment Agency's (EA) Flood and Coastal Erosion Risk Management Roadmap.[14]

- **The Environment Agency has a target standard for warning system coverage and quality, and a commitment to improve warnings for surface water flooding.** Improvements in modelling and communication technology create opportunities for early warning systems.

- **Defra and the Environment Agency have started valuing the impact on mental health from flooding and coastal erosion.** Guidance from Defra and the Environment Agency values mental health losses per adult per flood event at £3,028 (for flooding 30-100 cm above internal floor levels). The representative value for erosion in the year the home is eroded is £9,546 per adult.

(a) Outcome 1: Communities are prepared for climate shocks

The score for this outcome is **limited policies and plans.** Mandatory reporting by local authorities, public information and engagement and support for vulnerable groups are not yet in place. There are warning systems in place for flooding and heat waves. The new annual resilience reporting duty is a positive development.

- **Financial instruments.** There are currently no specific Government funds supporting uptake of adaptation measures by vulnerable groups.

Local authorities are not currently required to report on their adaptation actions at local level.

- **Information and reporting.**
  - Local authorities are not currently required to report under the adaptation reporting power (ARP) or through any other reporting mechanism.
  - To date, there has not been a national-level information campaign on climate risks and actions individuals can take to adapt to climate change.
  - The Heat-Health alert service is provided by UKHSA from June till September. It is designed to help healthcare professionals manage through periods of extreme temperature. When certain heat thresholds are passed, a warning is issued and sent to relevant health professionals and those working in social care. This enables health and social care professionals to take action to minimise the impact of the heat on people's health. UKHSA issued its first level four heat health warning in July 2022 (indicating a national emergency) with some locations exceeding 40˚C for the first time.[15]
  - The Government Resilience Framework published in 2022 includes a new reporting duty for an annual resilience report to Parliament from 2025. These reports should include resilience to all climate risks, not just flooding, which may impact local communities.

(b) Outcome 2: Communities can respond to climate shocks

The score for this outcome reflects **partial policies and plans.** Some of the key policy milestones are in place, particularly around standards and legislation, but consideration of vulnerable groups is currently missing and resilience standards could be strengthened. The new UK Government Resilience Framework has suggested several potential steps forward for local-level adaptation which would be positive if implemented.

- **Legislation and regulation.** A recent review of the Civil Contingencies Act found that it remains broadly fit for purpose and has established a consistent level of civil protection across the UK. The Act identifies category one responders (e.g. emergency services, local authorities, health bodies, the Environment Agency) and category two responders (e.g. utilities companies, transport companies) which both have duties to carry out emergency plans.

Following a recommendation from the review, the Met Office were made a category 2 responder to enable preparation across Local Resilience Forums (LRFs) for severe weather events.[16,17] The Flood and Coastal Erosion Risk Management Roadmap published in 2022 places welcome focus on increasing awareness of flood and coastal erosion risk. For example, the Environment Agency has committed to improving the digital flood risk monitoring service with updated data and creation of a package of digital communication and education tools. Actions in the Roadmap also cover triennial 'health checks' by the Environment Agency on local resilience forum flood plans, and piloting of 'local resilience hubs' to bring together authorities, volunteers, community groups and third sector organisations.

- **Standards.** National Resilience Standards for first responders were last updated in 2020, reflecting a consensus view of what good looks like and what Local Resilience Forums (LRFs) should be looking to implement, achieve and be able to demonstrate. The standards set out the mandatory obligations under the CCA and voluntary standards or good and leading practice. The Government is currently considering whether to place these standards on a statutory footing, following a recommendation from the review (see Box 12.2). Community response guidance published in 2018 for local authority chief executive officers explains the role of local authorities in civil resilience and what preparedness for civil emergencies looks like in relation to the CCA.[18] While the guidance doesn't explicitly reference climate change, it discusses response to emergencies like severe storms, floods and infrastructure failures. The National Flood Emergency Framework for England provides further guidance on emergency preparedness and response to floods by first responders.[19]

The Government has committed to funding Local Resilience Forums in England which will enable long-term planning.

- **Financial instruments.** The Department for Levelling Up, Housing and Communities (DLUHC) have announced a funding settlement for the first time for LRFs in England which should enable recruitment of new staff, longer-term planning and a wide range of projects. Subsidies and grants for post-event repairs should be accompanied by long-term resilience funds. Communities and local authorities may receive grants for repair work after a flood event, however, subsidies and taxes to incentivise proactive work before an event will be more cost-effective in the longer-term. From 2021, grant-in-aid government funding applications for flood recovery considered mental health and wellbeing during appraisal which is a positive development.

- **Information and reporting.** Emergency responders are required to produce community risk registers. However, the recent post-implementation review of the CCA recommended this requirement be strengthened to include consideration of particularly vulnerable groups to different risks.[20]

(c) Outcome 3: Local cultural heritage is conserved

The score for this outcome is **limited policies and plans.** Some of the key policy milestones are in place, particularly around standards and legislation, but mandatory reporting from key organisations is missing, presenting a gap in our understanding of any change in climate risks to cultural heritage assets.

Legislation for conservation of heritage assets is complex and divided across different regimes.

- **Legislation and regulation.** Protection for designated cultural heritage assets. Legislation for protecting heritage assets has developed in a piecemeal fashion, with a number of different designation regimes that identify different categories of heritage asset.

Designation types include world heritage sites, protected wrecks, scheduled monuments, listed buildings, registered parks and gardens, registered battlefields, conservation areas, and locally listed buildings and sites. There are also some landscape-scale designations that include features of cultural heritage significance, such as National Parks and Areas of Outstanding Natural Beauty. The designations provide a tool for understanding significance and allow for special considerations to be made in planning and decision-making. It is worth noting that there may also be many significant heritage assets not yet been assessed for designation, but which may be important to local communities.

- **Planning.** In addition to the primary legislation associated with each designation type, historic assets are also protected further through both the terrestrial and marine planning policy frameworks. For example, the National Planning Policy Framework and UK Marine Policy Statement set out how decisions related to heritage are balanced alongside considerations for other sectors. Furthermore, there are more localised planning polices nested through associated plans such as local plans and marine plans. National Parks and AONBs will also have their own adopted policies which can offer more prescriptive local levels of protection.

- **Standards.** Building standards for cultural heritage assets. Current building regulations explicitly recognise special considerations needed for listed buildings; buildings situated in designated conservation areas; buildings which are of architectural or historic interest; and vernacular buildings of traditional form and construction.

- **Information and reporting.** Mandatory reporting from organisations responsible for historic sites. Organisations with responsibility for historic sites are invited to report under the ARP but reporting is not currently mandatory.

Box 12.2
Policy developments since 2021

Since the Committee's last progress report in 2021, the key policy developments relevant to community-level adaptation are:

- The UK Government Resilience Framework. Published in December 2022, this framework articulates a new strategic approach to resilience. While it references climate change as one challenge, the framework covers a wide range of potential risks. It includes a commitment to strengthen Local Resilience Forums (LRFs) in England and strengthened standards for statutory responders to consider community resilience as an essential part of their work. It also commits to an annual statement to Parliament on civil contingencies risk and the UK Government's performance on resilience which would be a welcome source of information. Full-time Chief Resilience Officers will be piloted for each Local Resilience Forum area to increase local level leadership and accountability. The Government will also consider putting the current National Resilience Standards on a statutory footing and requiring categorised responders to publicly state how they are meeting their obligations under the CCA.[21]
- A three-year funding settlement for LRFs in England. Following a pilot funding project in 2021 which resulted in increased capacity and capability across LRFs in England, DLUHC have committed to a three-year funding settlement of £22 million for LRFs in England[22] which should enable recruitment of new staff and a wide range of projects. This is a very positive step forwards as LRFs were previously funded through direct and in-kind contributions from partner organisations.

Source: Cabinet Office (2022)

(d) Recommendations for closing policy gaps

Based on the assessment of policy and planning progress, we have identified recommendations to close key policy gaps for community preparedness and response (Table 12.2).

Table 12.2
Recommendations

Primary responsibility	Recommendation	Timing
DLUHC	Make the National Resilience Standards a statutory requirement.	2024
DLUHC	Ensure the new reporting duty under the resilience framework from 2025 includes resilience to all climate risks, not just flooding, which may impact local communities.	2025
Defra	Extend the scope of the fourth round of the Adaptation Reporting Power (ARP4) to include local authorities.	2023
Defra	Undertake an assessment of the characteristics of vulnerability and adaptive capacity across England.	2025
Defra	Include community engagement activities (such as citizens assemblies) under NAP3 to put fairness at the centre of efforts to implement a vision for a well-adapted UK. This engagement programme should focus on exploring issues of fairness in some of the most challenging aspects of adaptation (e.g. coastal retreat) and in the provision of public funding for adaptation.	2023

Endnotes

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[3] Climate Emergency Scorecard data (2022), https://mysociety.github.io/climate_scorecard_data_2022/datasets/scorecard-data/

[4] ONS (2022) *Worries about climate change, Great Britain: September to October 2022,* https://www.ons.gov.uk/peoplepopulationandcommunity/wellbeing/articles/worriesaboutclimatechangegreatbritain/septembertooctober2022

[5] Environment Agency (March 2021) *Public Flood Survey 2020-21. Research carried out by QA Research Ltd.*

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[10] Environment Agency (January 2022). Public Flood Survey 2021-2022. Research carried out by QA Research Ltd.

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[15] Met Office Press Office (2022) See: https://www.metoffice.gov.uk/about-us/press-office/news/weather-and-climate/2022/2022-provisionally-warmest-year-on-record-for-uk

[16] Cabinet Office (2022) *Civil Contingencies Act Post-implementation Review,* https://www.gov.uk/government/publications/civil-contingencies-act-2004-post-implementation-review-report-2022

[17] Met Office (2023) *Met Office role in national resilience recognised,* https://www.metoffice.gov.uk/about-us/press-office/news/corporate/2023/cat-2-responder-status

[18] Ministry of Housing, Communities and Local Government (2018) *Local Authorities preparedness for civil emergencies,* https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/759744/181116_LA_preparedness_guide_for_cx_v6.10__004_.pdf

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[21] Cabinet Office (2022) *The UK Government Resilience Framework*

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ROYAL OAK
Bengal
Restaurant
Takeaway
Bengal
Restaurant

Chapter 13

Business

Table 13.1
Progress summary – Business

	Delivery and implementation	Policies and plans	Summary
Outcome 1: Public and private adaptation measures are implemented to minimise risks to business sites.	Insufficient progress	Limited policies and plans	• Key data on the exposure and vulnerability of business assets are not publicly available, and the quality and level of detail varies. Data that are available on flood damages do not indicate whether genuine reductions in exposure and vulnerability are occurring given lack of time-series data. • There is some financial support for businesses to recover and adapt after extreme weather events. • The proposed non-household water use target was not included in the environmental targets. • There is a lack of aligned and consistent adaptation standards for business.
Outcome 2: Businesses have access to insurance and capital including for adaptation.	Unable to evaluate	Limited policies and plans	• There are some indications of a material reduction in access to lending and insurance for sectors which were most exposed to physical risks. • Currently, real-time monitoring is hampered by limited data on credit constraints, adaptation-linked financial products and insurance. • There is a lack of substantial plans for dedicated finance or insurance schemes to support businesses to adapt. • Work to establish adaptation taxonomy for green finance expected to have a positive impact.
Outcome 3: Productivity losses due to physical climate risks are minimised.	Unable to evaluate	Insufficient policies and plans	• There is some evidence that businesses are experiencing worker productivity losses, but it is largely unquantified. More analysis is needed to fill this evidence-gap. • There is guidance on current work temperatures but no planning for maintaining productivity given future changes.
Outcome 4: Supply chain risks are identified and managed.	Insufficient progress	Limited policies and plans	• Risks are rising for domestic and international supply chains. Exposure to climate hazards is set to increase in the UK and internationally. • There are published guides and case studies on adaptation and resilience in supply chains. The new Resilience Directorate could deliver a more strategic approach to supply chain resilience, but it is too early to tell. • Business capacity to manage climate-risks along supply chains remains limited due to a lack of standards and information.
Outcome 5: Risks and actions are disclosed and managed by businesses.	Mixed progress	Limited policies and plans	• More businesses are now covered by risk disclosure such as the Task Force on Climate-related Financial Disclosures (TCFD), but quality of disclosure of adaptation action remains a key gap. • Mandatory risk disclosure expected to have an impact on risk awareness but low quality of physical risk disclosure and gap in information about adaptation action remains.

Relevant risks from CCRA3:
B1 Risks to business from flooding; B2 Risks to businesses and infrastructure from coastal change; B3 Risks to businesses from water scarcity; B5 Risks to business from reduced employee productivity due to infrastructure disruption and higher temperatures in working environments; B6 Risks to business from disruption to supply chains and distribution networks; B7 Opportunities for business from changes in demand for goods and services.

This chapter covers adaptation to climate change by businesses. The focus is on assessing the UK Government's contributions in supporting businesses to adapt to climate change. As documented in the most recent Climate Change Risk Assessment (CCRA) climate change creates impacts on UK business activity in a range of ways:[1]

- Business sites, operations and supply chains are exposed to direct disruption by flooding and storms, coastal change due to erosion, risks of reduced water availability and higher temperatures in working environments.
- Businesses are also indirectly exposed to the full range of weather and climate risks (both domestically and internationally) through infrastructure failure and shocks to the prices of key commodities.
- Some business sectors may also find opportunities for new or expanded commercial activities from a changing climate. Warmer summers may lead to possible opportunities for increased tourism, improved growing conditions for particular agricultural products (such as wine and soft fruit) and opportunities to provide goods and services to meet a growing need for adaptation across the economy.
- Businesses also hold the potential to influence behaviour and wider society choices through demonstrating new business models, along with creating goods and services that deliver adaptation outcomes.

At the start of 2022, there were 4.8 million private sector businesses in England, and 99.9% of these were small medium sized enterprises (SMEs).* Although there are far fewer of them, large businesses account for a significant share (41%) of English employment and turnover (50%).[2] Wholesale and Retail Trade are the single largest industry section in terms of turnover (Table 13.2), although financial and insurance activities are excluded from the data set because turnover is not available on a comparable basis (See Chapter 14 for more information on UK financial system). Notably, around 50% of food consumed in the UK is imported.[3]

Table 13.2
England Private Sector breakdown by Industry section 2022

Industry sections	Share of England private sector turnover
Wholesale and Retail Trade; Repair of Motor Vehicles and Motorcycles	36%
Manufacturing	13%
Professional, Scientific and Technical Activities	10%
Information and Communication	8%
Construction	8%

* As defined by number of employees. A small business has 0-49 employees, medium 50 to 249 and large 250 or more employees.

