Department for Environment Food & Rural Affairs

Accounting for the effects of climate change

Supplementary Green Book guidance

April 2025

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Chapter 1. Introduction and background

1.1 The purpose of the guidance

This supplementary guidance to HM Treasury's Green Book supports analysts and policymakers to ensure that policies, programmes and projects are resilient to the effects of climate change, and that such effects are being taken into account when appraising options.

This guidance:

- builds on the conventional Green Book appraisal methodology to account for the effects of climate change
- supports analysts and policymakers to identify if and how their proposals could be affected by climate risks
- supports analysts and policymakers to design adaptation measures in response to climate risks

  supports analysts to appraise the costs and benefits of policy options with climate change included in the baseline.

The focus of the guidance is to provide proportionate advice on accounting for the effects of climate change for analysts and policymakers. For additional technical guidance on appraising the effects of climate change consult **Annex D** for further resources.

Please note that while this guidance uses examples of adaptation to flooding, projects seeking funding from the Flood and Coastal Defence Grant-in-Aid (GiA) for flood works should refer to the Environment Agency's own guidance on flood risk management.

1.2 The importance of considering the effects of climate change

Our climate has already changed and will continue to do so due to man-made greenhouse gas emissions. While reducing emissions has significant benefits, the effects of current emission cuts will only be seen after 2040 because of delays in the climate system. This means that further climate change is unavoidable for at least the next 15 years (Watkiss 2023). The UK contributes a relatively small share of global greenhouse gas emissions, so even if the government meets its Net Zero target, it is still possible for further warming of up to 4°C to occur this century.

Many policies, programmes and projects will be directly or indirectly affected by a changing climate (reflected in, amongst other things, their effectiveness and costs). The risks and effects of climate change can substantially impact on the value for money of these proposals in ways that can make a difference to decision-making (see **Section 4.1**). It may also be possible to build adaptation measures into policy options and this can affect the value for money they offer (see **Section 3.2**). Therefore, it is important to account for the effects of climate change and the value-for-money of climate resilient policy options in appraisal. This is distinct from a consideration of the social cost of emissions which is covered in a separate guidance document.

Chapter 2. Approach to climate resilient appraisal

2.1 When to conduct climate resilient appraisal

It is important to take a proportionate approach to climate risk appraisal. To determine whether following the additional steps in this guidance is necessary please consult the three screening questions in Table 1. If you answer 'Yes' to at least one question, your proposal is in-scope of the guidance. When answering the screening questions consider the following climate hazards (a fuller summary of climate risks is available in **Annex A**):

- **extreme weather events** (damage and disruption from flooding and storms)
- **sea-level rise** (damage and disruption from coastal flooding)
- **overheating** (impact on productivity and health)
- **drought** (impacts on production and supply-chains)

Table 1. Climate screening questions

Screening question	Guidance
1. Could vulnerability to climate change affect the success of your policy?	Consider how the success of your proposal would be affected by the impact of climate change on physical assets such as infrastructure, buildings, and equipment; people, including effects on health and productivity; nature, including the environment, animals, and resources; and the macroeconomy, including inflation, growth, and financial risk.
2. Could your policy increase vulnerability to the effects of climate change?	Consider whether your policy could increase the vulnerability of people, assets, animals, or the natural environment to climate risks. For instance, a policy that involves building non-resilient infrastructure could 'lock-in' higher climate risk for future users.
3. Could your policy increase resilience to the effects of climate change?	Consider whether your proposal potentially increases resilience to climate change. For example, investment in wetland restoration can have benefits for climate resilience.

Table 2. Examples of policies in and out of scope of the guidance.

Policy	In-scope	Rationale
A hospital building programme	Yes	This involves significant investment in physical assets that are potentially vulnerable to climate change and requires services from NHS staff who are potentially vulnerable to climate risks.
The Environment Act 2021	Yes	This legislation has policy goals that depend on the climate resilience of physical assets in the form of natural resources.
An investment in mental health support	Yes	This intervention has policy goals which are vulnerable to the impact of extreme heat on mental health.
Vapes and Tobacco Bill	No	This regulatory policy does not directly depend on physical assets or people vulnerable to climate change and does not increase risks for others.
Digital Markets, Competition and Consumers Act 2024	No	This regulatory policy does not directly depend on physical assets or people vulnerable to climate change and does not increase risks for others.
Increase in R&D investment	No	R&D investment is not directly vulnerable to climate impacts and is unlikely to directly impact on climate risk or resilience.

Figure 1 provides a triage decision making tool to identify the minimum appropriate appraisal approach given potential climate risk to the policy. The tool explains the steps for identifying if a Climate Risk Assessment (CRA) is needed and outlines a proportionate approach to incorporating climate scenarios.

Figure 1. Climate triage tool

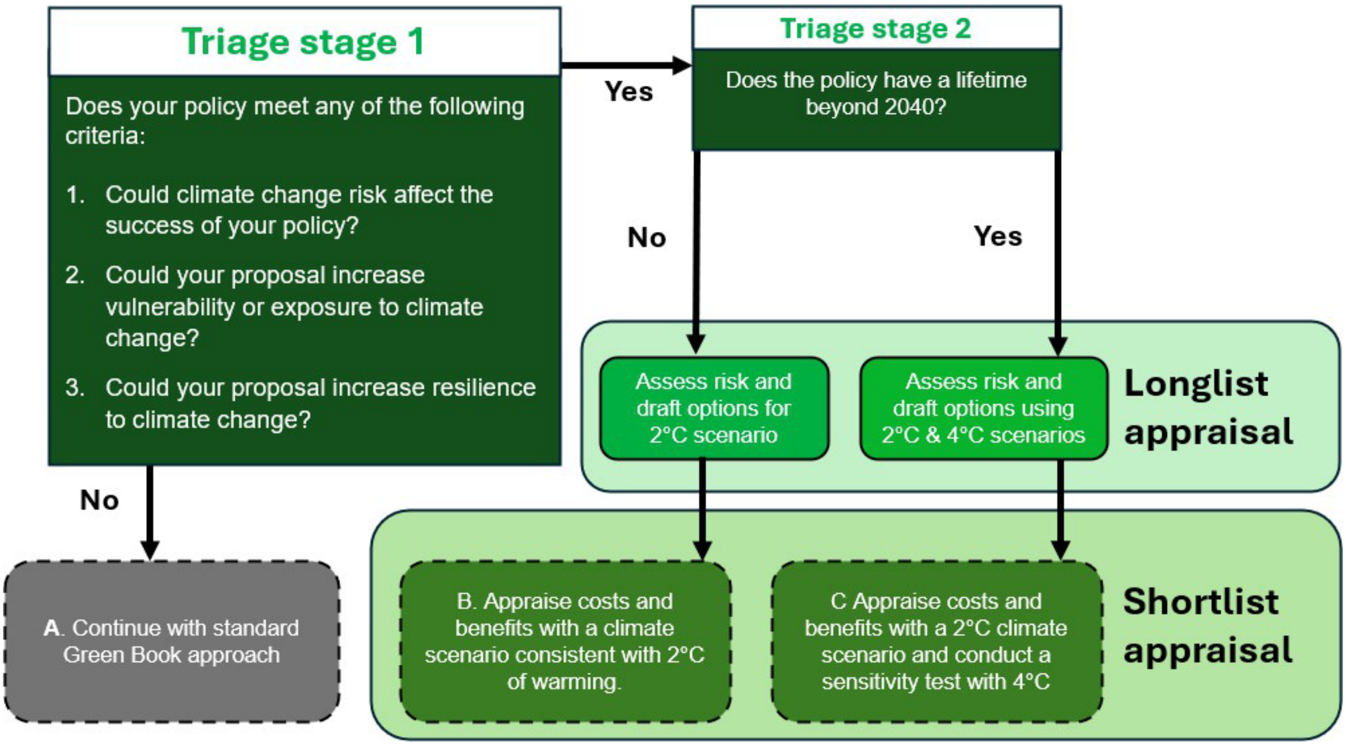


Figure 1 shows a decision-making tree. The first box is labelled 'Triage stage 1' which asks the 3 screening questions (1. Could vulnerability to climate change affect the success of your policy?', 2. 'Could your policy increase vulnerability to the effects of climate change?',3.. 'Could your policy increase resilience to the effects of climate change?'. If the answer to all 3 is 'No' then continue with the standard Green Book approach. If the answer to any of questions is 'Yes' then carry out a climate risk assessment. The next triage stage asks whether the policy has a lifetime beyond 2040. If 'No' then appraise costs and benefits using climate change scenario of 2°C of warming. If 'Yes' then appraise costs and benefits using climate change scenarios consistent with 2°C and 4°C of warming.

2.2 How to conduct climate resilient appraisal

This section outlines the approach and step-by-step process for climate-resilient appraisal. This guidance does not replace the Green Book approach. Rather, it builds on and elaborates it to explicitly account for the effects of climate change, ensuring decisions are resilient to future risks. In practice, economic appraisal that fully account for the effects of climate change build neatly on the Green Book approach (as shown in Figure 2) at 3 key stages:

Figure 2. Standard Green Book appraisal process

Figure 2 shows the usual policy appraisal process, starting with policy rationale, moving to developing options, then appraisal of costs and benefits, followed by deciding on an option, and finishing with monitoring and evaluating the chosen option.

Stage 1: Developing options – identifying climate risks and adaptation options

As with the typical appraisal process, policy options are developed based on a rationale for intervention. With climate-resilient appraisal, an assessment of potential climate risks to delivery of outcomes is also considered at this stage. Once risks have been identified, options can be improved and revised to include adaptation measures at the design stage, where net benefits will be highest. Assessing risk and developing climate-resilient policy options are covered in Chapter 3.

Stage 2: Appraisal of options – incorporating climate change impacts into the baseline for shortlist appraisal

This involves including the effects and impacts of climate change in the counterfactual baseline and the analysis of the costs and benefits of the shortlisted options. Given the high levels of uncertainty around future climate change, it may be necessary to consider alternative climate scenarios as sensitivity tests, where climate change impacts differ over longer time horizons. Comparing options with adaptation measures to a counterfactual without adaptation helps identify options that provide the best value for money, given the climate risks. The process of climate-resilient shortlist appraisal is described in detail in Chapter 4.

Stage 3: Monitoring and evaluation – valuing flexibility, monitoring thresholds and adapting accordingly

When deciding on which option to pursue, some additional weight should be given to options that address uncertainty. This, for instance, may mean that policy options which can flex over time or that are more robust to multiple futures, may be preferable. These attributes can potentially be quantified and included in the appraisal, or at least considered when selecting the final options. As monitoring and evaluation (M&E) makes the information on risks and the effectiveness of options clearer over time, more flexible options can be adapted according to changing information. Guidance on how to apply M&E to an adaptation context is provided in Chapter 5.