Administrative and Support Service Activities	7%
Transportation and Storage	4%
Mining and Quarrying; Electricity, Gas and Air Conditioning Supply; Water Supply; Sewerage, Waste Management and Remediation Activities	4%
Human Health and Social Work Activities	2%
Accommodation and Food Service Activities	2%
Arts, Entertainment and Recreation	2%
Real Estate Activities	2%
Agriculture, Forestry and Fishing	1%
Other Service Activities	1%
Education	1%
Financial and Insurance Activities	N/A

Source: BEIS (2022) *Business population estimates for the UK and regions 2022: statistical release.*
Notes: Financial and insurance activities are excluded from the data set because turnover is not available on a comparable basis.

Relevant policy in this area is largely devolved, with each nation having responsibility for supporting domestic businesses, innovation and economic development. However, macro-economic policy is largely controlled by the HM Treasury. Current economic policy priorities for the UK Government include: recovering from the economic impacts of the COVID-19 pandemic, building the capacity for long-term sustainable growth in the economy and helping businesses to reduce their greenhouse gas emissions to Net Zero. Key UK policy developments include the 'Build Back Better: our plan for growth' and the Industrial Decarbonisation Strategy.

Physical climate risks and their impact on businesses in the UK are highly interdependent, with a range of cross-cutting aspects.

Physical climate risks and their impact on businesses in the UK are highly interdependent, with a range of cross-cutting aspects. The other chapters within this report where these linkages are most pronounced include:

- **Nature and working land and seas** (Chapters 2 and 3): Changes in the natural environment impact natural capital, particularly in agriculture and fisheries as business sectors.
- **Infrastructure** (Chapters 5 – 8): Most business functions depend on reliable infrastructure, with disruptions posing a key risk for site operations, access to markets, supply chain and distribution networks, and employee productivity.
- **Buildings** (Chapter 10): Overheating of buildings poses risks to employee well-being and productivity, and the state of the built environment and adaptation responses depend on business action, including investment and construction procedures.
- **Finance** (Chapter 14): Global exposure of UK financial sector through international transactions.

For businesses, successful adaptation to climate change means that a reliable supply of goods and services, and a thriving economy, is maintained despite climate change; and that, where they exist, the economic opportunities of climate change are realised. Adaptation also limits the extent of damages, losses and disruption to business sites, production processes and the workforce.

While often used in conjunction with 'resilience' within the business community, the focus of this chapter is specifically on responding to physical climate risks, and not broader actions to deliver a low-carbon economy that is resilient to changing markets or regulations.

We set out a monitoring map of the key elements for how the business sector can be adapted to climate change (Figure 13.1). The key outcomes that we identify that need to be achieved for a well-adapted business sector are:

- **Public and private adaptation measures are implemented to minimise risks to business sites.** Physical climate impacts, such as extreme weather events, pose a risk to business sites and operations. Adaptation to these will require adaptation actions from business themselves (such as preventing workplaces from overheating) as well as wider public adaptation.

- **Businesses have access to insurance and capital including for adaptation.** Businesses will need capital to take adaptation actions and insurance to insulate them from climate shocks – access to these markets, at reasonable cost, is therefore a key element of climate resilience for all business sectors.

- **Productivity losses due to physical climate risks are minimised.** Climate change impacts, such as extreme heat or weather-related travel disruption, can make it difficult for staff to conduct their roles. Without adaptation measures, there is a risk of resulting productivity losses, ultimately impacting on business output and profitability.

- **Supply chain risks are identified and managed**. UK businesses rely on well-functioning supply chains, both domestically and internationally, to deliver goods and services, including for adaptation actions. There are many risks to supply chains from climate change. These include transport disruption, and loss of production overseas. The interconnectivity of the UK's infrastructure and supply-chains also means that climate-related risks to supply chains could lead to cascading failures in service provision.

- **Risks and actions are disclosed and managed by businesses**. Businesses will need to undertake robust climate risk assessments to identify the necessary adaptation actions they will have to take. Government coordination with businesses to create a transparent information disclosure regime can in turn drive possible incentives for those businesses that are taking effective action (for example from customers and investors).

Businesses of all sizes will need to adapt to climate change.

Businesses of all sizes will need to adapt to climate change. Both large business and SMEs have an important role to play in delivering adaptation across the wider economy as well as adapting themselves to ensure a reliable supply of goods and services.

It is in the interests of businesses of all sizes to adapt to climate change to both manage risks but also to realise potential new opportunities. However, the policies and enablers to support businesses of varying sizes are different.Enabling factors that need to be in place to deliver these outcomes are wide-ranging and include:

- **Governance.** Companies need to embed climate change risks and adaptation into their internal risk governance strategies. This includes development of climate-sensitive business continuity plans, integration of adaptation into climate-related mandatory reporting structures, assigning Board-level responsibility for climate adaptation and establishing responsible investment policies.

- **Engagement and education** will be needed to embed climate adaptation skills within companies. Establishing capacity for risk assessment and scenario analysis helps companies identify key risk areas and potential effective actions. Developing the skills needed to raise finance successfully for adaptation is important, along with dedicated engagement with suppliers on climate adaptation. For SMEs, there should be good access to adaptation guidance and tools.

- **Funding and investment** are needed to deliver adaptation interventions, for example through adaptation-linked financial products. Insurance products designed for adaptation can catalyse adaptation action. Government funding for pilots and support for development of new markets is a powerful enabler.

- **Data and monitoring** are essential to enable robust risk assessment, tracking of effective actions, data on adaptation intervention costs and benefits, and understanding of interdependencies. Building greater evidence to quantify and monetise benefits of adaptation action can enable investment.

- **Research** will be needed to drive innovation in future-ready goods and services, business processes and supply chains, along with identifying any opportunities from climate change.

Key policy milestones required cover legislation and regulation, information and reporting, standards and financial instruments.

Key policy milestones which must be in place to deliver a well-adapted business sector include:

- **Legislation and regulation.** Mandatory disclosure of business risks and adaptation responses by large companies, along with green finance taxonomies that cover adaptation can drive transparency and enable effective decision-making. Setting a water reduction target for businesses to drive water efficiency is needed to address water availability risks. Government procurement rules that give weight to adaptation plans for suppliers can establish high standards and provide incentives to develop climate resilient products and services.

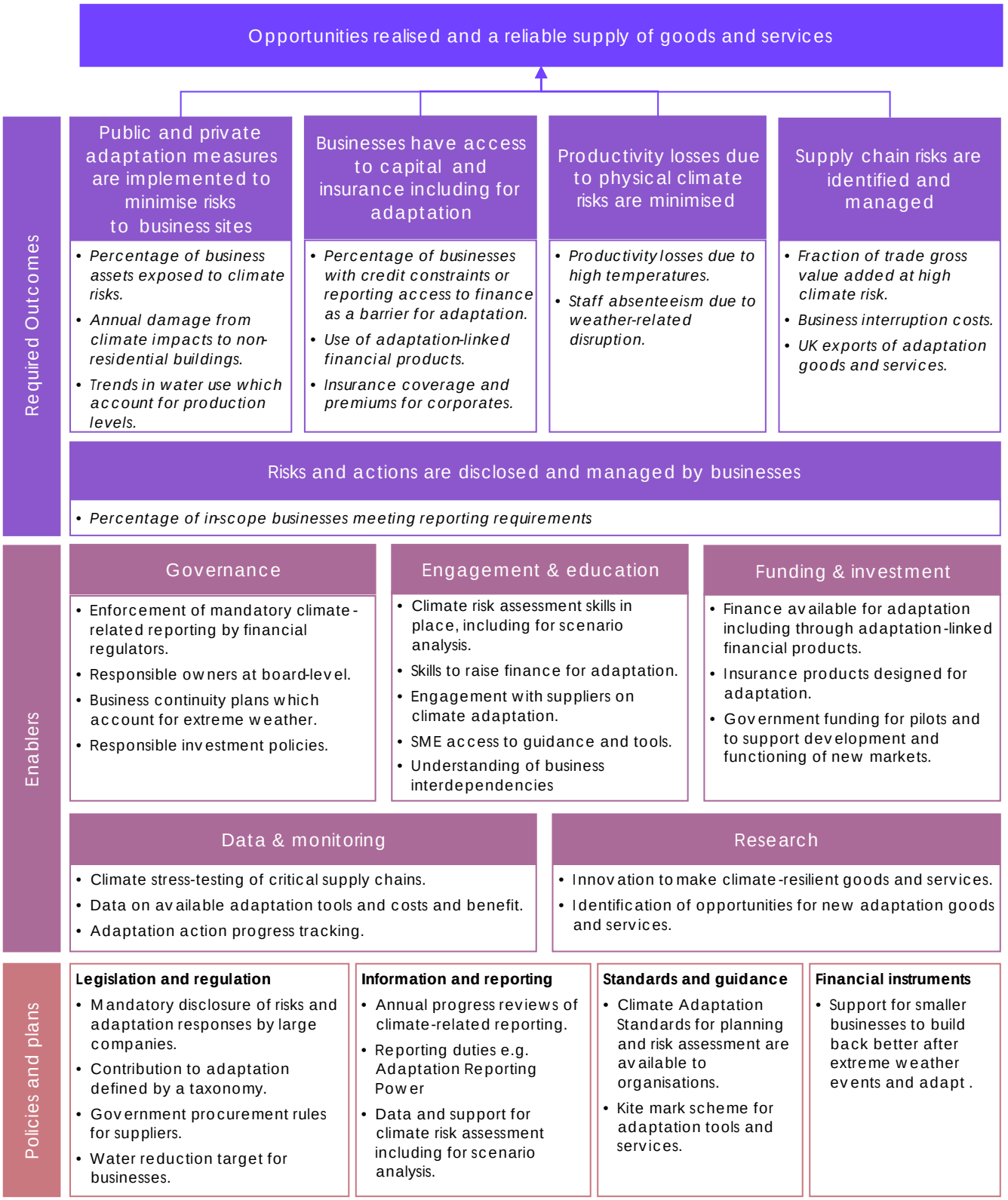
- **Information and reporting.** Public body reporting powers enable government to request reports from critical infrastructure providers on their adaptation plans and delivery. Other policy levers include data and assessment support for climate-related scenario analyses and reporting. Larger businesses often have greater organisational capacity for undertaking climate risk analysis and developing adaptation actions in response, though government still has an enabling role in determining consistent standards, scenarios and data provision. Smaller businesses have less capacity to assess their risks, devise responses and recover after

extreme weather events. They require clear central resources, where they can access the information they need to make business continuity plans for extreme weather and changes in the climate.

- **Standards.** Consistent standards for adaptation planning, tools and services, for example through a Kite mark scheme.

- **Financial instruments.** The impact of extreme weather events can be damaging for businesses, and additional grants and subsidies can reduce the time for which they are unable to trade, the likelihood of closing down and the economic and social consequences.

Figure 13.1 Monitoring map for business



Source: CCC analysis
Notes: Italicised text indicates suggested measures for each outcome.

Much of the information relating to business risk assessments, adaptation actions, and effectiveness of actions are not publicly available.

A number of outcomes are classed as 'unable to evaluate' for this progress report. While there have been steps forward in corporate risk disclosures, much of the information relating to business risk assessments, adaptation actions, and effectiveness of actions are not publicly available. A key enabler will be to invest in the data ecosystem that can allow decision-makers to access data about adaptation action taken. This will require engagement between business and government.

We assess available indicators of delivery and implementation in turn for each of our identified adaptation outcomes.

(a) Outcome 1: Public and private adaptation measures are implemented to minimise risks to business sites

A lack of available information makes progress on this outcome hard to evaluate. Where proxy data exist, they indicate **insufficient progress**.

- **Lack of quantified assessment of total business assets exposed to climate risks.** Key data on the financial exposure of business assets at a national level are not publicly available. Information is available on property exposure. The number of non-residential buildings at high risk from river and sea flooding in England in March 2023 was 39,179(c1% of all non-residential buildings).*,[4]

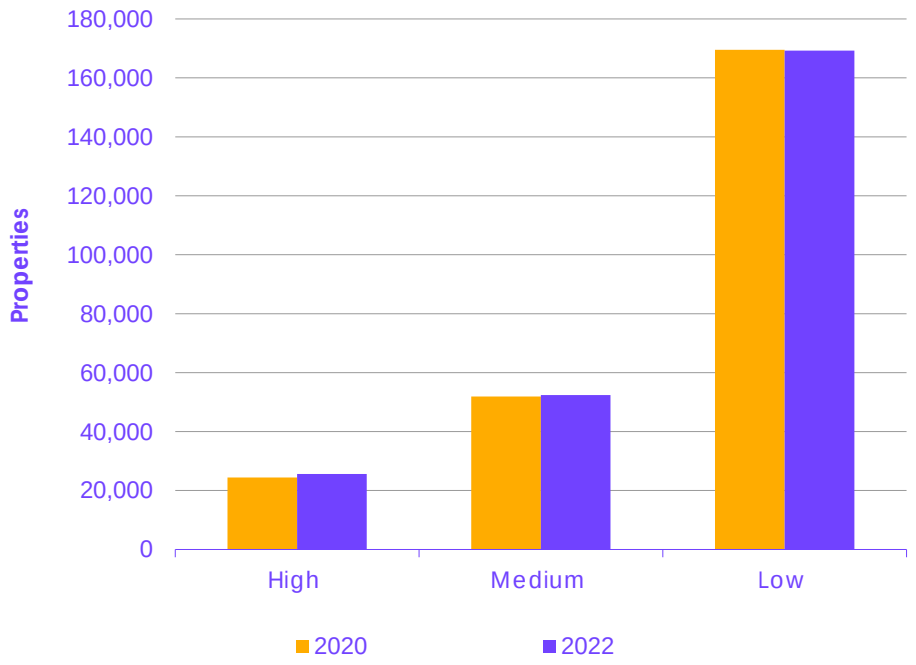
Number of 'business' properties at risk from surface water flooding has increased by 5% since 2020.

- **The number of non-residential buildings at risk of surface water and river and sea flooding has increased since 2020.** Analysis conducted indicates that the total number of 'business' properties at risk from surface water flooding in England has increased by 5% since 2020 (Figure 13.2).†,[5] And the number in England at high risk from river and sea flooding has increased by 1% since 2020.[6]

* Flood risk categories used by the Environment Agency (EA): High - greater than or equal to 3.3% chance in any given year (1 in 30); Medium - less than 3.3% (1 in 30) but greater than or equal to 1% (1 in 100) chance in any given year; Low - less than 1% (1 in 100) but greater than or equal to 0.1% (1 in 1,000) chance in any given year; Very Low - less than 0.1% chance in any given year (1 in 1,000)

† Covers retail, offices, warehouses, leisure, industry, and miscellaneous property types.

Figure 13.2 Number of 'business' properties at low, medium, and high likelihood of surface water flooding



Source: Ffoulkes C, Hockridge B, Oliver H, and Palmer L (2023) *Research to update indicators which monitor progress in adaptation. ADAS report for the Climate Change Committee.*
Notes: Likelihood of flooding categories reflect those used by the Environment Agency. These are: High risk - greater than or equal to 3.3% chance in any given year (a 1 in 30 chance); Medium risk - less than 3.3% (1 in 30) but greater than or equal to 1% (1 in 100) chance in any given year; Low risk - less than 1% (1 in 100) but greater than or equal to 0.1% (1 in 1,000) chance in any given year; Very Low risk - less than 0.1% chance in any given year (1 in 1,000.) 'Business' property types include retail, offices, warehouses, leisure, industry, and miscellaneous property types.

- **Annual financial damages due to climate change could increase due to increased flooding and extreme weather events.** Although available evidence to provide an economy-wide picture that tracks financial damages to businesses from flooding and extreme weather is limited, there is a growing evidence base from specific extreme weather incidents and modelling that climate change impacts on businesses can be significant now and will grow in future without additional adaptation (Box 13.1).

Present day expected annual damages from flooding to non-residential properties across the UK average around £670 million.

Box 13.1
Evidence on current and projected damages to businesses from extreme weather

Extreme weather incidents. There are some initial estimates for the financial impact on businesses of extreme weather based on insurance claim information from the Association of British Insurers (ABI).

- Winter Floods 2019-20:[7]
  - Of the estimated £110 million pay-outs, £45 million covered damage to homes and possessions; £58 million for business property and stock, with £7.5 million relating to damaged vehicles.
- Storms Dudley, Eunice and Franklin that hit much of the UK during February 2022:[8]
  - There have been 177,000 claims notified for damaged homes, businesses and vehicles, with total pay-outs of £497 million expected.
  - Of these claims, 169,500 relate to property damage costing £473 million.

Projected flooding impacts. Present day expected annual damages from flooding to non-residential properties across the UK, average around £670 million.[9] Damages could increase in a 2°C warming scenario by around 27% by 2050 and 40% by 2080. In a 4°C scenario they increase by around 44% by 2050 and 75% by 2080. These projections assume no changes in the asset base or size of the economy.[10]

Source: Actuarial Post (2019) *Yorkshire and Midlands flood damage pay-outs to top £100m;* Association of British Insurers (2022) *Insurers expect to pay out nearly £500 million to support customers hit by damage from extreme weather in 2021,* UK Climate Risk (2021) *CCRA3 Briefing: Business.*

- **Non-household consumption from the public water supply was 2,540 Ml/d in England in 2021/22**.[11] This is 9% less than in 2019/20, although reduction is expected due to impacts of COVID-19 over the period. Additional data which take into account production levels are still required to assess genuine improvements in water efficiency. Data on the uptake of water efficiency measures is held by water companies but is not collated at a national scale. Most of the draft plans from English water companies are currently forecasting an increase in non-household water demand by 2050.[12]

There is little data publicly available on resultant business adaptation actions and investment.

- **The available national data is mainly focused on identified climate risks, with less data publicly available on the resultant business adaptation actions and investment.** Case studies can provide some insight into current adaptation actions underway. A recent assessment of the third round of the Adaptation Reporting Power (ARP) looked at the performance of water companies. It found that reports from the water sector were strong across the range of assessment criteria. Most reports have assessed a range of climate scenarios consistent with 2°C and 4°C global warming levels out to the 2080s, almost all reports have linked actions to risks and most had appropriate monitoring and evaluation in place.[13]

(b) Outcome 2: Businesses have access to insurance and capital including for adaptation

Businesses require access to insurance and capital to fund adaptation actions.

Private businesses are responsible for investing in the resilience of their specific commercial sites and their supply chains. They require access to insurance and capital to fund these adaptation actions.

A lack of publicly accessible information makes progress on this outcome **unable to evaluate.**

- **Preliminary scenario analysis from the Bank of England indicates potential reductions in access to lending and insurance.**

  – Findings from the Bank of England's Climate Biennial Exploratory Scenario exercise (CBES) imply a potential future material reduction in access to lending and insurance for sectors which are most exposed to physical risks.[14] For physical risk exposure, sectors with the highest projected impacts included manufacturing, crop and animal production, and forestry and fishing.[15]

  – The Bank's 'no additional action' scenario explores the physical risks that would begin to materialise if governments around the world fail to enact policy responses to global warming. In this scenario banks would reduce lending to properties facing greater physical risks, and insurers would substantially increase the premiums they charge to insure against such risks.[16] However, this is a modelled scenario and not a

prediction. Current assessments are limited due to the immaturity of scenario analysis and several key data gaps.

It is currently difficult to assess how common adaptation-linked financial instruments are and how wide-ranging their applications are.

- **It is currently difficult to assess how common adaptation-linked financial instruments are and how wide-ranging their applications are.**

  – As outlined in the CCC's 'Investment for a well-adapted UK' report, the investment needs for adaptation are increasing, particularly in key systems such as flood protection, nature restoration and infrastructure.[17] To meet these needs, more business involvement and private investments are required.

  – Private sector investment in adaptation is not formally assessed or tracked, but based on what evidence is available it is currently not at the level required.[18] A key reason many private organisations have been hesitant to invest in adaptation to date is their uncertainty about whether the relevant business models have been proven. However, the number of successful case studies is growing with one example given in Box 13.2.

Box 13.2
Case study: Water sector private investment to increase resilience to droughts and flooding (England and Wales)

Investment need: Private investment to increase the resilience of the water system

Investment support mechanisms: Capital and operational investment by private water companies, regulated by Ofwat. A £51 billion price and service package was set for the five years from 2020-24, including £13 billion allocated for new infrastructure to increase resilience. £643 million was allocated to increase the resilience of water and wastewater infrastructure against potential failures. £469 million was allocated for drought resilience – developing new water resources and enabling transfer of water across the country. Water companies plan to invest £650 million to install at least two million new water meters over the 2020-25 period, to provide more insight into consumer demands and help identify leaks.

Revenues generated:

- Revenue allowances are set by Ofwat in each price review. Adjustments are made to allowed revenue to reflect service performance. Investment in resilience reduces the revenue at risk from failure to meet service performance requirements.

Financial barriers:

- Raising funds for projects with future benefits can be hampered in some cases by too much focus on outcomes for current consumers. Water companies' adaptation investment projects are ultimately financed by higher customer bills. Customers may be unwilling to pay for adaptation that they may not benefit from, or benefit less from, than future customers.

Source: CCC (2023) *Investment for a Well-Adapted UK.*

(c) Outcome 3: Productivity losses due to physical climate risks are minimised

A lack of accessible information on staff absenteeism or productivity losses makes progress on this outcome **unable to evaluate**.

- **Further research and modelling of productivity losses due to high temperatures is needed.** There is some evidence that UK businesses are experiencing worker productivity impacts due to extreme heat, but this risk remains largely unquantified.

Despite a limited UK-specific evidence base, one study suggests that a 2°C warming trajectory could cost around 0.4% of economic output for London in a warm year due to a reduction in productivity.*,[19] More research and analysis would help to fill this evidence-gap and identify beneficial actions.[20] There is no accessible public data set on staff absenteeism due to weather-related disruption. For more information on health adaptation outcomes see Chapter 11.

(d) Outcome 4: Supply chain risks are identified and managed

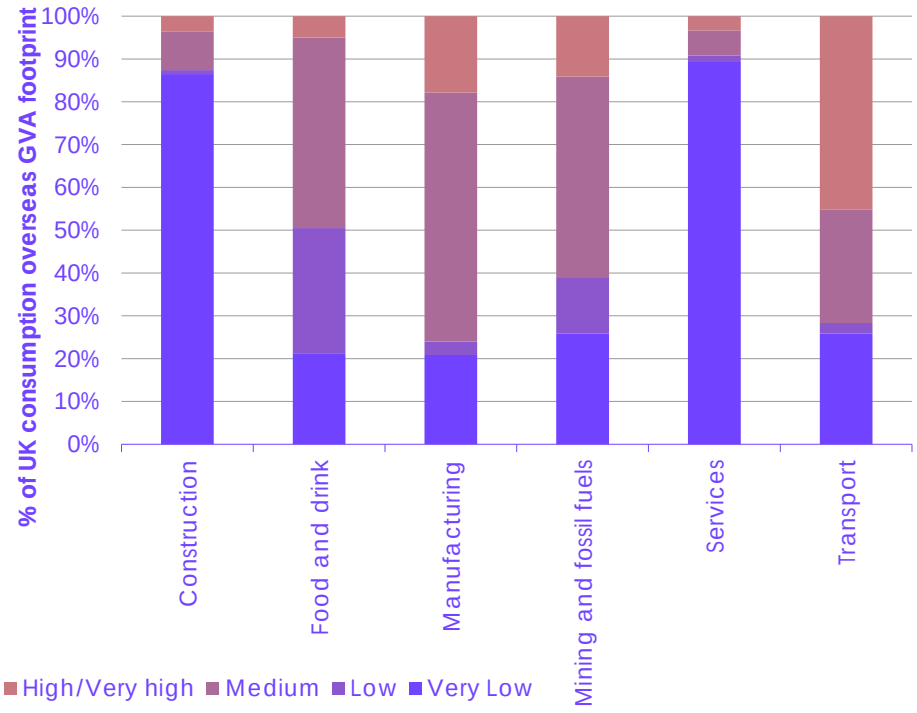
Currently domestic supply chains are experiencing disruption due to floods, droughts, high temperatures and other extreme weather in the UK.[21] But there is a lack of consistent monitoring data for this outcome over time. Where information is available it indicates **insufficient progress.**

Risks are rising for domestic and international supply chains, with exposure to climate hazards set to increase in the UK.

- **An estimated 20% of the UK's trade depends on production in regions and sectors at 'medium' to 'very high' climate risks.** Initial CCC analysis of trade and climate risk data indicates that risks are rising for domestic and international supply chains, with exposure to climate hazards set to increase in the UK. An analysis of changes in relevant climate hazards suggests that 20% of the economic value in the overseas supply chains which currently serve UK consumption is dependent on economic production in foreign sectors and regions with 'medium' to 'very high' levels of risk from relevant climate hazards (Figure 13.3).[22] Particular sectors with higher levels of climate risk include the UK's consumption of food and drink products, manufactured products, transport services and fossil fuel and mining products.[23] See Chapter 4 for more information on adaptation in food supply chains.

* The study compared the impact of high temperatures on productivity in London, Bilbao and Antwerp. London was found to have a small relative drop in productivity compared to the other sectors, due to the nature of its economy being oriented towards services.

Figure 13.3 Climate risks to UK overseas economic relationships under a 2°C scenario



Source: CCC analysis; University of Leeds, Warren, R. et al. (2022) *Literature review: climate impacts at the global, regional and country scale. Climate services for a net zero resilient world*. UK Government.
Notes: UK trade data is used consistent with the datasets used to estimate UK consumption emissions (University of Leeds) and an international input-output model to estimate the value generated (gross value added) within each country for final goods and services consumed in the UK. This GVA footprint is categorised into groupings of climate vulnerability based on a classification of changes in the climate hazard indicators which are relevant to that economic activity (averaged over counties in a trade data region) from the dataset compiled by Warren et al.)

- **Business interruption costs due to supply-chain climate disruptions are not tracked, but poor adaptation in other key systems highlights risks.** In a recent survey of 52 countries (majority based in Europe) 50% of respondents across a range of sectors experienced disruptions or delays in the supply chain due to severe weather events.[24] Respondents reported that climate risks and extreme weather affected supply chains in a range of ways. 50% of respondents had been unable to acquire critical products, or had suffered delays in acquisition, as transportation routes had been disrupted. And 22% had experienced the same because a supplier's manufacturing operations was affected by extreme weather. 33% had to stockpile more, 32% had to pay more to source goods and 9% experienced supplier liquidation, where extreme weather had destroyed a business.[25] The available information also indicates that many key UK infrastructure systems which businesses rely on, such as telecoms, ICT and the transport network, are currently not resilient against climate change. See Chapters 7 and 8 for more information.

(e) Outcome 5: Risks and actions are disclosed and managed by businesses

Available indicators demonstrate **mixed progress** for this outcome, with disclosure coverage growing but gaps found in relation to reporting on adaptation action and risk management.

More businesses are reporting physical climate risks, but disclosures on risk management and adaptation remain a key gap.

- **More businesses are reporting physical climate risks, but disclosures on risk management and adaptation remain a key gap.**
  - A review of the TCFD-aligned disclosures from over 170 listed companies* in 2022 found that:[26]
    - Over 90% of responding companies self-reported that they had made disclosures consistent with the TCFD's Governance and Risk Management pillars. But this dropped to below 90% for the Strategy and Metrics and Targets pillars.
    - 81% of companies indicated that they had made disclosures consistent with all seven recommended disclosures that are expected for compliance.
    - The sample of companies assessed (31) which made disclosures that were either partially or mostly consistent with the TCFD framework increased significantly compared with 2020.
- The Financial Reporting Council (FRC) finds that "Risk management of climate-related matters was integrated into the overall risk management process of most companies, but it was not always clear how climate risks had been prioritised against other risks, and materiality was often not well explained."†,[27]
- Although comprising 50% of employment in England, SMEs currently remain out of scope for the mandatory disclosure schemes with little consolidated information available to assess their management of climate risk.[28]

(f) Progress on enablers

To achieve these outcomes for well-adapted businesses, multiple enabling factors must be in place. There is limited data available to assess progress in achieving enablers.

- **Governance.** Survey data from The Business Continuity Institute (BCI) members finds that only 37% of responding organisations currently have a C-suite level appointment who is responsible for promoting resilience at all levels in the organisation.[29]
- **Engagement and education.** The UK Government will make training on resilience accessible to private sector partners, including through the UK Resilience Academy.[30] The SME Climate Hub‡ provides information to small businesses on reaching net-zero, but with limited resources on how to take adaptation action.
- **Funding and investment.** Investment from public and private sectors will be needed to build climate resilience. Currently there are barriers to investment in adaptation, particularly from the private sector which is limiting ability to prepare for climate change. See Chapter 14 for more

* Of the 171 premium listed commercial companies with December 2021 year ends that had published their Annual Financial Report by end-April 2022 and their compliance with FCA Listing Rules.