Figure 3. Building on the Green Book approach to account for climate change

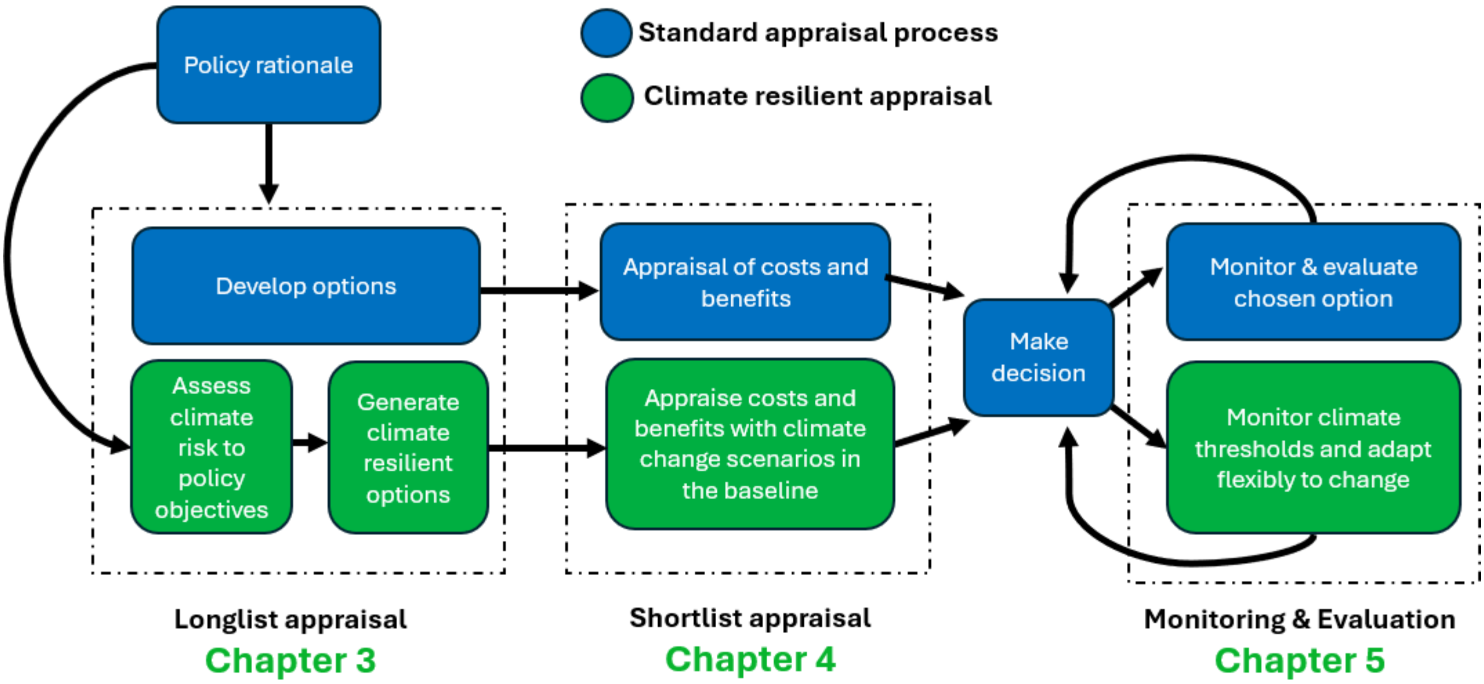


Figure 3 compares the standard Green Book appraisal process with the additional elements introduced in a climate resilient appraisal. In addition to the conventional appraisal process, climate resilient appraisal requires a climate risk assessment, the creation of resilient options, appraisal with climate change in the baseline, and the monitoring of climate thresholds.

Chapter 3. Assessing climate risk and drafting resilient options

3.1 Climate risk assessment

As outlined in Figure 1, a climate risk assessment (CRA) should be conducted if the proposal answers 'Yes' to any of the 3 screening questions in Chapter 2. Risk assessments help identify the likelihood and consequences of climate risks for a policy. Additionally, CRA provides an evidence base for valuing costs and benefits to be used at the shortlist appraisal stage. There is no set template for conducting a CRA; it should be conducted proportionately as part of evidence gathering to inform appraisal. CRA involves 3 steps:

1. Choose a climate change scenario. To assess climate risk it is first necessary to assess how much climate change your policy will experience. For a policy with a lifetime up to 2040, risk should be understood using a climate scenario consistent with 2°C of warming by 2100. For policies with lifetimes beyond 2040 you should assess risk using a scenario consistent with 2°C to 4°C of warming by 2100. **Annex C** shows a summary of how climate impacts vary across different warming scenarios.

2. Identify the relevant climate risks. The Independent Assessment of UK Climate Risk identifies 61 climate risks and opportunities for the UK. Consult **Annex A** to scope out which climate risks are relevant to your policy. This list is not exhaustive but provides a general overview of climate risks. It is important to consider the direct and indirect risks of climate change.

3. Evaluate climate risk. Using the hazard-exposure-vulnerability framework (see Figure 5 below) assess present-day and future climate risk severity. Location specific risk-assessment is supported by the Climate Risk Indicators, and the Local Authority Climate Service (LACS). Estimates of the economic impact of climate risks are available from the Monetary Valuation Report for the Third Climate Change Risk Assessment (CCRA3).

The rest of **Section 3.1** expands on climate change scenarios, the hazard-exposure-vulnerability framework, and the concept of indirect risk. **Section 3.1.4** provides an illustrative example of a CRA.

3.1.1 Climate change scenarios

Assessing climate risks involves significant uncertainty, primarily due to the unpredictability of future emissions and, to a lesser extent, the climate system's response. Changes in the UK's climate up to 2040 can be predicted with reasonable certainty and are not expected to vary significantly with different emissions trajectories. Beyond 2040, UK climate scenarios diverge considerably based on emissions pathways. To manage this uncertainty, simplified climate change scenarios should be used.

Figure 4. Projected changes in global surface temperature compared to 1850-1900.

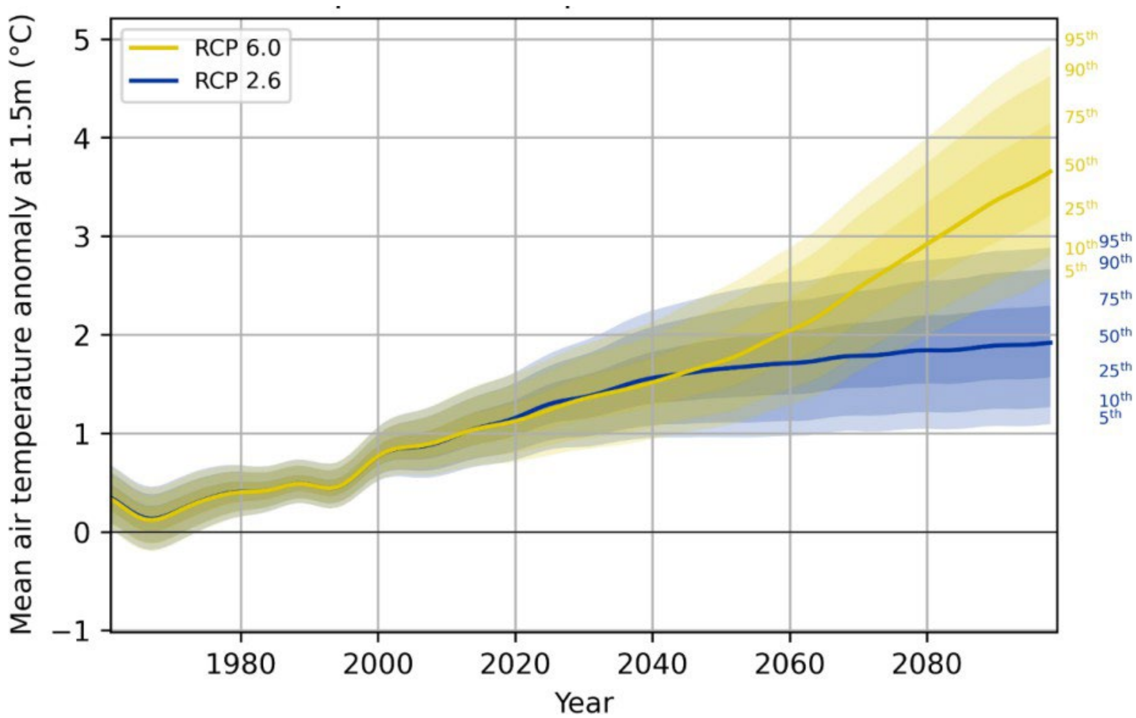


Figure 4 shows mean temperatures from 1960 to the present day with projected temperatures to 2060. The mean temperature rises by 1.5°C by 2040, and at this point, two lines diverge showing projected mean temperature rises of 2°C and 4°C above pre-industrial levels. As the temperature rises, the gaps between the predicted levels also increases. By 2100 the projected mean temperature is 2°C and X 4°C above preindustrial levels. Source: CCRA3 Technical Report

For policies with a lifetime up to 2040, risks should be assessed using a 2°C warming scenario. For policies extending beyond 2040, risks should be assessed against 2 scenarios, one consistent with 2°C and another consistent with 4°C of warming. This accounts for the divergence in projections shown in Figure 4. In the data sources for this assessment, please use the corresponding RCPs (Representative Concentration Pathways). RCP 2.6 is broadly consistent with a 2°C warming scenario and RCP 6.0 is broadly consistent with a 4°C warming scenario, although RCP8.5 can also be used where data is not available for RCP6.0.

For information on how different warming scenarios relate to the expected impacts of climate change, please refer to:

- the Climate Risk Indicators explorer for physical effects
- the Monetary Valuation Report for CCRA3 for economic effects
- **Annex C** for a high-level summary of both physical and economic impacts

3.1.2 Climate hazard, exposure and vulnerability

Climate risk can be understood using the International Panel on Climate Change (IPCC) framework of hazard, exposure and vulnerability (see Figure 5). Each of these factors is defined below and all three should be considered when conducting a CRA. Start by assessing the present-day level of risk and then assess climate risk using the relevant climate change scenarios.

Climate hazard

Climate hazard refers to the adverse physical impacts of climate change that may cause damage or loss to people, assets or systems. This includes 'chronic' climate hazards that unfold gradually over time, such as sea-level rise. Climate hazards also include intense and extreme events, such as heavy rainfall, floods or heatwaves. Table 3 below gives an example of present-day and future risk levels for three climate hazards.

Exposure to climate change

Exposure refers to the presence of persons, assets, or systems that could be adversely affected by climate hazards. A person or system is more exposed to climate hazards if they are in an area of higher risk. For example, a railway that connects a coastal town is more likely to be exposed to the effects of sea-level rise and coastal storms.

Vulnerability to climate change

Vulnerability is the propensity of persons, assets, or systems to suffer adverse effects when impacted by climate hazards. Vulnerability is the result of sensitivity and a lack of adaptive capacity.

Sensitivity

A person, asset or system is more sensitive to climate hazards if they are more affected by climate variability or change. For example, the elderly are more sensitive to the health effects of extreme heat (UKHSA 2022).

Adaptive capacity

This refers to the ability of people, assets, or systems to respond to potential damages or opportunities resulting from climate hazards. For example, a hospital with a back-up generator is less vulnerable to energy supply disruptions caused by flooding.

Figure 5. Hazard, exposure, vulnerability framework

Figure 5 shows 3 overlapping circles, representing climate hazard (defined as the adverse physical effects of climate change), climate exposure (defined as geographic proximity to hazard) and climate vulnerability (defined as the susceptibility of exposed people to be adversely affected). The overlap between the 3 circles is labelled 'climate risk'.

Table 3. Examples of present-day and future climate hazards

Climate hazard	Present day risk	Future risk
Heatwaves	The July 2022 heatwave saw the highest temperature ever recorded – 40.3C	By 2050, hot summers like the one in 2018 could happen every other year.
Heavy rainfall	October 2023 saw parts of England and Scotland record twice their monthly average rainfall	By 2070, extreme winter rainfall events are expected to increase by up to 25%
Wildfires	Figures suggest that the number of wildfires have been increasing in recent years.	Wildfires could be 50% more likely by 2100 due to increases in temperature and low summer rainfall.

Source: Met Office

3.1.3 Indirect risk from climate change

A CRA should take account of indirect climate risks. Indirect risk refers to a situation where vulnerabilities in one part of this system can create problems in others. Types of indirect risks include:

- **interdependencies**: where 2 or more sectors or organisations are mutually linked and dependent on each other
- **dependencies**: where one sector or organisation relies on another
- **cascading risks**: when a single event or trend triggers a cascading reaction, for example where disruptions caused by extreme weather impact multiple organisations or sectors.

An example of a cascading risk is power failure triggered by extreme weather. Transport for London faced a cascading risk in 2019 when an extreme weather event caused a power outage, leading to traffic light failures across London (TFL 2023). For a visual overview of indirect risks and interdependencies, refer to the system maps in Annex F of the CCRA3 report on interacting infrastructure risks.

3.1.4. Illustrative hypothetical CRA

Consider a hypothetical policy aimed at reducing food spoilage and food poisoning in the UK food supply chain. The objective is to assess whether a CRA is necessary. The success of this policy would be influenced by the vulnerability of food safety to overheating. Therefore, the policy falls within the scope of the guidance, as determined by Screening Question 1.

Step 1: Choosing a climate scenario

The policy does not involve any long-lasting assets and has an expected lifetime extending to 2050. Consequently, the policy should assess risks against climate scenarios projecting up to 4°C of warming by 2100.

Step 2: Identifying relevant climate risks

As part of the CRA, policymakers reviewed the 61 climate risks and opportunities listed in the Third Climate Change Risk Assessment (CCRA3). The following risks were identified as particularly relevant to the policy:

- **N7**: risks to agriculture from pests, pathogens, and invasive non-native species
- **H9**: risks to food safety and food security from UK climate impacts
- **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
- **N6:** risks to and opportunities for agriculture

Step 3: Evaluating the Risks

Bacteria that cause food poisoning can multiply faster in higher temperatures, increasing the risk of spoilage during heatwaves (FSA 2024). **Annex C** indicates that the number of heatwaves per year is expected to increase to between 1.52 and 1.65 events per year, a rise of 55% to 68%. This increased heat could lead to more food spoilage and food poisoning cases.