† Based on a sample of 25 companies.

‡ This is an initiative of the International Chamber of Commerce, the Exponential Roadmap Initiative, the We Mean Business coalition and the United Nations Race to Zero campaign.

information on the Government's role in supporting adaptation investment.[31]

Access to climate stress-testing and adaptation tools that detail costs and benefits is nascent.

- **Data and monitoring.** Tools which allow businesses to assess the costs and benefits of climate stress-testing and adaptation are still in their early stages of development. But some information is already available to support businesses in conducting climate risks assessments. For example, the Group on Earth Observations Global Agricultural Monitoring (GEOGLAM) initiative provides crop monitoring for major food types and the Department for International Trade's (DIT) recently launched Global Supply Chains Intelligence Pilot.

- **Research.** Key research areas include innovation for climate-resilient goods and services and identifying potential opportunities from climate change. There is a strong innovation ecosystem within the UK but limited consolidated data on how much funding and effort is currently targeted towards adaptation.

In our 2021 progress report our recommendations focused on getting the Government to provide sufficient resources to fully support businesses of all sizes to set and deliver adaptation action plans and implement mandatory climate disclosure. This included recommendations on making government data analysis of climate risks more accessible and usable to decision makers. Progress towards these recommendations and the overall outcomes are detailed below.

(a) Outcome 1: Public and private adaptation measures are implemented to minimise risks to business sites

The key policy milestones required for this outcome are partially in place. The policy score for this outcome is **limited**.

There is some financial support in place for businesses to recover and adapt after extreme weather events.

- **Financial instruments.** There is some financial support in place for businesses to recover and adapt after extreme weather events. For example, through programmes in place as part of the Environment Agency's Flood and Coastal Erosion Risk Management (FCERM) roadmap.[32] Incentives for businesses to install sustainable drainage systems remain limited.

- **Legislation and regulation.** A proposed 9% reduction in non-household demand by 2037 was not included in final Environment Act targets despite support from across water retailers and market operators.[33,34]

- **Standards.** The British Standards Institute has created a standard on 'Adaptation to climate change. Guidelines on vulnerability, impacts and risk assessment' (ISO 14091) that is applicable for all sizes and types of organisations.[35]

(b) Outcome 2: Businesses have access to insurance and capital including for adaptation

The key policy milestones required for this outcome are partially in place. The policy score for this outcome is **limited.**

Private businesses are responsible for investing in the resilience of their specific commercial sites and their supply chains. This requires a range of incentives that allow businesses to raise capital to invest in resilience and well-designed regulation to enable investment in all regulated sectors.

- **Financial instruments.** Currently the UK lacks substantial dedicated schemes which provide financial support for businesses to deliver climate adaptation at scale.

  Flood Re is only for homes and not businesses or non-residential buildings.

  – Flood Re is only for homes and not businesses or non-residential buildings.

  – The British Business Bank focuses on making finance markets work better for smaller businesses. But currently it has not carried out specific research (as it has for smaller business and Net Zero) nor does it have specific programmes for climate change adaptation.[36]

  - The UK Infrastructure Bank (UKIB) was launched in 2021, tasked with accelerating investment into ambitious infrastructure projects. However, to date the UKIB has focused on emissions reduction in financing projects and is yet to demonstrate a firm commitment to addressing Net Zero and adaptation together.[37]

  - Green bonds are those where the proceeds from the bonds will be exclusively applied to finance or re-finance projects with clear environmental benefits. Climate bonds can be used to address climate change or increase resilience though are a small proportion of the current market. Sector-specific climate resilience criteria are the primary reference for issuers of green bonds seeking certification and approach to mainstream adaptation and resilience.[38]

  - Banks can also offer products like green mortgages which provide incentives for households and businesses to take adaptation action. To date, these have focused more on mitigation and energy efficiency.

- **Legislation and regulation.** The UK Government is developing a UK Green Taxonomy, that will include climate change adaptation. This is expected to have a positive impact on business access to capital for adaptation. As the UK develops this further, more detailed work is needed on the design and implementation of an enhanced set of adaptation Technical Screening Criteria.[39] As part of this, a Land Use, Nature and Adapted Systems Advisory Group has now been established.

(c) Outcome 3: Productivity losses due to physical climate risks are minimised

The key policy milestones required for this outcome are not in place. The policy score for this outcome is **insufficient.**

Business continuity planning that considers climate risks is still limited in general.

- **Standards.** The Health and Safety Executive (HSE) provides guidance on temperatures, as well as heat stress and thermal comfort including the provision of a Heat Stress Checklist for businesses.[40] Business continuity planning (BCP) is still limited in general, but with pockets of guidance such as The Care Provider Alliance national guidance on BCP for social care providers which includes planning for severe weather. However the BCPs do not constitute a long-term adaptation plan.[41,42] See also Chapter 11.

(d) Outcome 4: Supply chain risks are identified and managed

The key policy milestones required for this outcome are partially in place. The policy score for this outcome is **limited.**

- **Standards and Guidance.** The Department for International Trade (DIT) developed a resilience framework in 2022 that highlights five areas for building resilience in supply chains.[43] Currently, climate change is not explicitly considered here. But the focus on the importance of data and visibility in managing supply chains could help build a strong foundation to later add in climate adaptation guidance. In 2022 the UK also launched a joint initiative with the Government of Australia to develop and improve public sector approaches to managing critical supply chain risks.[44] But to date neither of these approaches offer a standardised approach for climate adaptation planning or a kite mark style-scheme for adaptation tools and services.

- **Information and reporting.**

  - International supply-chains: The Department for Business and Trade is supporting UK businesses to co-operate with international partners to transform adaptation and resilience measures into practical solutions. They have launched an Export Capability Guide for Adaptation and Resilience which sets out the UK's capabilities. This includes setting up early warning systems for extreme weather conditions, building sustainable flood defences, and helping farmers manage farming systems in changing environments.[45]

  - For domestic supply chains: The Adaptation Reporting Power (ARP) enables the UK Government to request reports from critical infrastructure providers on the current and predicted effects of climate change on their organisation; their proposals for adapting to climate change; and progress made towards their implementation. However, compliance with these requests remains voluntary.

Extending the scope of ARP to include key supply chains, such as food, would increase the value of ARP.

  - Extending the scope of ARP to include key supply chains, such as food, would increase the value of ARP in providing a picture of the current resilience of goods and services. See Chapter 8 for further assessment of adaptation across the UK's transport network.

    - Rail: There are credible adaptation policies and plans in place for the rail network. Indicators show some increased impacts on rail infrastructure, especially heat and wind, but reduced impacts from flooding.

    - Strategic road network: The second Road Investment Strategy includes a vision for climate resilience. National Highways has reported its climate change risk assessment and adaptation plans under the latest round of the Adaptation Reporting Power.

- **Legislation and regulation.** 2021 National Procurement Policy Statement sets 'tackling climate change and reducing waste' as a priority outcome, but with little specific consideration of how this links to climate resilience.[46] The Environment Agency have amended their procurement process to take account of changing risks from weather and climate, offering some potential lessons.[47]

(e) Outcome 5: Risks and actions are disclosed and managed by businesses

The key policy milestones required for this outcome are partially in place. The policy score for this outcome is **limited**.

Progress has been made to extend the scope of UK companies required to disclose from 2022 onwards.

- **Legislation and regulation.**

  - In 2021 the Government announced new Sustainability Disclosure Requirements (SDR) and an accompanying Roadmap to Sustainable Investing. SDR is made up of several different parts which cover adaptation (Table 13.3).

  - Progress has been made to extend the scope of UK companies required to disclose from 2022 onwards. UK Parliament approved two regulations requiring TCFD-aligned, climate-related financial disclosure of UK companies with more than 500 employees that are listed in

section 414CA of the Companies Act 2006, and limited liability partnerships with more than 500 employees and turnover of more than £500 million.[48]

– More work is needed to address the current low quality of physical risk disclosures and close the gap between risk disclosure and adaptation action.

Table 13.3
Key parts of the UK's Sustainability Disclosure Requirements and how they attempt to include adaptation

Initiative	What is it?	How does it include adaptation?
Taskforce on Climate-Related Financial Disclosures (TCFD)	To comply with the recommendations, organisations must disclose specific information in relation to how their governance, strategy, risk management, metrics and targets help them assess and manage their response to climate-related risks and opportunities. The UK Government announced its intention to make TCFD-aligned disclosures mandatory by 2025. This is gradually being introduced for different categories of organisation including listed commercial companies, UK-registered large companies, banks and building companies, insurance companies, asset managers, life insurers and FCA-regulated and occupational pension schemes.	Reporting on physical climate risks and adaptation under governance, strategy, risk management metrics and targets, has been part of the recommendations since their creation. Organisations are asked to consider multiple climate scenarios, though only a 2°C or lower scenario is explicitly requested. Examples are provided for reporting organisations such as required or discretionary increases in capital and operational expenditures to address adaptation.
International Sustainability Standards Board (ISSB) Climate-related Disclosures	The International Financial Reporting Standards Foundation set up a new International Sustainability Standards Board to advise on new global reporting standards for sustainability. These will cover very similar areas to the TCFD recommendations but require more granular financial information. The ISSB consulted on a Climate-related Disclosures draft in 2022 with plans to finalise it in 2023. The UK Government has announced that it will create a mechanism to adopt and endorse ISSB standards for the UK, effectively replacing the TCFD disclosures.	Reporting should allow understanding of resilience of an organisation's strategy to climate-related changes. This should include scenario analysis and the effect of current or planned investments in adaptation or opportunities for climate resilience. How reporting organisations expect their financial performance to change over time, given their strategy to address climate-related risks and opportunities. For example, physical damage to assets from climate events and the cost of climate adaptation.
UK Green Taxonomy	Sets out the criteria which specific economic activities must meet to be considered environmentally sustainable and therefore 'Taxonomy-aligned'. Certain companies will be required to disclose the percentage of their capital expenditure, operational expenditure and turnover that relates to Taxonomy-aligned activities. Providers of investment products will be required to disclose the extent to which those products are Taxonomy-aligned. The UK Government is due to consult on the Technical Screening Criteria and standards for each of the environmental objectives before laying legislation before Parliament.	Adaptation is one of six environmental objectives. Technical Screening Criteria are due to be developed for adaptation which will be based on those used for the EU's Taxonomy for Sustainable Activities. To be considered taxonomy-aligned an economic activity must make a 'substantial contribution to' one of the environmental objectives and 'do no significant' harm to any of the others. In the EU's Taxonomy for Sustainable Activities, significant contributions and avoiding significant harm are based on undertaking robust assessments of physical climate risk and setting out actions in response, including consideration of Nature Based Solutions and Blue-Green Infrastructure.

Source: CCC Analysis; HMG (2021) *Greening Finance: A Roadmap to Sustainable Investing*; HM Treasury (2020) *Interim Report of the UK's Joint Government-Regulator TCFD Taskforce;* TCFD (2021) *Implementing the Recommendations of the Task Force on Climate-related Financial Disclosures;* European Commission (2021) *Commission Delegated Regulation (EU) 2021/2139,* Official Journal of the European Union.

- **Information and reporting.** HMT has launched the UK Transition Plan Taskforce (TPT). This will develop a set of sectoral transition plan templates that also include responding to climate risk. This is a good step towards standardising accessible approaches and tools for businesses. For small businesses, the SME Climate Hub provides information for reaching net-zero. But this does not provide the same level of information on how to adapt to climate change impacts.

(f) Recommendations to close policy gaps

Although there has been progress since our last report in 2021 (Box 13.3) significant policy and planning gaps remain in this area. We provide a set of targeted recommendations to close those gaps (Table 13.4).

Most critically, the third National Adaptation Programme (NAP3) should set out the Government's vision of what a resilient UK would be like. It should support this vision by clearly laying out specific and measurable resilience standards and targets, which are supported by a consistent regulatory landscape that enables business planning.

Box 13.3
Policy developments since 2021

- October 2021: The Government's "Greening Finance: A Roadmap to sustainable Investing" introduced a plan for new economy-wide Sustainability Disclosure Requirements.[49]
- In 2021 the Government announced new Sustainability Disclosure Requirements (SDR) and an accompanying Roadmap to Sustainable Investing.[50] SDR is made up of several different parts which cover adaptation.
- April 2022, HMT launched the UK Transition Plan Taskforce (TPT) to support companies in developing and disclosing transition plans.[51] This predominantly covers climate change mitigation but also climate resilience and adaptation. There will be a Transition Plan Taskforce Adaptation Working Group starting in 2023.
- January 2022: The UK Parliament approved two regulations requiring TCFD-aligned, climate-related financial disclosure of UK companies (with more than 500 employees that are listed in section 414CA of the Companies Act 2006. The other regulation applies to limited liability partnerships with more than 500 employees and turnover of more than £500 million).
- June 2022: The Environment Agency set out Flood and coastal Erosion Risk Management Strategy Roadmap which includes specific actions related to businesses.
  - The Environment Agency will work with partners and the insurance industry to review the recovery phase from a broad selection of historic major flood events, while learning from other major civil emergencies. This review will share lessons learnt on how people and businesses can be better supported after flooding to get back to normal quicker.
  - The Flood and Coastal Resilience Innovation Programme which will enable local authorities, businesses and communities in 25 places to test and demonstrate innovative practical resilience actions.

- The Green Technical Advisory Group published advice to Government on the development of the UK's Green Taxonomy in October 2022. A Land Use, Nature and Adapted Systems Advisory Group has now been established to advise on the design and implementation of an enhanced set of adaptation Technical Screening Criteria.
- December 2022: New Resilience Directorate announced as part of the UK Government Resilience Framework.

Table 13.4
Recommendations

Primary responsibility	Recommendation	Timing
HMT, DESNZ	Ensure that the Sustainability Disclosure Requirements and supporting policies result in large businesses disclosing their current and future supply chain risks from extreme weather and climate change. This should include reporting the financial impacts of supply chain disruption and considering multiple climate change scenarios.	2023
HMT	Provide financial support for smaller businesses to recover and adapt after extreme weather events (similar to existing grants which are usually offered after flooding or as Flood Re does for homeowners).	2024
FCDO	Increase capacity building through its overseas programmes to improve global capacity for climate resilience, including supply chains, health systems and early warning systems for climate hazards. Overseas programmes should work to reduce underlying vulnerabilities to climate risks and not just respond to disasters.	2024
DBT	Carry out stress testing exercises to understand the resilience of essential goods supply chains. This should include assessing the effectiveness of solutions like parallel supply chains or diversifying supplier locations based on assessments of climate risk.	2024
DESNZ	Increase resources for adaptation as part of the existing SME Climate Hub.	2023
DBT	Ensure that resilience to extreme weather and climate change is part of industrial and security strategies such as the British Energy Security and Critical Minerals strategies.	2023
DESNZ	Publish more accessible monitoring and data analysis of climate risks in order to support businesses to improve their resilience.	2023
Cabinet Office	Carry out a review of the impacts of recent supply chain disruption and how businesses and governments responded. Use the findings as part of building a strong resilience capability for the UK by taking an overarching view of systemic and interacting risks.	2023
Cabinet Office	Review the value of an early warning system for global climate shocks and enhancing the ability of the Government to make fast decisions by bringing in technical advice and expertise when needed.	2023
Defra	Extend the scope of ARP4 to include food supply chains. Defra should also ensure that all organisations who meet the criteria for participation are being invited to report.	2024
HMT, DESNZ	The UK should strengthen adaptation reporting requirements across the Sustainability Disclosure regime and build on the work of the Transition Pathways Taskforce (on Net Zero-related corporate transition plans) to define common standards for what a high-quality adaptation transition plan should look like. This should include how relevant physical climate risks are measured and managed as well as how the plans would contribute to wider societal adaptation to climate change.	2023

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Chapter 14

Finance

Table 14.1
Progress summary – Finance

	Delivery and implementation	Policies and plans	Summary
Outcome 1: All financial institutions incorporate physical risks into financial decision-making	Unable to evaluate	Limited policies and plans	• Key data on financial exposure to climate risks is limited, with a heavy reliance on uncertain scenario analyses. • There is progress to embed adaptation in financial regulators' activity, although it is still nascent. • There is a lack of reliable indicators on how risk information is used in financial decisions.
Outcome 2: UK financial services are a global leader in adaptation	Unable to evaluate	Insufficient policies and plans	• UK scores highly in green finance ratings but not specific to adaptation. • Lack of consolidated information on size of the market for adaptation goods and services. • General plans for seizing opportunities in Green Finance Strategy, but taxonomy for adaptation still under development.
Outcome 3: No viable adaptation project fails for lack of finance	Insufficient progress	Insufficient policies and plans	• Many barriers for adaptation investment although data on number of investments and projects affected are not collected. • Little data on availability of financial instruments for adaptation projects and programmes. • Adaptation not yet strongly included in public financial institutions' climate strategies • Data on credit constraints, adaptation-linked financial products and insurance are very limited. • There is a lack of significant plans for finance or insurance schemes to support businesses to adapt.
Outcome 4: Risks and actions are disclosed and managed by financial institutions	Mixed progress	Limited policies and plans	• Mandatory disclosure expanded in scope and work to establish a UK Green Taxonomy underway. • These need further development to address low quality of physical risk disclosures and fully integrate adaptation activities into reporting. • While work has progressed on Net Zero transition plans, it is only just beginning on adaptation plans and adaptation plan-related disclosures. • Lack of agreed methodology for measuring the positive or negative contribution an investment portfolio is making or has made to adaptation outcomes.

Relevant risks from CCRA3:
B4: Risks to finance, investment and insurance including access to capital for businesses. ID8: Risks to the UK financial sector from climate change risks overseas.

The financial system is a highly connected network of financial institutions – such as insurance companies, stock exchanges, and investment banks – that work together to exchange and transfer capital from one place to another. Through the financial system, investors receive capital to fund projects and receive a return on their investments.[1,2]

Financial services are a key element of the UK's national economy. In 2021, the financial services sector contributed £173.6 billion to the UK economy, 8.3% of total economic output. Exports of UK financial services were worth £61.3 billion in 2021 and imports were worth £16.6 billion, a surplus in financial services trade of £44.7 billion.[3]

Financial services across the UK are subject to a single set of regulations. The Bank of England is responsible for maintaining overall financial stability by monitoring and responding to risks including climate change. Other important roles are served by the regulatory bodies: the Financial Conduct Authority (regulate financial services firms and financial markets in the UK to ensure fair outcomes for consumers); the Financial Reporting Council (regulate auditors, accountants and actuaries, and set the UK's Corporate Governance and Stewardship Codes); the Prudential Regulation Authority (regulate and supervise financial services firms) and The Pensions Regulator (regulate workplace pension schemes).

The financial system is exposed to climate impacts directly through loans and investments that have exposure to physical impacts, and indirectly from its interaction with all parts of the economy.

The functioning and stability of this system needs to be maintained despite climate shocks (Box 14.1). These physical climate risks impact across the different risk categories that financial institutions face (such as credit risk, liability risk, and operational risk), and ultimately macro-financial risks.[4] Additionally, the financial system needs to enable households, infrastructure providers and businesses to adapt to climate change through facilitating access to financial products and services. Significant investment will be needed over the next decade in several key areas to adapt to physical climate risks in the UK across flood protection, public water systems, housing, nature restoration, and infrastructure.

Box 14.1
Climate hazards to UK financial system

- The financial system is exposed to climate impacts directly through loans and investments that have exposure to physical impacts, and indirectly from its interaction with all parts of the economy, both in the UK and overseas.
- In global terms, the UK is one of the most exposed countries due to its high financial leverage and high centrality in the global financial network. In terms of domestic risks, flooding is the most significant risk for the financial system.
- There may be significant financial exposure to extreme weather impacts in other countries, especially through globally linked insurance markets and investments.
- Given the networked nature of the financial system any large-scale negative impacts due to mismanaged risk exposure can cascade through the system quite rapidly.
- There is also a risk that access to capital for businesses will be negatively impacted by climate change through decline in availability and affordability of insurance, a reduction in the value of assets and investments, and increased credit risks and rising costs of capital for firms exposed to physical climate risks.

Source: CCC (2021) *Independent Assessment of UK Climate Risk.* Mandel et al. (2020) Risks on Global Financial Stability Induced by Climate Change.

Successful adaptation means ensuring that the functioning of the UK's financial system remains stable despite climate change and enables adaptation in the real economy. Building a well-adapted financial system is also necessary for the provision of capital for effective adaptation and to secure availability and affordability of insurance over time.

The focus of this report is on the management of physical climate risks, rather than responses to broader sets of risks, such as transition risks. Whilst these often go hand-in-hand, this assessment is focused on actions taken in response to physical climate hazards.

The financial system is included as a standalone chapter for the first time in this report. The Committee expects this chapter and its monitoring map to continue to develop as further evidence becomes available.

We structure our assessment of adaptation in this sector around a monitoring map identifying clear outcomes, enabling factors and policy milestones to bring them about (Figure 14.1).

To deliver a well-adapted financial system, we identify several required outcomes that need to be achieved:

- **All financial institutions incorporate physical risks into financial decision-making**. Understanding and integrating into decision-making the potential physical risks can help to steer capital towards activities that are adapted to a changing climate, as well as avoid investment in activities that increase climate risks (maladaptation).

The UK has one of the largest financial sectors globally that could be mobilised to deliver high quality adaptation financial services.

- **UK financial services are a global leader in adaptation.** The UK has one of the largest financial sectors globally that could be mobilised to deliver high quality adaptation financial services and products to enable wide-spread action in the UK and abroad.

- **No viable adaptation project fails for lack of finance**.* Increasing the UK's climate resilience requires investment at many scales. Lack of available and appropriately priced finance can limit the projects which go ahead. Financial institutions' contribution to providing insurance, lending and investment is key to enable implementation of adaptation measures by businesses and households.

- **Risks and actions are disclosed and managed by financial institutions**. Undertaking robust climate risk assessments enables financial institutions to identify the necessary adaptation actions. Creating a transparent information disclosure regime can provide a foundation that creates accountability and drives effective adaptation action, particularly by investors.

Enabling factors that need to be in place to deliver these outcomes are wide-ranging and include:

* We use the term 'viable' to mean adaptation projects with benefits exceeding costs.

- **Governance** measures to embed consideration of climate-related risks into financial conduct, macroprudential, microprudential, and monetary policy decision-making. Enforcement of high-quality climate-related reporting by financial regulators is needed, along with a functioning internal climate risk governance system of financial service providers, assigned responsible owners and internal committees.

- **Engagement and education** to build skills across financial institutions in areas such as: risk assessment, scenario analysis, and how to successfully raise finance for adaptation. This can be supported by an increased availability of modelling tools to assess physical risks. Engagement is needed to build awareness of adaptation by corporates and households, and awareness of insurance options.

- **Funding and investment** such as adaptation-linked financial products or government funding for pilots and supporting new markets. Key is to develop financial instruments that monetise adaptation and insurance products designed for adaptation.

Robust data collection is crucial for monitoring financial flows to adaptation.

- **Data and monitoring** that covers corporate assets and financial flows to adaptation, along with establishing ways to verify adaptation plans, and quantify the effectiveness and return on investment of adaptation actions.

- **Research** to support development of mechanisms to direct finance towards adaptation and identify opportunities for new adaptation goods and services.

To increase the prevalence of the enabling factors and deliver the identified outcomes consistent with a well-adapted financial system, we have identified a number of key policy milestones that are required from Government.

- **Legislation and regulation**. Adaptation needs to be incorporated into the mandates of public finance institutions with supervisory expectations and regulations set, including over bank and insurer capital requirements. This should be supported by a sustainable finance taxonomy that considers adaptation and a mandatory disclosure regime of climate risks and adaptation responses.

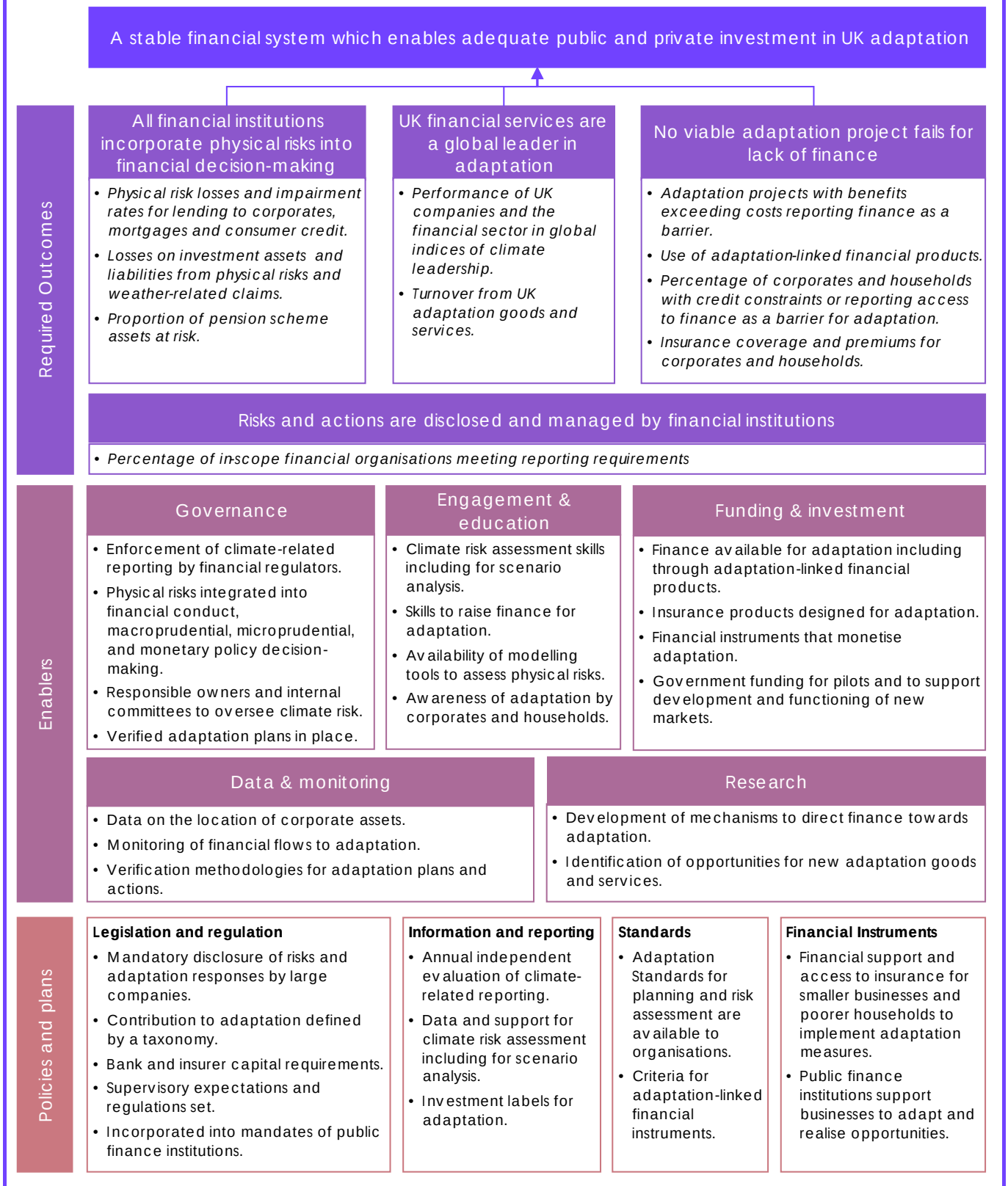
- **Information and reporting**. Annual progress reviews of climate-related reporting can contribute to high levels of transparency and identification of areas for action. A robust data ecosystem is needed for climate risk assessments, independent evaluation, and for creating investment labels for adaptation.

- **Standards.** Consistent standards and criteria for adaptation planning, risk assessment and adaptation-linked financial instruments.

Targeted financial support will be needed for households and businesses to adapt.

- **Financial instruments.** Funding provided for adaptation directly from national or local government or its agencies. This could be in the form of funding for ongoing operational expenditures or capital funding (e.g. grants) for upfront investment. This could also include targeted financial support and access to insurance for smaller businesses and poorer households to implement adaptation measures and also realise opportunities, such as reduced insurance or mortgage premiums.

Figure 14.1 Monitoring map for finance



Source: CCC analysis
Notes: Italicised text indicates suggested measures for each outcome.

In this section we assess available evidence and indicators on the delivery and implementation of each of our identified adaptation outcome for the finance sector in turn.