According to the Monetary Valuation Report for CCRA3, by the 2050s:

- **N7**: expected cost in the tens of millions of pounds per year
- **H9**: expected cost in the millions to tens of millions of pounds per year
- **ID1**: expected cost/opportunity in the billions of pounds per year
- **ID2:** expected opportunities for UK food availability are hundreds of millions per year
- **N6:** expected cost/opportunities for agriculture are hundreds of millions per year

The CRA indicates significant climate impacts relevant to the policy that should be considered during appraisal, including at the longlist drafting stage. For example, longlisted policy options could include climate resilience measures, such as requiring food retailers and distributors to understand the risks to food safety and to take measures to reduce spoilage and waste and risk to human health under a changing climate.

Figure 6. Food safety CRA summarised

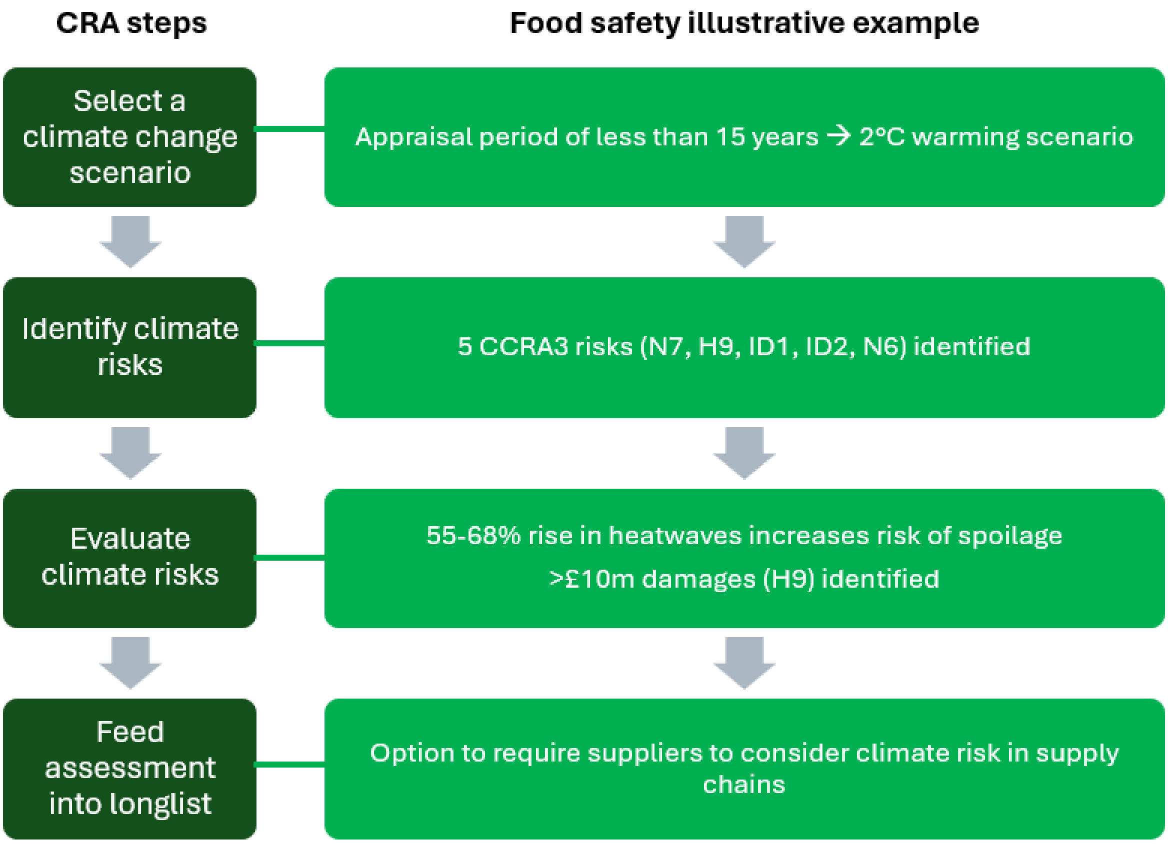


Figure 6 shows 4 steps of a climate risk assessment, and an accompanying example based on a food-safety policy. Step 1 involves choosing a climate scenario, which is 2C of warming by 2100 in the example. Step 2 involves identifying climate risk, with 5 CCRA3 risks identified in the example. The next step is evaluating climate risks, which relates to over £10m in damages in the example. Step 4 involves feeding assessment results into longlist, which corresponds to an option to require suppliers to consider climate risk in the supply chain in the example.

End of section checklist

- ✓ **I have selected an appropriate climate change scenario (or set of scenarios) given my policy lifetime.**
- ✓ **I have identified which climate change risks are relevant to my policy, project, or programme, including indirect risk.**
- ✓ **I have made use of the Third Climate Change Risk Assessment to identify the relevant climate risks and their expected monetary impact.**

✓ **I have assessed the risk for my policy in terms of hazard, exposure and vulnerability.**

3.2 Developing resilient policy options

3.2.1 Rationale for intervention

If adaptation is a core objective of your policy, you must explain why government action on adaptation is necessary. This explanation should include a description of the barriers that prevent the private sector from delivering adaptation efforts in the absence of government intervention. For a discussion on how market failures can hinder adaptation without government action, refer to the Analytical Annex of the First National Adaptation Programme (NAP1).

In most cases, the primary rationale for intervention is not adaptation, but the need for climate resilience can be considered alongside the primary rationale. One rationale for incorporating climate resilience into policy is cost-effectiveness. Climate-resilient policy options can provide economic benefits by reducing the future costs of climate change. Adaptation policies deliver significant economic benefits, with each £1 invested in adaptation typically resulting in £2 to £10 in net economic benefits (Watkiss 2021). Besides reducing potential losses from climate change, well-designed adaptation policies often generate economic, social, and environmental co-benefits (see **Section 4.1.4** below).

3.2.2 Apply the principles of good adaptation policy

Climate change adaptation refers to the adjustments needed in response to changes to our planet's climate. Once the potential impacts of climate risks have been identified the next step is to consider adaptation policy options to reduce these risks. When drafting resilient options, it is important to:

1. Integrate adaptation into other policies. Integrate the adaptation measure into the proposed policy, programme or project to ensure that the reduction in climate risk supports the intended societal objective.
2. Address inequalities. Climate change will impact all sections of society, but some groups are more vulnerable than others. The elderly, people with disabilities, and low-income households face disproportionate risk from climate change, potentially exacerbating existing inequalities (see Figure 7 below). These distributional effects should be considered, and policies should have a neutral or beneficial impact on reducing inequality.
3. Prevent lock-in. Lock-in involves cases where early actions or decisions potentially increase future risk in ways which are difficult to reverse. For example, building un-resilient housing could 'lock-in' higher costs retrofitting costs, with windows and shutters being four times more expensive to retrofit compared to inclusion at the design stage (CCC 2021)

4. Prepare for low likelihood but high consequence climate impacts. When climate change risks involve extremes, it is important to consider the distribution of events as well as the expected annual damages. Lower likelihood but more severe risks can have disproportionate impacts. Adaptation policies should be resilient to unpredictable and extreme climate impacts. This includes unpredictable extreme weather events, such as 1-in-100-year rainfall extremes. Additionally, for exceptionally long-lived and high impact policies the effect of climate tipping points on the UK should be incorporated into policy design (Met Office 2021).
5. Adapt to 2°C assess the risk for 4°C. For policies with a lifetime up to 2040, ensure they are resilient to a scenario of 2°C warming by 2100. For policies extending beyond 2040, ensure resilience to warming between 2°C and 4°C, adjusting the policy's standard of resilience based on your risk appetite.

For more information on the principles of good adaptation please consult the CCC's Independent Assessment of UK Climate Change Risk.

Figure 7. Climate change exacerbates inequalities

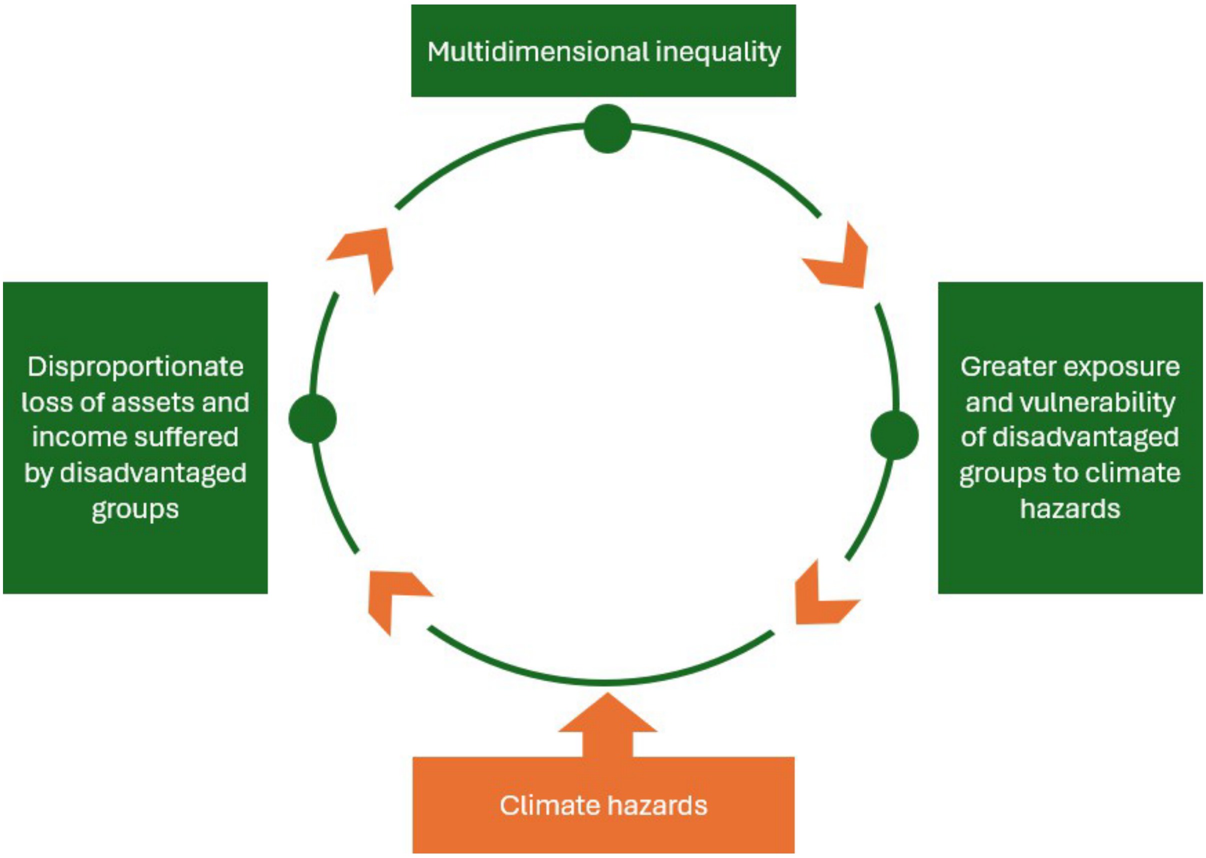


Figure 7 shows a cycle which starts with climate hazards, which disproportionately impact the assets and income of disadvantaged groups, which deepens multi-dimensional inequality which results in greater exposure of disadvantaged groups to climate hazards. Source: CCC (2021)

3.2.3 Generate a longlist including at least one resilient option

The longlist should include at least one policy option that is resilient to climate change. Adaptation measures reduce the vulnerability or exposure of an asset, person or organisation to climate impacts. For example, adding a cooling-roof to a public building can reduce the risks posed by extreme heat.