(a) Outcome 1: All financial institutions incorporate physical risks into financial decision-making

Progress on this outcome is **unable to evaluate** due to a lack of consolidated information. Available indicators suggest some progress in considering climate impacts, but it is unclear if this translates into reduced financial exposure to climate hazards due to lack of accessible time-series data, such as losses on investment assets from physical risks.

It is acknowledged across financial actors that current climate scenario analysis exercises are at an early stage, given the complexities of scenario analysis and climate risks modelling, as well as the lack of necessary data.[5]

Scenario modelling can give an initial, yet uncertain, assessment of potential financial losses due to climate change.

- **Significant losses on investment assets and liabilities for the UK financial system is plausible under higher levels of future climate change.**
  - The Bank of England Climate Biennial Exploratory Scenario (CBES) was conducted for the first time in 2021 (Box 14.2). This exercise found in the modelled scenario in which no additional action is taken to tackle climate change, insurers projected a 50% rise in average annualised financial losses on UK exposures by 2050 compared to 2020. The largest increases in projected insurance losses are a result of flooding in the UK (Figure 14.2).[6] Findings of the CBES exercise also project a drag on profits of banks and insurers based on current portfolios if physical climate risks are not effectively managed.[7]
  - There is a lot of uncertainty for these projections given current immaturity of firm approaches and complexity of modelling. It is positive the assessment considers adaptation plans that are already being implemented and are highly likely to be completed.[8] When CBES is repeated there will be more information about how risks and expected losses under future climate change are changing over time.

Box 14.2
The Bank of England's Climate Biennial Exploratory Scenario

The Bank of England has set a climate objective of ensuring the macroeconomy, the financial system, and the Bank of England itself are resilient to the risks from climate change and playing a leading role in supporting the transition to a Net Zero economy.

As part of its Climate Biennial Exploratory Scenario (CBES) it ran an exploratory scenario exercise on climate risk, involving the largest UK banks and insurers.

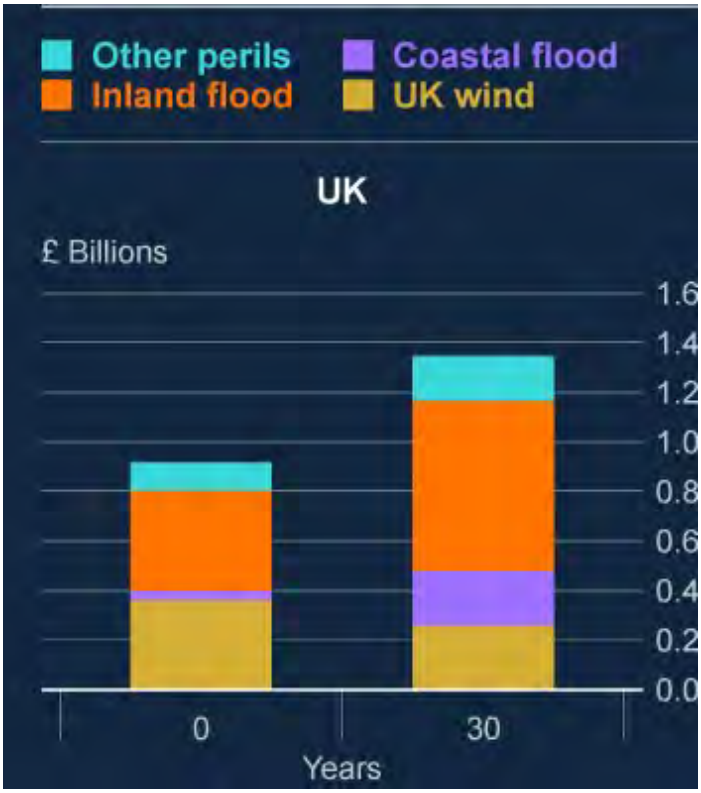
The CBES scenarios are not forecasts of the most likely future outcomes. Instead, they are plausible representations of what might happen based on different future paths of climate policies, technological developments and consumer behaviour, aimed at limiting the rise in global temperatures. Each scenario is assumed to take place over a period of 30 years.

Some of the key messages from the results were:

- Over time climate risks will become a persistent drag on banks' and insurers' profitability – particularly if they don't manage them effectively. While they vary across firms and scenarios, overall loss rates are equivalent to an average drag on annual profits of around 10-15%.
- Costs to the financial sector will be substantially lower if early, orderly action is taken. For example, projected climate-related bank credit losses were 30% higher in the Late Action (LA) scenario than the Early Action (EA) scenario. Among other factors, this reflects that in the scenario, adjusting late and abruptly to climate risk triggers a messy recession – with rising unemployment as the corporate sector adjusts.
- No Additional Action (NAA) on climate delivers the worst outcome from the considered scenarios. The NA scenario results in severe negative outcomes for life and general insurers over the next 30 years. UK and international general insurers, respectively, projected a rise in average annualised losses of around 50% and 70%. These costs would likely be passed on to consumers through higher premiums. Under this scenario, there would be a reduction in access to lending and insurance for sectors and households assessed as being more vulnerable to climate change.

Source: Bank of England (2022) *Results of the 2021 Climate Biennial Exploratory Scenario (CBES).*

Figure 14.2 Average annual losses on liabilities in CBES No Additional Action scenario

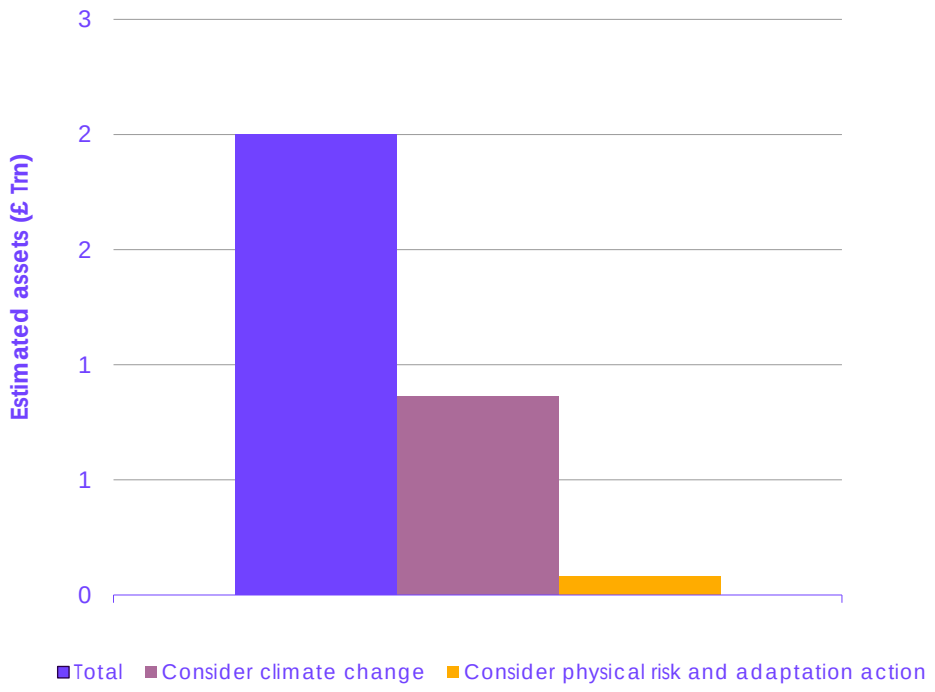


Source: Bank of England (2022) *Results of the 2021 Climate Biennial Exploratory Scenario (CBES).*
Notes: Chart shows most material three perils in terms of their impact on US and UK general insurance losses. 'Other Perils' includes freeze-thaw weathering and subsidence.

- **Financial exposures to physical climate risks in the UK are beginning to be better understood, but gaps remain.** Over the long-term the global exposure to the UK through the finance sector is deemed to be significant as it is highly networked and exposed to risk overseas.[9] The proportion of pension scheme assets at risk is not available. This creates significant knowledge gaps, particularly because occupational pension schemes in the UK hold almost £2 trillion in assets, making them the largest single group of institutional investors in the UK.[10]

- **A recent survey by The Pensions Regulator found that 43% of pension schemes took account of climate change when formulating their investment strategies.** But, for those that did consider climate change, physical risk and subsequent adaptation actions were overlooked, with only 4% giving very significant consideration to physical risks in investment and funding strategies (Figure 14.3).[11]

Figure 14.3 UK pension schemes and consideration of physical risk



Source: The Pensions Regulator (2021) *Climate adaptation report.*

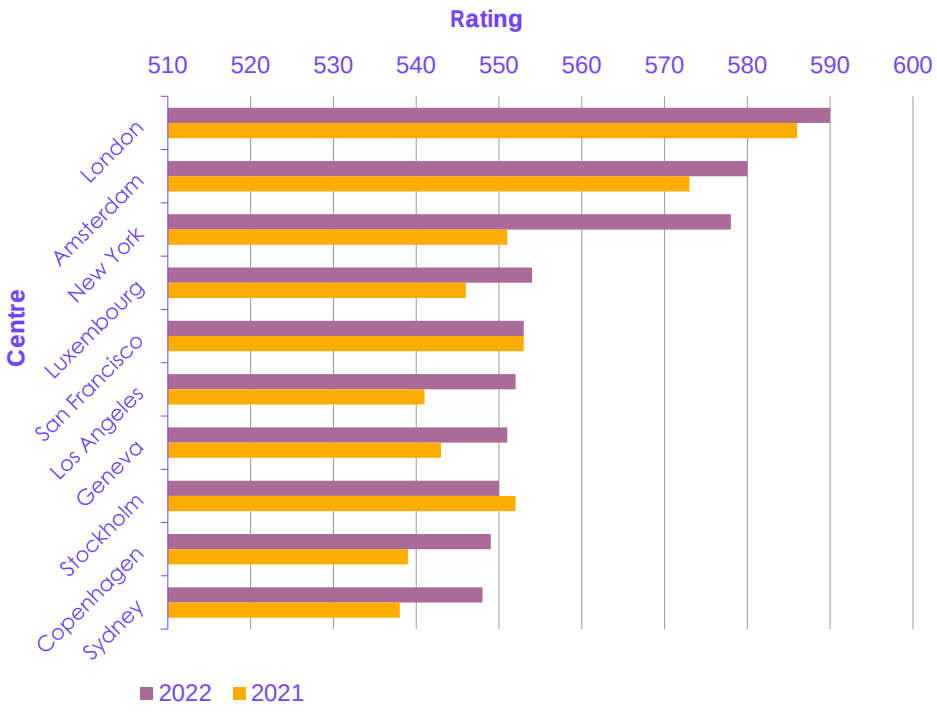
(b) Outcome 2: UK Financial Services are a global leader in adaptation

A lack of comparable adaptation finance indices makes progress on this outcome **unable to evaluate.** Whilst the UK ranks highly on some green finance indices, these focus on a broad set of green finance objectives rather than adaptation. There is also a lack of publicly accessible data to assess UK exports of adaptation goods and services.

There is little evidence that insurance products have clear conditions, requirements, or incentives for policyholders to adapt to the potential risks.

- **The UK performs well in global rankings of financial sector climate leadership, but these are not specific to adaptation.** London is considered a leading hub globally for green finance – ranked first in the world, overtaking Amsterdam, according to a recent index (Figure 14.4).[12] In 2021, the UK also ranked 5th among countries in green bond issuance with issuance of around $30 billion.[13] London operates a global insurance market with particular products covering both direct climate change events such as property damages or agricultural losses as well as indirect impacts such as business interruption, but there is little evidence that these insurance products have clear conditions, requirements, or incentives for policyholders to adapt to the potential risks.[14]

Figure 14.4 Global Green Finance Index 2022



Source: Long Finance & Financial Centre Futures (2022) *The Global Green Finance Index 10.*
Notes: 'Rating' is assessed across the depth to which green finance has penetrated the business of the financial centre question and the quality of the green finance products and services on offer.

(c) Outcome 3: No viable adaptation project fails for lack of finance

There is **insufficient progress** for this outcome. Evidence indicates significant additional investment is needed to close adaptation funding gaps in multiple key areas (flooding, public water system, reducing overheating in homes) required to build climate resilience, and that other significant investment gaps remain.[15]

The current level of understanding of investment levels in adaptation remains very low.

- **Financial flows for adaptation are not well tracked.** The current understanding of investment levels in adaptation remains very low and there is no systematic tracking of possible maladaptation due to investment decisions. There is no systematic data on use of adaptation-linked financial instruments in either the public or private sectors. New data and analytics are required for measuring how portfolios and loan books contribute to fragility and maladaptation, as well as adaptation and resilience.

- **Viable adaptation projects are highlighting access to finance as barrier.***

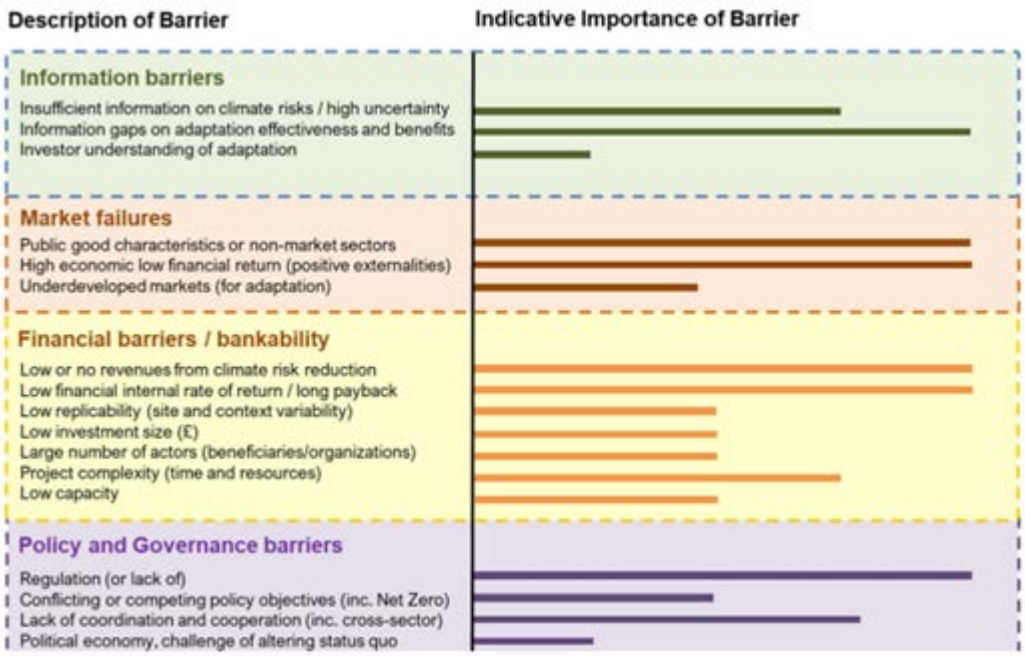
  – Whilst there is not currently systematic data available on number of viable adaptation projects failing to be implemented due to lack of finance, a body of research points towards the prevalence of barriers currently in place for accessing adaptation finance.[16,17]

* We use the term 'viable' to mean adaptation projects with benefits exceeding costs.