For a summary of different adaptation approaches, refer to Table 4 below. For sources cataloguing adaptation measures please consult:

- the Third National Adaptation Programme (NAP3) (Defra 2023)
- Adaptation inventory (Jenkins 2021)
- Adaptation options (Climate ADAPT)
- Local Climate Adaptation Tool LCAT (University of Exeter 2024)

Table 4: Examples of adaptation actions

Adaptation category	Description	Examples
Structural solutions	These involve engineering solutions, such as the construction of physical systems to reduce climate impacts	• Flood barriers • External shutters and shading
Technological solutions	Leveraging science and technology to reduce risk	• Early warning systems • Irrigation systems
Nature based solutions	Utilising or investing in ecosystem services to reduce climate risk	• Natural drainage solutions • Green roofs

Adaptation category	Description	Examples
Planning and regulation	Planning and regulatory measures to reduce risk	• Building codes to reduce overheating • Land-use planning
Behavioural measures	Influencing and awareness raising to reduce climate risks	• Heatwave awareness • Water conservation campaign
Systemic economic adjustments	Systemic changes to the economic system to reduce climate change risks	• Relocation of economic activity away from affected sectors or to new opportunities

3.3.4 Selecting a climate resilient shortlist

Critical Success Factors (CSFs) are the essential attributes that a proposal must have if it is to successfully deliver its objectives and are a core part of the standard Green Book guidance (HMT 2022). While climate resilience can be considered an additional success factor, it is often best integrated into the 5 fundamental CSFs. Table 5 below outlines these 5 basic CSFs, which apply to all proposals, and how they relate to resilience:

Table 5. Critical Success Factors and climate resilience

Critical Success Factor	Relation to resilience
Strategic fit and meets business needs	Adaptation may be required for a policy to meet its spending objectives. In the case of pure adaptation, resilience is the objective.

Potential value for money	Adaptation measures can increase value-for-money by avoiding losses and through the co-benefits.
Supplier capacity and capability	Delivering resilient policy options may require specific capabilities, skills and resilience among suppliers.
Potential affordability	Well-adapted policies may require additional funding but can reduce depreciation rates.
Potential achievability	How well can the organisation integrate adaptation and skills required, including consideration of uncertainties.

The Options Framework should be used to narrow the longlist of policy options to a shortlist of viable ones. The shortlist must include at least one climate-resilient policy option, usually either as the Preferred Way Forward or as a higher ambition option. The Business-As-Usual (BAU) scenario should include climate change in the baseline for comparison of resilient options. Table 6 below illustrates how to present a shortlist which includes adaptation options, using the example of a major road retrofit project vulnerable to climate change.

Table 6. Climate resilient shortlist

Option	Description	Climate resilient appraisal	Example in a climate change appraisal
Business As Usual	A quantified BAU is used as a benchmark counterfactual.	Benchmark counterfactual + climate change effects.	Due to climate change, maintenance and disruption costs are expected to increase.
Do minimum option	Just meets the business needs required by the SMART objectives.	Current or very low level of additional resilience	The maintenance budget is increased over time to match the anticipated rise in costs. Disruptions

			increase due to extreme weather events.
A less ambitious preferred way forward	This option may take longer, delivering less value, but cost less or carry less risk.	Usually less resilient than preferred more ambitious option.	The road is retrofitted with improved drainage systems.
Preferred way forward	This is the recommended option.	Usually resilient to the effects of climate change.	The road is retrofitted with improved drainage systems with a nature-based approach to flood prevention.
A more ambitious preferred way forward	This may be more expensive, delivering more value but at higher cost with increased risks.	Usually, higher resilience to the effects of climate change and/or additional features.	A new highway is built along a less exposed route, with resilience included at the design stage.

End of section checklist

- ✓ **Where relevant, I have considered the rationale for climate adaptation policy**
- ✓ **I have applied the principles of good adaptation to design a longlist of resilient options**
- ✓ **I have included climate change considerations into my CSFs**
- ✓ **I have assembled a shortlist that includes at least one climate resilient option**

Chapter 4. Appraising costs and benefits with climate change

4.1 Including climate change in the baseline of appraisal

4.1.1 Comparing options with climate change in the baseline

While the extent of future climate change remains uncertain, it is certain that climate change will persist. Consequently, we cannot assume that the costs and benefits of policies will remain the same. It is essential to factor anticipated climate impacts into appraisals to ensure that the preferred option remains cost-effective in a changing climate.

Shortlisted options should be appraised against a warming scenario broadly consistent with 2°C of warming by 2100 (RCP 2.6). Appraisal of policies with q lifetime beyond 2040 should also include a climate sensitivity test consistent with 4°C of warming by 2100 (RCP 6.0 or RCP 8.5). See **Section 3.1.1** for more on climate scenarios and RCPs.

Consider a hypothetical illustrative appraisal of a project to refurbish an ageing public building, such as a school or hospital. Discount rates are not applied here for simplicity. The appraisal examines 3 options:

1. **Do minimum**: increase the school maintenance budget.
2. **Intermediate option**: undertake a major refurbishment to enhance capacity and resolve existing issues.
3. **Higher ambition**: all measures in the intermediate option, with added climate resilience incorporated.

Table 7. Climate change affects policy options' costs and benefits

Climate change scenario	Do minimum option	Intermediate option	Higher ambition option
	Increase repairs budget	Major refurbishment	Major refurbishment and climate resilience

Scenario 1. **No future climate change**	Cost: £1m Benefit: £2m NPV = £1m	Cost: £5m Benefit: £15m NPV = £10m	Cost: £8m Benefit: £15m NPV = £7m
Scenario 2. **Climate change**	Cost: £1m Benefit: £1m NPV = £0m	Cost: £5m Benefit: £10m NPV = £5m	Cost: £8m Benefit: £15m NPV = £7m

Scenario 1: no future climate change

The intermediate option is the most cost-effective with an NPV of £10m. The higher ambition option offers slightly higher benefits due to reduced present-day damages, but this is outweighed by much higher costs.

Scenario 2: 2°C warming by 2100

The higher ambition option is the most cost effective with a NPV of £7m. This is because the benefits of the refurbished building are resilient to the effects of climate change, while the benefits of the non-resilient intermediate option were greatly reduced.

4.1.2 Valuing costs and benefits with climate change

Once the effects of climate change are considered, the balance of costs and benefits between options can change significantly. Therefore, it is crucial to incorporate the impacts of climate change into social cost-benefit analysis (CBA) as much as possible

Information on the impacts of climate change is presented in **Annex C** alongside examples of how this data can be used for appraisal. Further information on the economic impacts of climate change can be found in resources linked to in **Annex D**. For hypothetical examples of how to appraise policies with climate change consult **Annex B**.

This section covers 2 analytical techniques with relevance to appraisal under a changing climate: expected value and non-market valuation.

Expected value

Climate change impacts often involve uncertainty which can be managed using ‘expected value’ calculations. These ‘risk costs’ are calculated by multiplying the potential cost of an impact by its likelihood. For data on the probability of extreme weather events, see **Annex C**. For example, if assume a heatwave on the level of 2018 reduces productivity in a public service by 1%, at a cost of £x per annum. By the 2050s such heatwaves could have a 50% annual probability (Met Office 2024). The Expected Annual Damage of future shortages is equal to the cost of the impact multiplied by the future probability (£x * 0.5 = £0.5x).

Standardised values

The Green Book's generic prices provide a useful way to estimate non-market values, such as climate costs and the benefits of climate adaptation. For more information on ‘generic values’ please consult the Enabling a Natural Capital Approach and the Policy Appraisal and Health supplementary guidance documents. For example, consider a policy of converting underused farmland into woodlands. Here, the Green Book’s standardised flood prevention value of £244 per hectare helps assess the resilience benefits of this policy. A policy that involves converting 1,000 hectares of farms into woodlands could be expected to deliver £244,000 in annual flood prevention benefits. For more information on ‘generic values’ please consult the Enabling a Natural Capital Approach and the Policy Appraisal and Health supplementary guidance documents.

4.1.3 Equalities and distributional analysis in climate resilient appraisal

The Public Sector Equalities Duty requires that impacts on protected groups and equalities issues are taken into account when a policy decision is made. Analysts should consider the distribution of climate impacts when appraising shortlisted options. For example, if a non-resilient policy option results in protected groups suffering disproportionately from climate hazards, this should be explicitly considered in the equalities analysis. Table 8 below illustrates how some groups with protected characteristics are impacted differently by climate change.

Table 8. Protected groups and climate risk

Protected characteristics	Overheating risk factors	Flooding risk factors
Pregnancy	Pregnant women exposed to heat are more likely to have miscarriages (CCC 2022)	Pregnant women can be less able to prepare for and respond to flooding emergencies (UKHSA 2023).

Disability	People with mental health illnesses are significantly more likely to have their health impacted by high temperatures.	Disrupted access to healthcare can make disabled people more vulnerable to health effects from flooding.
Age	Around 88% of casualties during the 2020 heatwave were over the age of 65<	Elderly people are more likely to live in communities that are exposed to coastal storms,

4.1.4 Valuing the co-benefits of adaptation

The primary rationale for climate resilience measures is to avoid losses from climate change. However, resilience measures also offer significant economic, social, and environmental co-benefits. Where possible, these co-benefits should be quantified to ensure that the value of resilient options is fully accounted for.

The Triple Dividend of Resilience (TDR) is a conceptual tool for quantifying and presenting the full benefits of adaptation interventions. The TDR approach categorizes the benefits of adaptation into 3 categories: avoided losses from climate change, induced economic benefits, and social and environmental benefits (Heubaum 2022). The different benefit streams identified by the TDR approach are summarised in Table 9 below.

Table 9. Triple dividend of Resilience

Dividend of adaptation	Description
First Dividend	**Avoided losses** – The reduction in damages from climate change that would have occurred without adaptive action (for example, the reduction in productivity loss from overheating)
Second Dividend	**Dynamic market benefits** – Dynamic market effects such as induced investment and productivity gains independent of climate change (for example, investing in flood barriers can enhance investor confidence and boost local economy)
	Social and environmental benefits – Wider social welfare benefits from adaptive measures (for example, improved

Third Dividend	habitats for biodiversity, wellbeing gains from natural landscapes being protected)

Quantifying the second dividend

The second dividend refers to economic benefits of adaptation investments that are independent of climate change. These benefits include:

- **productivity gains:** Adaptation policies can boost productivity independently of climate change. For example, urban tree planting reduces overheating risks and increase productivity under the present-day climate. The ecosystem-service of urban-cooling provided by the natural environment was recently valued at £310m per year(ONS 2022).
- **induced investment:** Adaptation benefits can stimulate economic activity and investment that would not occur otherwise. For example, coastal flood defences can strengthen local investment in tourism and real estate. Care must be taken not to include displaced effects such as diversion or deferral of economic activity from one location or time to another.

Quantifying the third dividend

The third dividend refers to social and environmental non-market benefits. For example, peatland restoration enhances flood resilience and mitigates carbon emissions (Defra 2021). For further guidance on how to value social and environmental impacts refer to **Section 4.1.2.**

Triple Dividend Case Study: The port of Felixstowe seawall

In 2009, construction began on a 1.3km seawall, designed to protect the port town of Felixstowe from rising sea-levels.

The first dividend benefit of this adaptation measure was the reduction of coastal property losses, with over 1,491 properties protected from the damage of coastal erosion resulting from climate change.

The second dividend benefits of the project included a boost to tourism after the construction of the seawall. The adaptation investment further stimulated public and private investment in Felixstowe's tourism industry, including refurbishing hotels and a new boardwalk.

The third dividend benefit of the adaptation policy infrastructure involved the restoration of gardens and recreational spaces, with knock on benefits for mental wellbeing for residents.

When only first dividend benefits are accounted for, the Benefit-Cost-Ratio (BCR) of the project is 15:1, with every £1 invested avoiding £15 of climate damages. However, when the full scope of second and third dividends are included in the appraisal, the BCR significantly increases to 32:1. This highlights the comprehensive value of considering all potential benefits of adaptation measures, beyond just avoided losses.

Table 10. Costs and benefits of Felixstowe seawall

Category	Cost/Benefit
Project cost	£15m
Project benefits	£489m
First dividend	£233m
Second dividend	£248m
Third dividend	£8m
Project BCR (First dividend)	15:1
Total project BCR	32:1

Source: Heubaum 2022

4.1.4 Presentation of unquantifiable costs and benefits

It may not be possible or proportionate to monetise every identified cost and benefit. At a minimum, non-monetised costs and benefits should be assessed recorded and presented as part of the appraisal. These impacts should be described qualitatively or quantified as much as possible, for example the expected magnitude, likelihood and duration of the impact. Presenting this information clearly will enable decision-makers to weigh up the options and take appropriate decisions. For an example of how to conduct social cost benefit analysis with unmonetisable impacts, see Box 1.