Barriers to adaptation finance are prevalent across financial, information, behaviour and market issues.

– Despite the evidence of high cost-benefit ratios for certain adaptation interventions, in most areas of adaptation there is often no clear revenue stream to provide returns to investors. This lack of a financial return in order to repay upfront funding is a fundamental barrier for attracting funding and finance from non-public sources. Information barriers and low levels of existing skills and expertise are also common.[18] The CCC's recent 'Investment for a well-adapted UK' report highlights this alongside other barriers limiting investment in building resilience in the UK across markets, information, bankability, policy and regulation, and behaviour (as shown in Figure 14.5).

Figure 14.5 Barriers to adaptation investment and their indicative importance



Source: Frontier Economics and Paul Watkiss Associates (2022) for the CCC. *Barriers to Financing Adaptation Actions in the UK.*

- **Case studies demonstrate some positive progress, but barriers to investment remain.** Nature-based solutions (NbS) to help manage flood risk can provide one example. The Government has committed to public money for public goods in nature and land management, alongside initial plans to leverage private finance, but this has not yet overcome the barriers that exist to the required investment in adaptation. The potential public and private funding streams for nature-based solutions to help manage flood risks can offer insights and lessons for wider adoption (Box 14.3).

Box 14.3
Potential revenue streams for nature-based solutions projects that reduce vulnerability to flood risks

Nature-based solutions (NbS) can help build the resilience of the natural environment to climate change impacts through actions to protect, sustainably manage and restore natural or modified ecosystems in both urban and rural areas.

Public funding - Environment Land Management schemes funding

- The Environment Act 2021 will establish incentives for landowners to implement NbS through the Environmental Land Management schemes (ELMs).
- If designed and implemented well, payments from ELMs could be a valuable revenue stream to support investment in NbS to reduce vulnerability to flood risk.
- There is significant potential for public funding sources to support NbS for flood risks, via ELM payments. Streams such as ELM could additionally leverage private investment alongside public money in encouraging delivery of climate adaptation outcomes, including flood management.

Other private revenues

- There are a number of potential private investment sources that could help support investment in NbS to reduce flood risk.
- These generally depend on markets for ecosystem services created by regulation (e.g. biodiversity net gain) or corporate Environmental, Social and Governance (ESG) commitments.
- Climate resilience benefits may often be realised as a co-benefit to a wider environmental benefit (such as carbon storage) that is monetised within these markets.

Source: CCC (2023) *Investment for a well-adapted UK.*

- **Flood insurance coverage is in place for households, but there is a modelled reduction in access to lending for those corporate sectors most exposed to physical climate risks.**

More households at risk of flooding can access multiple insurance quotes.

  - **More households at risk of flooding can access multiple insurance quotes.** The proportion of at-risk households with recent flood claims (in the last 5 years) able to obtain more than 10 different quotes for insurance has steadily increased since the introduction of Flood Re (Box 14.4), from 1% in early 2016 to a high of 98% in November 2021.[19]

  - **There is a lack of available data about the impact of adaptation measures on size of insurance pay-outs despite good evidence of the cost effectiveness of many adaptation measures.** Data from insurance providers could enable better tracking of the preparedness and risk assessment of buildings**.** For example, data from the Association of British Insurers suggests that the average domestic flood insurance claim value in 2021 was £20,094. This is in comparison to £2,771 for other domestic weather-related claims.[20] However, it remains unclear what role resilience measures play in determining the size of pay-outs and how this is reflected in insurance modelling and pricing.

  - **Findings from the Bank of England's Climate Biennial Exploratory Scenario (CBES) exercise imply a potential future material reduction in access to lending and insurance for sectors which were most exposed to physical risks**.[21] For physical risk exposure, sectors with the highest projected impacts included manufacturing, crop and animal production, and forestry and fishing.[22]

Box 14.4
Flood Re and flood insurance accessibility

Flood Re is a reinsurance company. It allows other insurance companies to insure themselves against losses because of flooding. This means that people who own and live in properties at flood risk areas are more able to access affordable home insurance.

Flood Re was established by Government legislation in 2016, to replace previous agreements between government and insurance companies to provide flood insurance coverage to domestic properties at risk of flooding. It is a not-for-profit, publicly accountable fund. The set-up costs were covered by the insurance industry, and the pool of money to cover claims comes from a charge for each policy which is passed to Flood Re and an additional £135 million annual levy from all home insurers in the UK.[23,24]

Source: ABI (2023) *Flood Re Explained*; Flood Re (2023)

(d) Outcome 4: Risks and actions are disclosed and managed by financial institutions

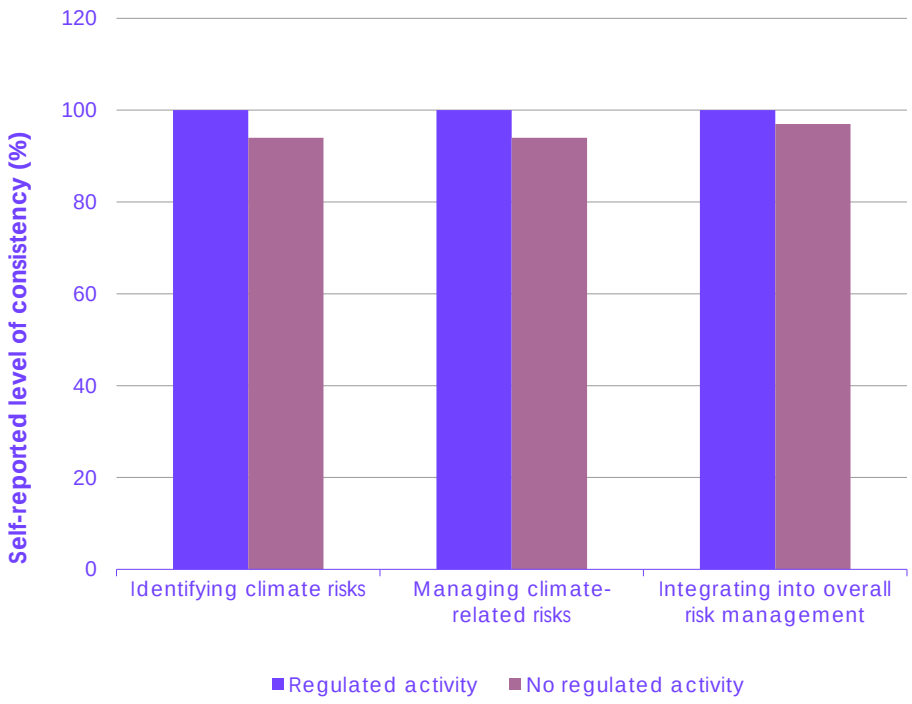
Further changes are urgently needed to improve disclosures to aid understanding of investment in adaptation and maladaptation.

There is **mixed progress** on this outcome, with disclosure coverage growing but gaps found in relation to reporting on adaptation action and risk management. Further changes are urgently needed to improve disclosures to aid understanding of investment in adaptation and maladaptation.

- **Whilst companies engaged in Financial Conduct Authority (FCA) regulated activity indicated high levels of alignment with the Task Force for Climate-related disclosures (TCFD), this is only the first step to managing physical climate risks.** The 2022 review of the TCFD disclosures by the FCA and the Financial Reporting Council (FRC) found that companies engaged in FCA-regulated activity (e.g. banks, insurance companies and other financial service companies) indicated higher levels of alignment for each of the eleven recommended disclosures (Figure 14.6).[25] However, there is little disaggregated information that separates physical climate risks from transition risks and information on adaptation efforts subsequently undertaken.

- **By the end of 2023, 81% of occupational pension scheme assets are expected to be in schemes making disclosures in line with TCFD recommendations**.[26] Yet, TCFD is currently weak on adaptation disclosures and data regarding actions taken. There is a need for more guidance and comparable reporting schemes that focus on adaptation action, rather than solely risk disclosure.

Figure 14.6 FCA-regulated organisations reporting



Source: Financial Conduct Authority (2022) *TCFD aligned disclosures by premium listed commercial companies.*
Notes: Chart shows most material three perils in terms of their impact on US and UK general insurance losses. 'Other Perils' includes freeze-thaw weathering and subsidence.

(e) Progress on enablers

There are very limited data available relating to enabling factors. Overall, an adaptation investment gap remains for the UK with the need to develop adaptation-linked financial products.[27] Whilst steps are being taken towards formalising the consideration of climate risks across financial institutions' decision-making (such as the Bank of England), it is in the early stages. More engagement and education is needed across financial institutions to build the necessary skills, as the current level of understanding of physical climate risks and investment in adaptation remains very low.

More engagement and education is needed across financial institutions to build the necessary skills to deliver effective adaptation actions.

Data and scenario analysis also remain a challenge for many financial institutions due to insufficient information on climate risks, and the benefits and effectiveness of adaptation options.[28] Many financial institutions are facing challenges in quantifying physical climate risk, with few having in-house modelling capabilities and most relying on a small number of third parties.[29] Progress has been significantly hampered by a lack of standardised data of sufficient quality to carry out risk assessment, such as the location of corporate assets.[30] Some key research is in the pipeline, for example the Prudential Regulation Authority (PRA) and the Bank of England will undertake further analysis to explore enhancements to the regulatory capital frameworks.[31]

In our 2021 Progress Report, recommendations focused around developing further ways to embed climate risk in financial decisions by UK financial institutions. It was also recommended to consider making adaptation plans mandatory for financial institutions and monitoring financial flows into climate action. Progress towards these recommendations and required outcomes are detailed below.

(a) Outcome 1: All financial institutions incorporate physical risks into financial decision-making

The key policy milestones required for this outcome are partially in place. The policy score for this outcome is **limited**. There have been positive efforts to consider adaptation across the UK's financial regulators and other financial institutions, but it is still nascent and lacks information on adaptation actions taken and an assessment of their effectiveness.

- **Information and reporting.**
  - Three financial regulators (Financial Conduct Authority, Prudential Regulation Authority and The Pensions Regulator) submitted Adaptation Reporting Power (ARP) reports setting out plans to embed adaptation in regulation and decisions of firms they regulate, but plans are still nascent and lack detail.
  - The Climate Financial Risk Forum and the Network of Central Banks and Supervisors for Greening the Financial System (NGFS) have published guidance on scenario analysis and bridging data gaps, though these mainly highlight challenges rather than solve these issues.[32,33,34]
  - In April 2022, HM Treasury launched the UK Transition Plan Taskforce (TPT) to support companies in developing and disclosing transition plans.[35] The TPT published its disclosure framework and implementation guidance for consultation in November 2022, which encouragingly also includes climate resilience and adaptation.

The recent Transition Plan Taskforce work programme encouragingly also includes climate resilience and adaptation.

- **Legislation and regulation.**
  - In 2021 the Government announced new Sustainability Disclosure Requirements (SDR) which bring together existing sustainability requirements, build on the UK's implementation of the recommendations of the TCFD, and make use of international standards. It includes disclosure requirements related to corporates, asset managers and asset owners, and creators of investment products.
  - The Government's Green Finance Strategy and its subsequent Roadmap seeks to 'green' the financial system to deliver on the Government's commitments for climate and nature restoration. The update to the Green Finance Strategy in 2023 should set out steps to ensure that the UK SDR initiatives (including the UK Green Taxonomy) are effective in improving understanding of adaptation investment needs, directing finance towards adaptation and ensuring that

regulators and auditors have the necessary expertise to monitor the quality of reporting and provide incentives for organisations to report on their adaptation actions.

  - In October 2021, the UK was the first country in the world to require trustees of occupational pension schemes to identify, manage, and report on the climate-related risks and opportunities within their portfolios. This is a welcome development, though reviews conducted suggest that significant progress needs to be made for this to be effective.[36]

(b) Outcome 2: UK financial services are a global leader in adaptation

The key policy milestones required for this outcome are not in place. The policy score for this outcome is **insufficient.**

- **Legislation and regulation.** The Government's Green Finance Strategy lays out high-level plans for seizing opportunities related to climate finance. There is a growing focus on adaptation, but this is still under development. The consideration of transition plans within the UK's SDR was a leading step forward.

- **Standards.** There is a need to accelerate the level of climate expertise across financial institutions if the UK is to become a global leader in adaptation. Supporting this with consistent standards for climate risk assessment and management, along with adaptation-linked financial instruments is a current gap.

Flood Re is an example of how insurance schemes can support adaptation.

- **Financial instruments.** Flood Re is an example of how insurance schemes can support adaptation through 'building back better' approaches after flood events. The not-for-profit insurance pool started offering discounted reinsurance in 2016. It was established through legislation and is owned and managed by the insurance industry. The pool caps domestic flood insurance prices to keep insurance premiums affordable in areas of higher flood risk. Its new 'Build Back Better' scheme is an important effort to increase flood resilience and offers a good example of how the insurance industry can support climate change adaptation. Consideration should be given to what replacement or similar insurance initiatives can and should look like and the contribution these can make to scaling private and household investment in climate adaptation.

(c) Outcome 3: No viable adaptation project fails for lack of finance

The key policy milestones required for this outcome are not in place. The policy score for this outcome is **insufficient**. Adaptation is not included in public financial institutions' climate strategies yet and there are limited broader plans for adaptation-linked financial instruments.

National policy frameworks do not provide a clear indication of the balance of public and private investment needed in different areas of adaptation.

- **National policy frameworks do not provide a clear indication of the balance of public and private investment needed in different areas of adaptation.** This is currently holding back private sector investment as businesses may expect adaptation actions to be paid for by Government or to be compensated for the damage from extreme weather and climate

events. This expectation of government support in times of loss can reduce willingness to invest in adaptation.