Box 1: Social Cost Benefit Analysis with non-monetised wellbeing options: illustrative example

This is a purely stylised example, please see the Environment Agency guidance for developing flooding business cases.

A new flooding scheme is under consideration for a community at risk of flooding. There are a variety of options for implementation. It is not possible to monetise the wellbeing impacts. However, these additional impacts are important to consider as they relate to further government objectives in the areas of health and the environment. Wellbeing impacts can be presented within the options to enable informed decisions. All estimates are provided in present value terms for a 20-year time period.

Do nothing:

Risk-adjusted costs of £78m-81mn due to predicted flood risks.

Option 1: Do minimum - Basic design

Flood protection benefits of £56m-62mn, construction and maintenance costs of £9mn.

Option 2: Design with additional access to enable walking and cycling on the flood barriers

Flood protection benefits of £56m-62mn, construction and maintenance costs of £10.2m. Wellbeing benefits: higher number of recreational visits / uses of the area over the 20-year time period, associated with improved wellbeing and mental health. The area will mainly be accessed by those in the local community, but it is expected that others from neighbouring communities will also access the recreational area. Option 2 results in £1.2m of additional costs compared with potential wellbeing benefits for 20,000 up to 22,000 people, who will more easily be able to use the structure for recreational purposes.

It is not possible to monetise the wellbeing benefits due to the lack of data for the particular project, however decision-makers can be presented with the comparison between option 1 and 2 – that is,. the option with and without this estimated wellbeing change, alongside the difference in costs. In this case, the value for money recommendation is based upon the net social value alongside the additional costs of including key objectives, with a description of the unmonetised benefits.

Source: HM Treasury, Wellbeing Guidance for Appraisal: Supplementary Green Book Guidance

End of section checklist

- ✓ I have included climate change in the baseline of my analysis
- ✓ Wherever possible, I have quantified the costs and benefits of my policy with consideration of climate impacts.
- ✓ Where relevant I have considered the distributional impact of my policy under a scenario of climate change
- ✓ I have quantified the co-benefits of adaptation
- ✓ Where needed, I have included a consideration of unquantifiable factors in the presentation of my results

4.2 Approaches to managing climate uncertainty

Policies with a lifetime extending beyond 2040 face significant uncertainty about the severity of future climate change. To manage this uncertainty, 2 Green Book aligned techniques are recommended in most cases:

1. **Sensitivity analysis**: shortlist appraisal of long-lived policies should test how a high warming scenario affects estimated value-for-money.
2. **Real options analysis**: a technique to explore whether additional flexibility can be added in the project design phase and utilised later when further information becomes available.

These methods are promoted based on their alignment with Green Book appraisal techniques. However, in some contexts, these techniques may be insufficiently sophisticated to address deep climate uncertainty. For policies where uncertain climate risk is a particularly important consideration, it may be necessary to use more advanced analytical techniques for managing uncertainty, as expanded on in **Section 4.2.3** below.

Alternatively, where it is impractical to quantify uncertainty, a qualitative assessment of climate uncertainty should be presented as part of the Cost-Benefit-Analysis. This ensures that decision-makers have the relevant information to make choices consistent with their risk appetite.

4.2.1 Climate uncertainty and sensitivity testing

Scenario analysis is a form of 'what if' analysis that is useful where there are significant future uncertainties. For policies beyond 2040 scenario analysis should be conducted to demonstrate the impact of a higher warming scenario on the cost-effectiveness of shortlisted options. The higher warming scenario should be consistent with 4°C of warming by 2100 (see **Section 3.1.1** for more on climate scenarios).

Sensitivity test illustrative example: flooding and public-building construction

For instance, imagine the creation of a new public building, such as a school or hospital in a high flood-risk area. The intermediate option involves constructing a new building but relying on the town's existing flood defences. The higher ambition option adds new flood defences to increase the public building's resilience to climate change (discount rates have not been applied for simplicity).

Central scenario

Under a 2°C warming scenario daily extreme rainfall is projected to increase by 20% by the 2080s, with a range of 5% to 30%. Under this warming scenario the town's flood defences reduce the risk to acceptable levels, and the flood risk to the public building remains low. The higher ambition option delivers an even higher level of resilience but is much more expensive. Therefore, the intermediate option offers the best value-for-money (see Table 10 below).

Sensitivity test

Under a 4°C warming scenario daily extreme rainfall is projected to increase by 70% by the 2080s, with a range of 50% to 100%. Now the town's flood defences are inadequate and the new building experiences significant flood damage. The necessary repairs add £100m in costs for the intermediate option, and the disruption to service provision reduces total benefits by £100m. The higher ambition option is resilient to higher climate change scenarios, so the costs and benefits remain unaffected, with a NPV of £250m. As a result, the higher ambition option now offers the best value-for-money due to its increased resilience to climate change.

Table 10: Climate sensitivity test example

Climate change scenario	Do minimum option Increased funding for existing building	Intermediate option New building	Higher ambition option New building with flood defences
Central scenario 2°C scenario	Cost: £10m Benefit: £12m NPV = £2m	Cost: £500m Benefit: £800m **NPV = £300m**	Cost: £550m Benefit: £800m NPV = £250m
Sensitivity test 4°C scenario	Cost: £10m Benefit: £10m NPV = £0m	Cost: £600m Benefit: £700m NPV = £100m	Cost: £550m Benefit: £800m **NPV = £250m**

The impact of a climate change sensitivity test on value-for-money should be communicated clearly. This ensures that decision-makers have sufficient information to choose an option appropriate to their risk appetite.

4.2.2. Real options analysis

Real options analysis (ROA) is a technique that highlights the value of additional flexibility as more information becomes available. ROA recognises that initial decisions can be adjusted based on new information, assigning more value to policy options that can be flexibly changed compared to conventional cost-benefit analysis.

ROA is particularly useful for projects facing significant uncertainty or those that are difficult to reverse after initial investment, such as policies dealing with uncertain future climate change impacts. ROA enables policymakers to evaluate and prioritise adaptation measures while considering these uncertainties.

For example, consider a proposal to invest in infrastructure to protect against river flooding due to climate change. Given the time required to build the infrastructure, it is best to act in advance, despite uncertain impacts. There are two options: invest in a standard wall or invest in groundworks for an upgradeable wall that can be quickly enhanced in the future. For simplicity, assume an equal probability of high or low climate change in the future.

The standard wall costs 100 and provides benefits of 170 from avoided flooding if high climate change impacts occur (zero benefit otherwise). The groundworks for the upgradeable wall cost 60, the future upgrade costs 50, and the benefit is also 170 if high climate change impacts occur. The upgrade can, however, be postponed until there is more certainty about future climate impacts. This can be represented visually in a decision tree (see Figure 8 below).

Figure 8. Real options analysis and seawall

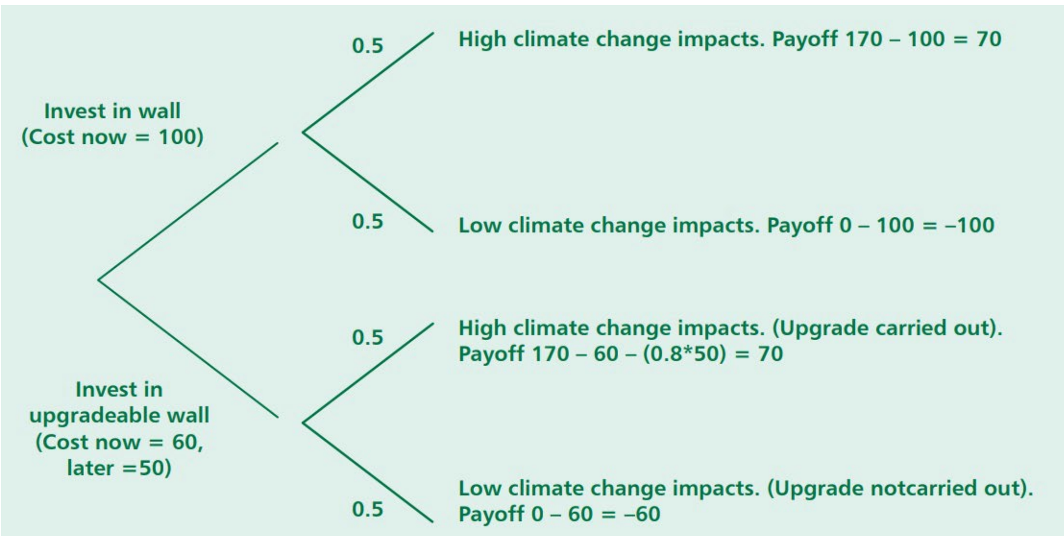


Figure 8 shows a decision tree on whether to invest in a standard sea-wall or an upgradable sea-wall. This branches off to 2 scenarios, which both have a, equally probable, high climate variant change and a low climate change impact variant. The pay-off from a standard seawall is 70 in the low impact scenario, and -100 in a high impact scenario. The pay-off of the upgradable wall is 70 in the low impact scenario and -60 in the high impact scenario. Source: Green Book 2022.

The expected value of the two walls is the sum of the probability of each scenario multiplied by the pay-off. The NPV of the conventional wall is **-15** [*(70*0.5)* + *(-100*0.5)* = -15]. This suggests that the investment should not proceed. The expected NPV of the upgradable wall by contrast is +**5** [*(70*0.5)* + *(-60*0.5)* = 5]. The flexibility to upgrade in the future is reflected in the higher NPV, which switches the investment decision towards the upgradable wall.

Flexible decision-making assumes that policymakers are aware of whether the threshold into a high-impact climate scenario has been crossed. In practice, this requires that a monitoring and evaluation framework is in place to measure climate thresholds and review decision-making (see **Section 5.1** below).

4.2.3. Advanced decision-making under uncertainty

Real options analysis and sensitivity testing are recommended as proportionate techniques for dealing with uncertainty. However, there is no universally applicable approach to economic appraisal, and in some cases, a more sophisticated method for addressing uncertainty may be required.

For advice on more advanced decision-making-under-uncertainty tools please consult ECONADAPT's report on 'The Economics of Climate Change Adaptation'. These methods can be resource-intensive and technically complex, so consideration should be paid to how to apply them practically.

End of section checklist

- ✓ I have considered the use of scenario analysis and sensitivity testing to manage uncertainty about the effects of future climate change.
- ✓ If my policy has a lifetime beyond 2040, I have tested the impact of an extreme warming scenario consistent with 4°C on the value-for-money of my preferred option.
- ✓ I have considered the use of Real Options Analysis and decision-trees to manage uncertainty about the effects of future climate change.
- ✓ Where proportionate, I have considered the use more advanced appraisal under uncertainty techniques such as multi-criteria-analysis, robust-decision-making, iterative management and portfolio analysis.
- ✓ Where needed I have presented uncertainty about the effects of climate change qualitatively to inform decision-makers.

Chapter 5. Monitoring and evaluating adaptation policy

5.1 Incorporating monitoring and evaluation into adaptation policy

The approach to monitoring and evaluation of policies which consider the impacts of climate change should not differ from that as recommended in the Green Book and Magenta Book. Given high levels of uncertainty around climate change projections (see **Section 3.1.1**) however, monitoring and evaluation (M&E) is even more important for ensuring continuous learning and flexibility of response in the face of new information. There are recommended methods of M&E for climate adaptation. Guidelines for this are available in the Annex 3 of the Third National Adaptation Programme.

5.1.1 Theory of change

Adapting to a changing climate is a dynamic problem involving complex environmental and socioeconomic systems, such as our food or energy systems. As a result, policies often cross sectoral and disciplinary boundaries and need to evolve as our understanding improves or priorities change. Due to the complexity of this challenge, a theory of change approach is recommended demonstrating the logic of interventions from action to impact in developing adaptative policy. This can be applied as a policy development tool, as well as for evaluation. Sources such as the Magenta Book and Defra Theory of Change toolkit provide further advice on use of theory of change.

Figure 8. A Theory of Change for adaptation

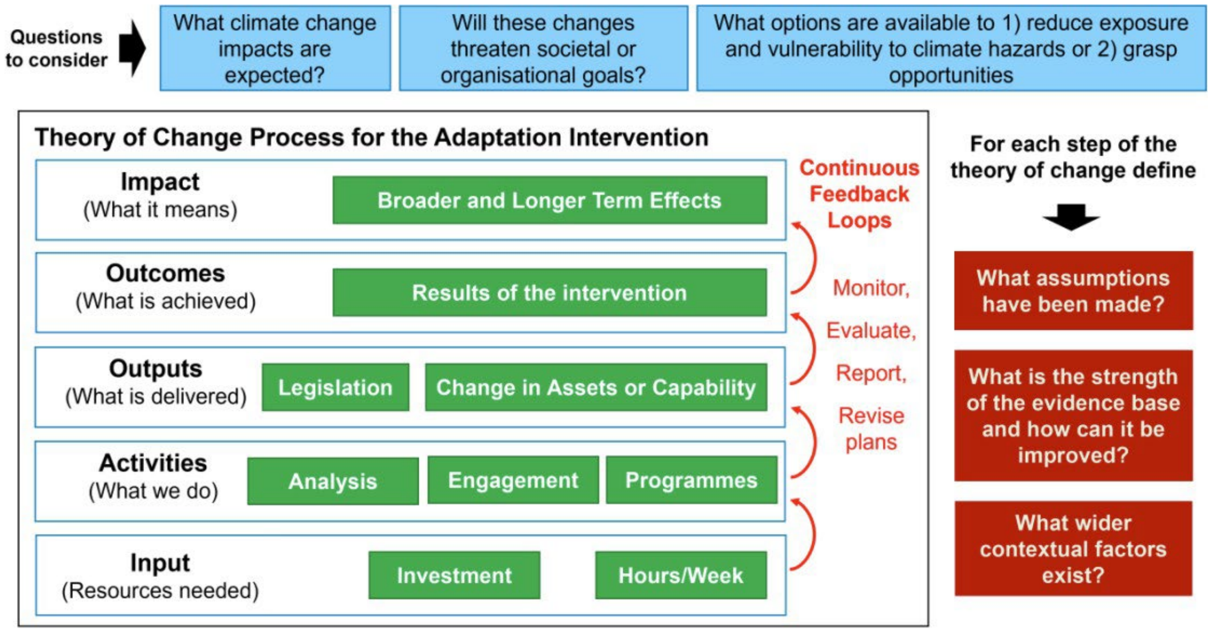


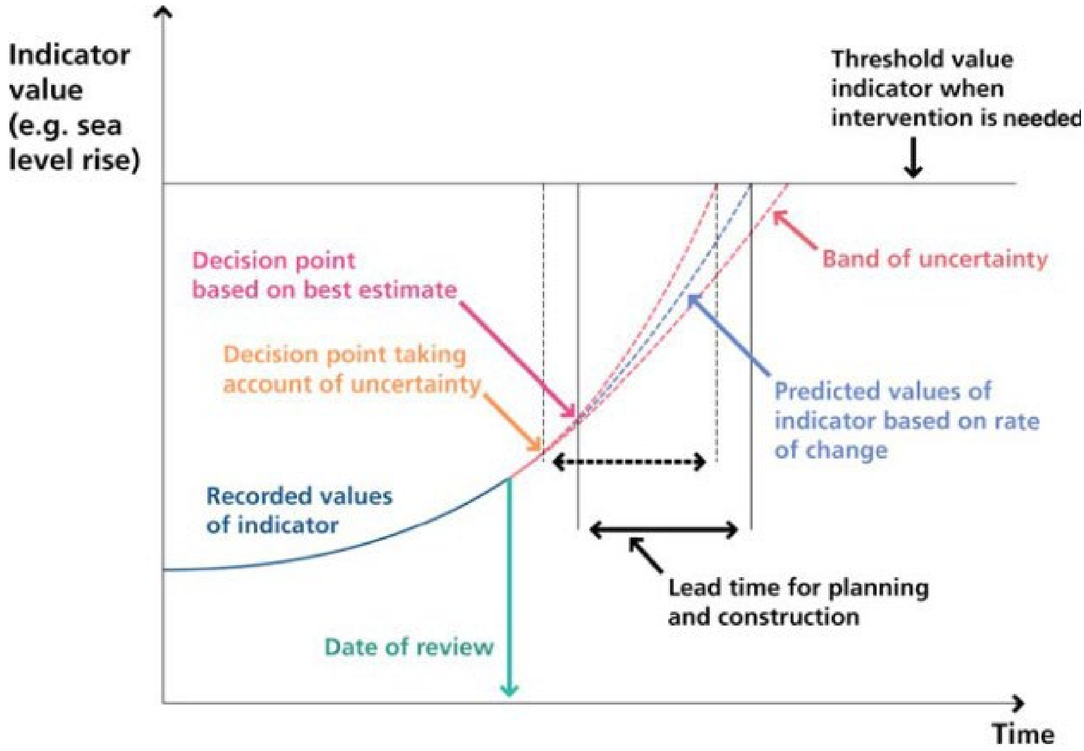
Figure 8 is a schematic of the recommended process for developing plans to adapt to climate change through a theory of change approach. Initially, the impacts of climate change on a range of future scenarios and the adaptation options available should be considered. The logical steps of the theory of change approach should then be followed to design an intervention or interventions. First, the impact desired should be clearly stated and then the necessary outputs, outputs, activities and inputs required to achieve it. Continuous feedback loops to monitor, evaluate, report and finally revise plans are needed throughout the process. Source: NAP3 Annex E.

5.1.2 Adaption pathways approach

The adaptive pathways approach allows decision makers to plan, prioritise and sequence investments in adaptation options - by identifying trigger points and thresholds that help to identify when to revisit decisions or actions. It helps people work out the critical relevant thresholds in their system of interest. An adaptation pathway process produces decision trees that plot the range of credible options for decision-makers to choose from based on their best judgement.

By monitoring climate impacts and the effectiveness of pathway actions, managers can decide whether to continue with the chosen pathway or shift to an alternative one to maintain acceptable levels of risk and performance. As shown in Figure 9 below, an adaptive pathway makes use of monitoring climate risk data, identifies thresholds and decision points, and factors in lead times for putting the adaptive measure in place. Box 2 shows how the adaptive pathways approach has been applied in the context of the Thames Barrier T2100 plan.

Figure 9: Thresholds, lead times and decision points in an adaptive pathway



Source: Ranger 2013

Railway adaptive pathways illustrative example

The adaptive pathway approach has been implemented at a centrally located railway station, which is already significantly affected by the urban heat island (UHI) effect and lacks sufficient vegetation and shade. Recent incidents, including a lineside fire and several heat-related delays, have highlighted the station's vulnerability.

A climate risk assessment (CRA) identified two primary climate risks: increased likelihood of technical failures (such as rail buckling and fires) and threats to the health and wellbeing of passengers and staff. These risks were assessed for a temperature range of 30°C to 50°C.

Next, adaptation options were considered for different warming thresholds. These options included structural adaptations (for example, modifications to building and train design, and overhead line equipment) and non-structural adaptations (for example, business planning, communications, and health and safety policies).

Each adaptation option is mapped to a specific climate threshold, indicating when the option would become beneficial and when it might lose effectiveness. This allows for adaptive measures to be phased in and out as temperatures rise, ensuring timely and appropriate responses. For instance, more efficient cooling systems could be introduced before summer temperatures consistently exceed 36°C.

Figure 10. Railway overheating adaptive pathway

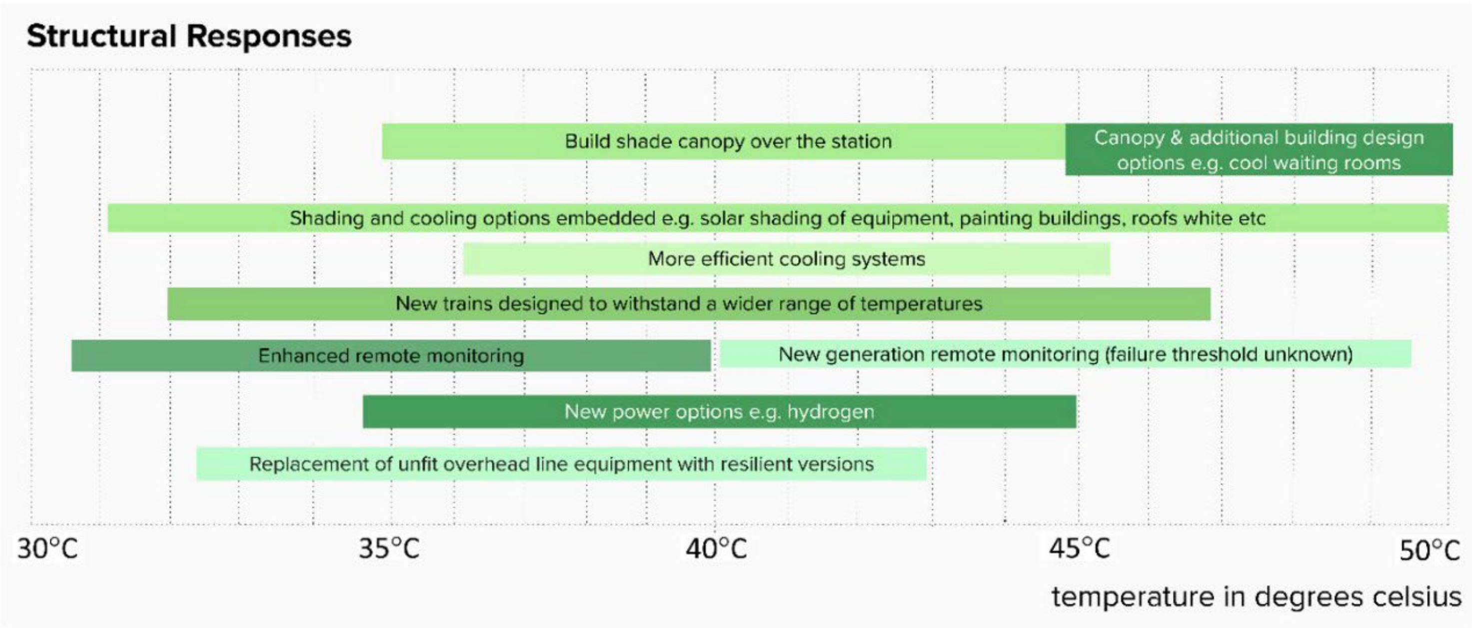


Figure 10 shows temperature in degrees on the horizontal axis, extending from 30 degrees to 50 degrees centigrade. The graphic shows green bars representing different adaptation measures that are effective at different temperatures. Source: Climate Sense 2024

Box 2. Thames Estuary 2100 adaptive pathway case study

The Thames Estuary 2100 strategy (TE2100) takes an adaptive approach to managing the risk of flooding in London and the estuary. The Environment Agency monitors how the estuary and climate is changing and adapts its approach in response by carrying out reviews every 5 years and updating the Plan every 10 years.

They monitor indicators of change every 5 years. These include changes to the following in the estuary:

- the number of people
- the number of homes and businesses
- habitat for wildlife
- the condition of flood defences

They also track and assess:

- updates to climate change projections, including the rate of sea level rise
- changes to government policy
- updates to scientific guidance

Every 10 years, they review and update the Thames Estuary 2100 Plan, to make sure it's still relevant and takes account of all these changes and uncertainties. The key findings from the 10-year monitoring review were published in 2021. They confirmed that:

- the plan provides benefit to 1.42 million people, 586,000 homes and £321 billion of residential property
- sea level in the estuary has risen over the last century
- sea level rise in the estuary has accelerated over the last few decades
- most tidal flood defences are still in a good condition - but defences are deteriorating faster due to climate change
- we need to improve our understanding of how we will manage the Thames Barrier and closures of the barrier over time

Find out more about major updates to Thames Estuary 2100 between 2012 and 2023

5.1.3 Selecting & monitoring climate change indicators

Indicators can refer to different stages of the adaptation process (see Figure 8). Monitoring indicators supplies evidence and insights to inform future policy development and decision-making, ensuring that adaptation actions remain effective and keep pace with the changing climate. It is useful to distinguish between the following indicators and the purposes they serve (OECD 2023).

Output indicators

Output indicators describe products or services created by adaptation interventions. They indicate whether actions have been implemented but do not indicate whether adaptation has been successful.

Example indicators include:

- newly adopted regulations
- training conducted
- new or upgraded infrastructure

Outcome indicators

Outcome indicators describe results of outputs. They indicate whether actions have increased resilience or lowered climate risks, climate impacts, economic damages or negative effects on human health.

Example indicators include:

- a reduction in construction of buildings in areas of high flood risk
- whether an adaptation measure has reduced the magnitude of infrastructure
- service disruptions caused by extreme weather
  recorded damages from flooding

Climate change impact indicators

Climate change impact indicators describe impacts attributed to climate change. They indicate reductions in climate impacts (or lower increases than would have been the case without adaptation).