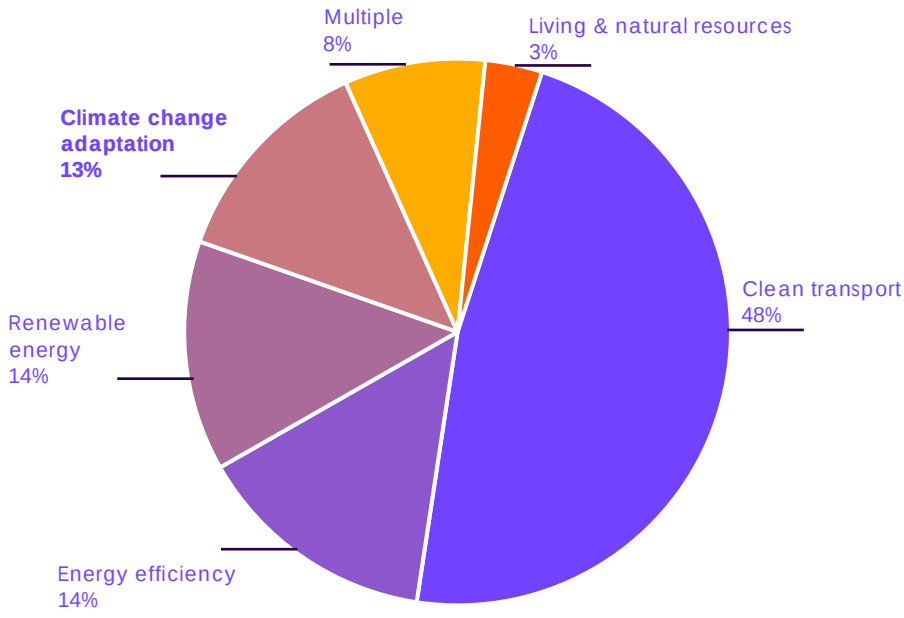
- **Since 2021, several of the UK's public financial institutions have further developed their climate change strategy although overall interventions focused on adaptation remain low.**

UK public financial institutions should create adaptation finance strategies.

  - The British Business Bank aims to drive sustainable growth and prosperity across the UK, but it currently has no programmes specific to climate change adaptation.[37] The UK Infrastructure bank also has been established to stimulate investment in infrastructure, but it is focussed more on Net Zero and less on climate resilience. UK public financial institutions (such as the UK Infrastructure Bank, British Business Bank, UK Export Finance, and British International Investment) should create adaptation finance strategies.

  - In June 2021 the Government published its Green Financing Framework to outline how funds leveraged from Government green bonds and gilts will be spent (Figure 14.7).[38] Adaptation was included as one of the eligible green expenditures, yet the only unique expenditure category for climate change adaptation was the EA Floods Programme for c.£1 billion per year.[39] Government already provided similar funding for flooding before the introduction of the Green Bonds and Gilts.

Figure 14.7 UK Green Finance Allocation 2020-2022



Source: HM Treasury and UK Debt Management Office (2021).
Notes: Figures include total of 2020-21 and 2021-22 allocation. Pollution Prevention and Control accounted for <1% and is not included.

- **Currently a lack of incentives to act and a low awareness of the benefits of adapting to climate risks prevent property owners from investing.**

  – Flood Re's 'Build Back Better' scheme will support homeowners to install Property Flood Resilience (PFR) of up to £10,000 above insurance claims. This is funded from the same pool of funds used to cover claims.[40] This is good progress, but it is important to note that this is currently the only adaptation mechanism that Flood Re has in place. Further incentives for PFR installation for homeowners and new build developers are required to ensure properties are sufficiently protected.

Further incentives for adaptation measures for homeowners are required to ensure properties are sufficiently protected.

  – The Government did not take forward proposals for reduced insurance premiums for households with PFR. There are currently no subsidies or taxes to incentivise PFR in non-residential buildings, and limited support for vulnerable households. Water and sewerage companies can also provide a source of funding for PFR grants – and help with project delivery – in addition to government schemes (see Chapter 10 for more info).

- **Policy action to create new markets and obligations on private enterprise to foster climate resilience is needed.** Private enterprise needs to invest in the aspects of resilience for which they are key beneficiaries, financed through either financial markets or internal investment. Depending on the sector, the business may be able to pass on some of the costs of the adaptation investment through to their customers. Policy action to create new markets and obligations on private enterprise to foster climate resilience, such as the requirement to ensure biodiversity net gain for planning applications, can also help private enterprise to contribute to investment in wider aspects of climate resilience (see Chapter 13 for more information).

Government should prioritise creating markets for adaptation outcomes across relevant legislation and policy programmes.

- **Standards.** Markets and revenues for adaptation investment often need to be created by effective regulation and standards. Government should set standards for resilience-linked financial instruments such as resilience bonds. Government should also prioritise creating markets for adaptation outcomes across relevant legislation and policy programmes, including initiatives on carbon market integrity and the Environmental Land Management Schemes.[41]

- **Legislation and regulation.** Establishing standard criteria for 'good' adaptation actions can help build investment confidence. As the UK develops its Green Taxonomy, more detailed work is needed on defining the technical screening criteria for adaptation.[42] A Land Use, Nature and Adapted Systems Advisory Group has now been established to advise on the design and implementation of an enhanced set of adaptation Technical Screening Criteria.

(d) Outcome 4: Risks and actions are disclosed and managed by financial institutions

The key policy milestones required for this outcome are partially in place. The policy score for this outcome is **limited**. There has been increased uptake of initiatives for climate-related financial disclosures, which have raised the profile of the economic consequences of climate change impacts and the need for adaptation. But this should be extended to further capture adaptation actions and track investment more effectively.

The FCA have extended the application of its TCFD-aligned Listing Rule for premium-listed commercial companies to a wider scope of listed issuers.

- **Legislation and regulation.** The UK Government has taken actions such as making climate-related reporting mandatory for listed companies and is developing a UK Green taxonomy, that will include climate change adaptation. The FCA have extended the application of its TCFD-aligned Listing Rule for premium-listed commercial companies to a wider scope of listed issuers and introduced TCFD-aligned disclosure requirements for asset managers and asset owners (including life insurers and FCA-regulated pension providers). However, in part because progress on reporting of physical climate risks and in particular their financial impacts has been slow and is inherently more complex, these initiatives do not yet provide an accurate understanding of risk or what investment needs might be required.[43]

The next scenario exercise should provide a clearer longer-term view to informing regulatory requirements.

- **Information and reporting.** The UK is contributing to the development of the Task Force for Nature Related Disclosure (TNFD). This provides a reporting framework for financial institutions' processes regarding identifying, assessing, and managing nature-related risks. This can help increase organisational knowledge on the interplay between nature and the economy, along with the potential for 'adaptation services' that nature provides. Together this could increase investment into nature-based adaptation. The first TNFD framework will be released in September 2023, initially on a voluntary basis for UK reporting organisations.[44] The Bank of England's CBES exercise (Box 14.2) concluded that Banks have made good progress in integrating climate risk into their governance and reporting frameworks and identifying portfolios most at risk of climate change. However, many face challenges in quantifying this risk, with few having in-house modelling capabilities and most relying on a small number of third parties. Progress has been significantly hampered by a lack of standardised data of sufficient quality to carry out risk assessment, such as the location of corporate assets. The next exercise should build upon the 2021 process to improve capabilities and provide a clearer longer-term view to inform regulatory requirements.

(e) Recommendations to close policy gaps

Although there has been progress since our last report in 2021 (Box 14.5) significant policy and planning gaps remain in this area. We provide a set of targeted recommendations to close those gaps (Table 14.2).

Box 14.5
Policy developments since 2021

Legislation and regulation:

- In 2021 the Government announced new Sustainability Disclosure Requirements (SDR) and an accompanying Roadmap to Sustainable Investing.[45] SDR is made up of several different parts which cover adaptation.
- The Green Technical Advisory Group published advice to Government on the development of the UK Green Taxonomy in October 2022. A Land Use, Nature and Adapted Systems Advisory Group has now been established to advise on the design and implementation of an enhanced set of adaptation Technical Screening Criteria.
- Task Force for Climate-related disclosures (TCFD)
  - October 2021: Regulations requiring trustees of occupational pension schemes with more than £5 billion in net relevant assets as well as all authorized master trust schemes and authorized collective money purchase schemes to make TCFD-aligned disclosures enter into force.

Occupational pension schemes with more than £1 billion in net relevant assets are subject to the regulations as of 1 October 2022.

  - December 2021: FCA extends application of climate-related disclosures effective from 1 January 2022 to the largest asset management firms (those with over £50 billion in assets under management) and largest asset owner firms (those with assets over £25 billion), and from 1 January 2023 for smaller firms.

  - TCFD alignment should require reporting organisations to carry out and report the results of scenario analysis, including adaptation options, however most climate scenarios used in TCFD reporting to date have rudimentary assumptions about adaptation and many TCFD reports do not feature adaptation at all.

- April 2022, HMT launched the UK Transition Plan Taskforce (TPT) to support companies in developing and disclosing transition plans.[46] This predominantly covers climate change mitigation but also climate resilience and adaptation. There will be a Transition Plan Taskforce Adaptation Working Group starting in 2023.

Financial instruments:

- In June 2021 the Government published its Green Financing Framework to outline how funds leveraged from Government green bonds and gilts will be spent. Adaptation was included as one of the eligible green expenditures.[47]

- Following the Flood Reinsurance (Amendment) Regulations in April 2022, a new scheme document allows Flood Re to pay claims from participating insurers which include a resilient repair amount up to £10,000 above the cost of like-for-like reinstatement of flood damage – known as 'Build Back Better'. These regulations extend to England, Wales, Scotland, and Northern Ireland.[48]

- UK Export Finance (UKEF) published its first climate change strategy in September 2021, committing it to increasing its support to clean growth and climate adaptation, understanding and mitigating its climate-related financial risks, and providing international leadership on climate change among export credit agencies and relevant financial institutions. It has put in place a £2 billion direct lending facility dedicated to financing clean growth projects and has stated a strategy of 'focused alignment' with the Sustainable Development Goals to support adaptation and resilience but it is not clear what this means in practice.

- The UK Infrastructure Bank (UKIB) was launched in 2021, tasked with accelerating investment into ambitious infrastructure projects. Investment is likely to be heavily weighted towards energy projects, reflecting their importance to the UK's Net Zero and energy security ambitions. The strategic plan states that the banks' ESG policy and framework will be developed to incorporate resilience to climate change as an additional pillar.

Information and reporting:

- The first CBES exercise conducted by Bank of England provided useful data and highlighted data gaps for physical risks and areas of improvement for banks and insurers in planning for climate risks.

- The Bank of England hosted a conference on climate change and capital requirements and the FCA begun doing work on sustainable investment labels to prevent greenwashing, although not specific to adaptation

- It is good progress that financial regulators were invited to participate in ARP, but it remains voluntary. Three (FCA, PRA and TPR) reported in 2022.[49]

- In November 2022, TNFD released the third version of its beta framework for market consultation. Release of version v1.0 of the full framework for market adoption will be in September 2023. Requires reporting of nature-related financial risks and opportunities on companies' financial accounts (income, balance sheet, cashflow). These include nature-based solutions for adaptation.

Table 14.2
Recommendations

Primary responsibility	Recommendation	Timing
OBR	The Office for Budget Responsibility should undertake a full review of how the impacts of climate change in the UK will affect the UK's macroeconomic performance and public finances, building on the analysis in their 2021 Fiscal Risks Report, to enable a full-cost benefit analysis for public investment in adaptation.	2023
UK Public finance institutions	UK public financial institutions (such as the UK Infrastructure Bank, British Business Bank, UK Export Finance, and British International Investment) – should create adaptation finance strategies, setting out how they will independently and collectively ensure that no viable UK climate adaptation project fails for lack of finance or insurance.	2023
UK Public finance institutions	UK public financial institutions should launch new sustainability-linked instruments tied to adaptation outcomes to help prime the market, potentially by offering guarantees to private issuers and lenders for adaptation-linked instruments.	2024
HMT, Bank of England	The Bank of England should examine how capital requirements for banks and insurers should be adjusted based on assessed climate risks in terms of how assets are impacted by climate risk, how existing and planned adaptation will influence this, and how some assets create climate risk and contribute to greater societal risk and fragility.	2023
HMT, Financial regulators	Financial regulators should provide directional guidance for financial institutions to measure physical climate risk and their contribution to climate adaptation (and maladaptation) outcomes across portfolios and loan books. This should be integrated into required climate-related disclosures as part of SDR, as well as enforced through microprudential supervision.	2024
HMT, DESNZ	The UK should build on the work of the Transition Pathways Taskforce (on Net Zero-related corporate transition plans) to define common standards for what a high-quality adaptation transition plan should look like. This should include how relevant physical climate risks are measured and managed as well as how the plans would contribute to wider societal adaptation to climate change.	2023
HMT, Defra, DESNZ	The updated Green Finance Strategy in 2023 and NAP3 should set out steps to ensure that the UK SDR initiatives (including the Green Taxonomy) are effective in improving our understanding of adaptation investment needs, directing finance towards adaptation and ensuring that regulators and auditors have the necessary expertise to monitor the quality of reporting, and provide incentives for organisations to report on their adaptation actions.	2023
HMT, Public Finance Institutions	Government and its implementing agencies should ensure that a growing fraction of their funding helps to support pioneering projects that seek to provide proof of concepts of how adaptation actions can be successfully funded and delivered through public-private partnership funding and financing.	Ongoing
DESNZ, ONS	Government can enable the provision of data as a public good. This could include directly investing in open risk and resilience data and metrics or developing platforms and tools to share relevant datasets, such as those collected by insurance companies.	2023
Bank of England	The interdependencies between physical, transition and liability risks must be considered for scenario analysis and stress testing. Stress testing of the financial system to climate change risks should be done regularly as data and methodological approaches improve our understanding of the risks and impacts.	2023

Defra, HMT, DESNZ	Government should prioritise creating markets for adaptation outcomes across relevant legislation and policy programmes, including initiatives on carbon market integrity and the Environmental Land Management Schemes.	2023
HMT, Defra	The refresh of the Green Finance Strategy in 2023, together with NAP3, should clarify where the Government expects adaptation actions to be funded through public sources and where private investment is expected. NAP3 should contain clear new funding commitments for investment in adaptation over the coming five year period and the breakdown across department budgets.	2023
Cabinet Office	The need for investment in adapting to climate change should be included within mandates/strategic priorities for all relevant regulated industry regulators and implementing agencies through resilience standards aligned to national-level objectives. There should be a duty for regulators to identify and create climate adaptation project pipelines, aligned with national adaptation objectives, and to set out how they will enable the realisation of that pipeline.	2028 at latest
UK Financial Regulators	Financial regulators in the UK should collaborate with international counterparts to establish a cost of capital observatory for physical risk, similar to efforts to track this for transition risk (for example by the International Energy Agency).	2023

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