Example indicators include:

- recorded instances of heat strokes due to hotter summers
- the extent and magnitude of flooding and drought
- adverse impacts on ecosystems

Climate change impact indicators can also be adaptation outcome indicators if the measured changes in climate impacts are linked to an adaptation intervention.

Box 3: Third National Adaptation Programme - Health and social care adaptation indicator

The NAP3 goal for H12 (risk to health and social care delivery) is to minimise the impact of climate change on the quality, effectiveness and timeliness of health and social care delivery. Different types of indicators have been identified and more may be developed.

Climate change impact indicator

The level of service disruption in health and social care resulting from severe weather events, such as reported overheating incidents.

Output indicators for individual actions

Output indicators to show progress in delivering on specific actions committed to for risk H12 include:

- the percentage of National Health Service (NHS) Trusts completing Climate Change Risk Assessment (CCRA tool)
  - tied to Action 1: NHS England will develop an interactive climate change risk assessment tool by 2025 to support the identification of

local climate change risks to NHS sites and key services to inform adaptation planning

- the number of NHS Trusts and Integrated Care Integrated Boards (ICB) that have incorporated adaptation into Green Plans
    - tied to Action 2: NHS England will strengthen adaptation provisions within the NHS Green Plan guidance by 2025 to support all Trusts and ICBs to include adaptation measures in individual Green Plans by 2027
- evaluation which shows eligible building works (excluding derogations) on new and existing NHS facilities align with the building standards
    - tied to Action 3: NHS England will include adaptation measures in the NHS standard contract for NHS buildings and services from 2023 and include adaptation measures within NHS building standards to increase the uptake of adaptation planning and activity.
- the proportion of providers subscribed to extreme weather alerts
    - tied to Action 4: the UK Health Security Agency published the Adverse Weather and Health Plan on 27 April 2023, which came into effect on 1 June 2023 - this will provide guidance to reduce the health risks associated with adverse weather events and support the uptake of prevention actions across the health and social care sector and in local communities.

Source: Third National Adaptation Programme, Annex 3

End of section checklist

✓ **I have considered the 'Theory of Change' for my adaptation policy option**

✓ **Where appropriate I have identified climate thresholds and future decision-points as part of an adaptive pathways approach to resilience.**

✓ **Where appropriate I have selected climate change indicators as part of a monitoring and evaluation plan.**

Chapter 6. Checklist for analysts

For policies with lifetimes **up to 2040:**

- assess whether climate change risk is relevant to the policy (section 2.1)
- complete a climate risk assessment (section 3.1)
- generate policy options that are resilient to climate change (section 3.2)
- evaluate the costs and benefits of each shortlisted policy option using 2°C climate change scenario in the baseline (section 4.1)
- include a narrative summarising any unquantified costs and benefits related to climate change and resilience (section 4.1)
- develop a Monitoring and Evaluation plan to enable flexible adaptation to climate change (section 5.1)

For policies with lifetimes **beyond 2040**:

- follow all steps outlined for policies with lifetimes up to 2040
- reduce uncertainty by conducting a climate sensitivity test using a 4°C warming scenario, or alternatively using Real Options Analysis to account for impacts of different warming scenarios (section 4.2)

Annex A. Climate risks and present-day impact table

The Third Climate Change Risk Assessment (CCRA3) evaluates 61 specific risks and opportunities that climate change presents to the UK. This table provides a summary of these risks and opportunities, with each entry colour-coded by sector. The '£' symbol indicates the current economic cost or opportunity associated with each risk. For more information about the future economic impact of these risks consult The Monetary Valuation Report for CCRA3.

Table 11. Climate Change Risks and Opportunities with present day impacts

N1 Risks to terrestrial species and habitats Unestimated cost/benefit	N2 Risks to terrestrial species and habitats from pests, pathogens and INNS Unestimated cost/benefit	N3 Opportunities from new species colonisations in terrestrial habitats Unestimated cost/benefit	N4 Risk to soils from changing conditions, including seasonal aridity and wetness £££	N5 Risks to natural carbon stores and sequestration from changing conditions ££££
N6 Risks to and opportunities for agricultural and forestry productivity £-£££ (variability)	N7 Risks to agriculture from pests, pathogens and INNS ££	N8 Risks to forestry from pests, pathogens and INNS ££	N9 Opportunities for agricultural and forestry productivity from new species ££	N10 Risks to aquifers and agricultural land from sea level rise £
N11 Risks to freshwater species and habitats £££	N12 Risks to freshwater species and habitats £	N13 Opportunities to marine species, habitats and fisheries £	N14 Risks to marine species, habitats and fisheries £-££	N15 Opportunities for marine species, habitats and fisheries £
N16 Risks to marine species and habitats £	N17 Risks and opportunities to coastal species and habitats £	N18 Risks and opportunities from to landscape character Unestimated cost/benefit	I1 Risks to infrastructure networks from cascading failures £££	I2 Risks to infrastructure services from river and surface water flooding £££

I3 - Risks to infrastructure services from coastal flooding and erosion ££	I4 Risks to bridges and pipelines from flooding and erosion ££	I5 Risks to transport networks from slope and embankment failure ££	I6 Risks to hydroelectric generation from low or high river flows £	I7 Risks to subterranean and surface infrastructure from subsidence ££
I8 Risks to public water supplies from reduced water availability ££	I9 Risks to energy generation from reduced water availability £	I10 Risks to energy from high and low temperatures, high winds, lightning ££	I11 Risks to offshore infrastructure from storms and high waves £	I12 Risks to transport from extreme weather ££-£££
I13 Risks to digital from high and low temperatures, high winds, lightning Unestimated cost/benefit	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 £££-££££	H4 Risks to the viability of coastal communities from sea level rise £
H5 Risks to building fabric £££	H6 Risks and opportunities from household energy demand £££	H7 Risks to health and wellbeing from changes in air quality £-££	H8 Risks to health from vector-borne disease £-££	H9 Risks to food safety and food security £
H10 Risks to water quality and household water supplies Unestimated cost/benefit	H11 Risks to cultural heritage Unestimated cost/benefit	H12 Risks to health and social care delivery Unestimated cost/benefit	H13 Risks to education and prison services Unestimated cost/benefit	B1 Risks to businesses from flooding ££££
B2 Risks to business locations and infrastructure from coastal change ££	B3 Risks to businesses from water scarcity ££	B4 Risks to finance, investment, insurance, access to capital ££	B5 Risks to business from reduced productivity, £	B6 Risks to business from disruption to supply chains ££

B7 Opportunities for business - changing demand for goods and services ££	ID1 Risks to UK food availability, safety, and quality from climate change overseas £££	ID2 Opportunities for UK food availability and exports £	ID3 Risks to the UK from climate-related international human mobility £	ID4 Risks to the UK from international violent conflict resulting from climate change £
ID5 Risks to international law and governance from climate change Unestimated cost/benefit	ID6 Opportunities (including Arctic ice melt) on international trade routes £	ID7 Risks from climate change on international trade routes £	ID8 Risk to the UK finance sector from climate change overseas £££	D9 Risk to UK public health from climate change overseas £
ID10 Risk multiplication from the interactions and cascades of named risks Unestimated cost				

Key

Natural Environment, Infrastructure, Health & the built environment

Business and industry, International dimensions

Sector codes explained

N=Natural environment, I= Infrastructure, H= Health & the built environment

B= Business and industry, ID= International dimensions

Present day climate impact

£ = £<10million/year

££ = £tens of millions/year

£££ = £hundreds of millions/year

££££ = £billions/year

Annex B. Resilient appraisal case studies

These hypothetical policies illustrate how the above guidance can be applied practically to policy settings. They are based on real examples but do not represent any government department's actual approach to appraisal. The values presented are illustrative and should not be regarded as accurate or reliable estimates.

Case study 1. Overheating in residential buildings

Problem under consideration

Each of the last 4 decades has been successively warmer than any decade that proceeded it since 1850. It is virtually certain that hot extremes, including heatwaves, have become more frequent and with continued global warming the frequency and intensity of these weather extremes are projected to increase (IPCC 2021).

By mid-century the UK could experience extreme heatwaves every other year (Met Office 2018). Warmer temperatures increase the risks of overheating in residential buildings, negatively impacting occupants' health. The baseline number of heat related casualties could increase by almost ten-fold by mid-century due to climate change (UKHSA 2023).

Market failures mean the costs of overheating are not fully reflected in prices, necessitating government intervention. These failures include a lack of information about adaptation measures and the risk of overheating, and limited incentives for building owners and developers to make needed investments.

Government must ensure that homes and other residential buildings can cope with the future warmer climate. In the absence of government intervention, barriers to private adaptation could result in maladaptive practices such as increased uptake of air conditioning, which results in higher energy consumption and carbon emission costs.

Policy under consideration

Introduce a requirement for limiting overheating in new residential buildings. This requires developers to address overheating at the point of construction, which is the most cost-effective time to include passive cooling. Passive cooling includes measures to reduce solar gains by reducing window size.

Costs of the adaptation policy

Loss of amenity values

One primary cost of the policy is the reduction in the size of the window area, which may reduce the value of the property. The cost of the reduced amenity value was not monetised, but it is assumed that the loss of amenity value is at least as large as the cost-savings from building with masonry rather than glazing.

Familiarisation cost

It has been estimated that it would take between 3.5 hours and 7.5 hours for each business to familiarise themselves with the contents of the new regulations. Around 17,000 businesses were affected by the new regulations, with a total estimated cost of £2m.

Benefits of the adaptation policy

Reduced mortality

One of the benefits of passive cooling is that it reduces the impact of high temperatures on mortality. Using ONS life expectancy and UKCP18 climate forecasts, it was determined that new building regulations would save 1,668 life-years compared to a business-as-usual scenario. Using the value of the Quality Adjusted Life Years (QALYS) each year of life saved was given the value of £60,000, resulting in reduced mortality benefits of £53m. This is an example of the First Dividend of Resilience.

Construction cost savings

Masonry walls are cheaper to install than glazing, with an estimated saving of £1,600 per dwelling. Affecting 283,000 homes over 10 years, this results in a Present Value (PV) of £356m. However, these savings are assumed to be offset by the loss of amenity value from reduced window space This is an example of the Second Dividend of Resilience.

Capital and replacement cost savings

Avoiding the high costs of retrofitting homes with air conditioning, the policy is estimated to save £362m in capital and replacement costs. Without the adaptation measure, the proportion of homes with air conditioning could rise significantly, necessitating replacements every 15 years. This is an example of the First Dividend of Resilience.

Energy cost savings

Passive cooling designs are more energy-efficient than mechanical air conditioning. The estimated energy cost savings, calculated using the Green Book supplementary guidance on valuing energy costs amount to £89m. This is an example of the First Dividend of Resilience.

Carbon cost savings

By reducing the need for air conditioning, the policy achieves a small carbon cost saving of £3m. This is an example of the Third Dividend of Resilience.

Total NPV

The total NPV of the policy is £505m (£507m – £2m)

Sensitivity analysis

Portable cooling units

The analysis assumed that in the absence of the policy there would be an increased uptake of air conditioning. If households use portable cooling units instead of fixed air conditioning, capital cost savings would reduce from £362m to £148m, while energy cost savings would increase from £89m to £148m. This results in an NPV of £350m.

Climate sensitivity test

The analysis assumes a central warming scenario of 2°C above preindustrial levels by 2100. Given the long-lived nature of built infrastructure, a climate sensitivity test was conducted for a 4°C warming scenario. In this scenario excess mortality is expected to be significantly higher. Assuming the benefits of adaptation scale proportionally, the NPV of the policy in this scenario would rise to £590m.

Equalities analysis

The policy is expected to reduce inequality. Without intervention, lower-income households may not afford the high cost of retrofitting air-conditioning. By requiring passive measures at the point of construction, this policy ensures that adequate cooling is accessible to all, regardless of income.

Table 12. Summary of economic impacts from proposed building regulation

Costs	£m, discounted
Transition costs	2
Loss of amenity	~356
Benefits	**£m, discounted**
First dividend. Energy savings	89
First dividend. Capital and replacement savings	362
First dividend. Mortality benefit	53
Second dividend. Construction cost savings	356
Third dividend. Total carbon savings	3

Total benefit	863
Value for money	£m, discounted
Net present value (NPV)	505
Sensitivity test- NPV with portable cooling	350
Sensitivity test- NPV 4C scenario	590
Other values	
Amount of energy saved (GWh)	2,847
Amount of CO_2 traded saved ($MtCO_2$)	0.03
Number of homes affected	283

Case study 2. Flood defences for Kirkstall railway

Problem under consideration

The railway at Kirkstall in north-west Leeds is a key location in the rail network, with typically 7 four-car trains passing through each hour, increasing to 10 during peak times. Historically prone to flooding, Kirkstall has experienced 13 significant floods between 2002 and 2017. Currently, there is an 87% annual probability of flooding that disrupts railway operations.

As the climate warms, hotter air holds more moisture, leading to more frequent heavy rainfall events. The latest State of the UK Climate report indicates that the UK has become wetter over the last few decades, with 2011 to 2020 being 9% wetter than 1961-to 1990 (Kendon 2024). Currently, there are around 7 days per year of intense rainfall, which could increase to 9 days in a 2°C scenario and up to 11 days in a 4°C scenario (Met Office).

More frequent intense rainfall events driven by climate change endanger the UK's transportation network. By the 2080s, under a 4°C scenario, the length of railways at significant risk from flooding is expected to rise to 3,600km, up from 2,500km at present. Flooding risk for the Kirkstall railway is likely to increase significantly, as peak river flows for the Aire and Calder catchment management area are expected to rise between 23 to 51% by the 2080s (Defra 2024).

The need to reduce potential economic disruption provides a rationale for government intervention to increase the resilience of this railway to flooding and the anticipated effects of climate change.

Proposed policy

The proposed policy includes engineering measures that would enhance resilience to present day and future flood risk. These measures involve installing 440 metres of steel sheet piling to prevent flooding from the river south of Kirkstall Bridge and constructing a 1230m clay bund flood embankment to prevent flooding from overland flows north of Kirkstall Bridge.

Figure 11. Overview of proposed work at Kirkstall railway

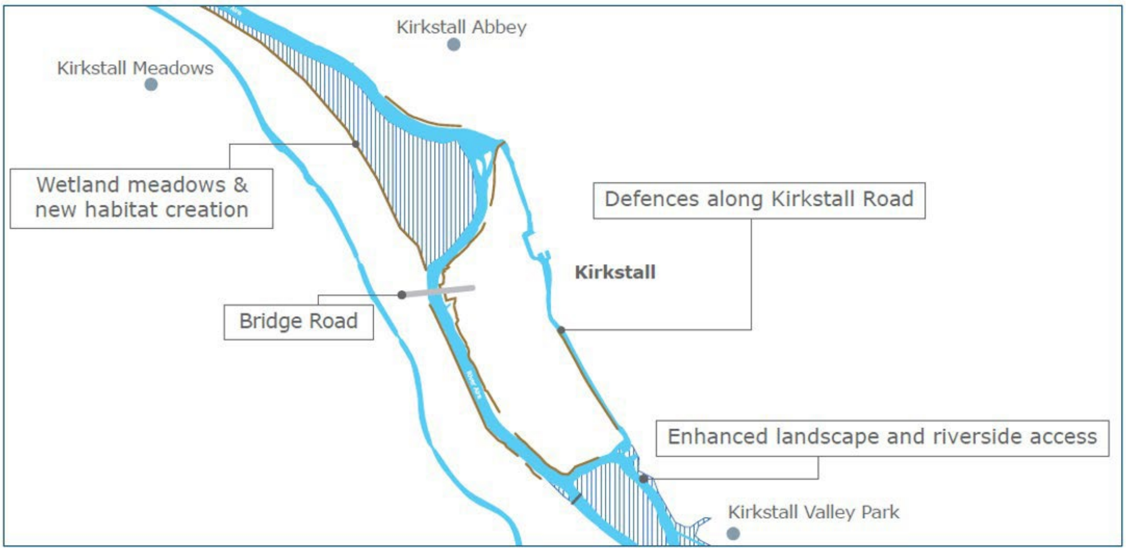


Figure 11 shows a river, at the top of the river Wetland meadows and habitat creation is indicated, towards the middle defences along Kirkstall Road is referenced, and towards the bottom enhanced landscape and riverside access is represented.

Costs of the adaptation option

Capital expenditure

Network Rail estimates the proposed work will cost £3.5 million, with no additional maintenance costs anticipated.

Benefits of the adaptation policy

Present day avoided losses

> Flooding at Kirkstall could result in a day's service loss between Leeds and Apperley Junction, cancelling 229 Northern Line services and 4 LNER services. This event would cost approximately £320,000. There is currently an 87% annual flood risk, so expected annual damage in the absence of intervention are £278,400. The proposed intervention would reduce the likelihood of flooding from 87% to 1%, reducing expected annual damage to £3,200. The present-day benefits of the policy would be £275,200 per annum, calculated as the difference between current and residual flood damages (£278,400 – £3,200 = £275,200).

Avoided losses with climate change

Assuming the flood prevention benefits of the policy increase proportionately with projected river flow allowances, then annual expected avoided losses would rise from £275,200 to £338,496 by the 2080s (a 23% increase). This is an example of the **First Dividend of Resilience**.

Wetlands creation

The proposal at Kirkstall Meadows would transform 2.4 hectares into a wetland habitat, featuring kingfisher banks, otter holts and wetland scrapes for fish. The biodiversity value of a marginal hectare of wetland is estimated at £420, so the policy would deliver £1,008 of environmental benefits per annum. This is an example of the **Third Dividend of Resilience**.

Net present value

Summing and discounting the costs and benefits of the policy up to 2080 under a central climate change scenario gives a net present value of £4.5m

Sensitivity analysis

Climate sensitivity test

Given the uncertainty surrounding the long-term impacts of climate change, a climate sensitivity test assesses whether different assumptions affect the value-for-money category. Assuming that avoided damages increase in proportion to peak-river flows, under a 4°*C* warming scenario the net present value of the policy increases to £5.3m.

Table 13. Costs and benefits of proposed intervention at Kirkstall railway (discounted over 2017 to 2080)

Costs	£ '000s, discounted
Total capital expenditure	3,480
Benefits	£ '000s, discounted
Total avoided losses up to 2080 (first dividend)	7,677
Total biodiversity benefits up to 2080 (third dividend)	27
Value for money	
NPV (2°*C warming scenario)* (£'000s, discounted)	4,520
NPV (4°*C sensitivity test)* (£'000s, discounted)	5,321
BCR (2°*C warming scenario)*	2.3

Annex C: Effects of climate change under 2°C and 4°C warming scenarios

This table provides information about some of the physical effects of climate change during this century under 2°C and 4°C warming scenarios. It should be noted that this data is mostly specific to England. Data for other nations and regions can be found using the Climate Risk Indicators website.

How to apply the table to appraisal

Values in this table can be used to assess climate risk and to value costs and benefits under a changing climate. The following hypotheticals demonstrate ways to use the guidance. For example,:

- in an appraisal of an expansion of NHS administrative capacity, the productivity of staff in the 2050s could be 0.15% lower than today due to overheating (see row 7)
- in an appraisal of a railway expansion programme, the number and possibly the cost of adverse weather days for the network is expected to rise by 23 to 73% by the 2080s depending on the warming scenario (see row 13)
- in an appraisal of water-conservation measures, the no action counterfactual could see the costs of drought increase by 228% by the 2080s under a high warming scenario (see row 17)
- in an appraisal of a school refurbishment programme, the non-adapted counterfactual scenario could see damages from school flooding plausibly increase by around 48-77% by the 2080s depending on the warming scenario (see row 30)

Table 14. Climate impacts across warming scenarios

Climate hazard	Metric	Hazard	Present	2°C 2050s	2°C 2080s	4°C 2080s
1. Extreme heatwave probability	Annual likelihood of heatwave similar to or exceeding 2018 (WSP 2020)	Heat	0%-20%	40-60%	40-60%	60-80%
2. Heat stress days	Days with shade Wet Bulb Globe Temperature (WBGT) above 25 (CRI 2024)	Heat	0.23	0.56	0.63	4.98

3. Met Office heatwaves	Events per year following Met Office definition (CRI 2024)	Heat	1.00	1.52	1.65	4.4
4. Summer maximum temperature	°C change from 1981 to 2010 mean (CRI 2024)	Heat	0.59	1.59	1.74	4.2
5. Road melt risk	Days with Tmax >25°C (CRI 2024)	Heat	15.67	21.93	23.15	50.17
6. Rail high temperature	Days with Tmax >30°C (CRI 2024)	Heat	1.60	2.73	2.91	9.73
7. Productivity impact due to over-heating (indoor)	% reduction of working time due to indoor overheating (Baglee 2012)	Heat	NA	-0.15%	-0.16%	-2.02%
8. Productivity losses-industry & construction	% reduction in labour productivity in industry and construction sectors by 2070 (COACCH 2018)	Heat	NA		-1%	-5%
9. Loss of staff hours due to over-heating	% rise in productivity losses relative to 2010 baseline (Baglee 2012)	Heat	NA	140%	150%	2,800 %

10. Extreme winter storm	Annual probability of winter rainfall on level with 2015 to 2016 (WSP 2020)	Rainfall and river flows	1%-5%	5%-20%	5%-20%	20%-50%
11. Winter rainfall	Seasonal total rainfall % change from 1981 to 2010 mean (CRI 2024)	Rainfall and river flows	+1.2%	+4.9%	+4.6%	+12.1 %
12. Summer rainfall	Seasonal total rainfall % change from 1981 to 2010 mean (CRI 2024)	Rainfall and river flows	-3.4%	-10.2%	-12.4%	-29.9%
13. Adverse rail days	Days with temperature, rainfall or windspeed beyond threshold (CRI 2024)	Rainfall and river flows	29.6	31.7	32.3	51.1
14. Daily extreme rainfall	Rainfall uplifts for future climate (1 to 6 hours) (CCC 2015)	Rainfall and river flows	NA	+10%	+20%	+50%
15. Peak river flows	Peak river flow relative to 1981 to 2000 baseline (EA 2023)	Rainfall and river flows	NA	+35%		+127%
16. >18-month drought	Probability of a drought lasting more than 18 months occurring (WSP 2020)	Drought	0-10%	10-20%	10-20%	20-50%

17. SPEI drought	Proportion of time with a Standardised Precipitation Evaporation Index less than -1.5 (CRI 2024)	Drought	8.7%	12.6%	13.8%	28.5%
18. Coastal flooding	Annual probability of significant breach of defences (WSP 2020)	Coastal	0-1%	5-50%	5-50%	50-100%
19. Sea-level rise	Metres of sea level rise for London relative to 1981 to 2000 baseline (EA 2024)	Coastal	0.1	0.4	0.8	1.2
20. Significant wildfire season	Annual probability of a significant wildfire season (WSP 2020)	Wildfire	0-10%	10-20%	10-20%	20-50%
21. Met Office Fire Danger	Days with very high Met Office Fire Severity Index (MOFSI) index (CRI 2024)	Wildfire	15.6	19.6	20.7	37.3
22. Expected annual damage from flooding	% increase in indirect and direct damages from all flooding under current levels of adaptation (low impact) (Sayers 2020)	Flooding damages	NA	+39%	+58%	+105%
23. Expected annual damages from surface	% increase in indirect and direct damages from	Flooding damages	NA	+44%	+63%	+106%

water flooding	surface water flooding (Sayers 2020)					
24. Expected annual damages from fluvial flooding	% increase in indirect and direct damages from fluvial flooding under current levels of adaptation (low impact) (Sayers 2020)	Flooding damages	NA	+27%	+31%	+58%
25. Expected annual damages from coastal flooding	% increase in indirect and direct damages from coastal flooding under current levels of adaptation (low impact) (Sayers 2020)	Flooding damages	NA	+66%	+135%	+244%
26. Major roads at risk	% increase in length of roads at most risk of flooding under current levels of adaptation (low impact) (Sayers 2020)	Flooding damages	NA	+54%	+72%	+113%
27. Railways at risk	% increase in length of railways at most risk of flooding under current levels of adaptation (low impact) (Sayers 2020)	Flooding damages	NA	+47%	+61%	+91%
28. Emergency services at risk	% increase in sites at most significant risk of flooding under current levels of adaptation (low impact) (Sayers 2020)	Flooding damages	NA	+44%	+60%	+90%

29. Hospitals at risk	% increase in sites at most significant risk of flooding under current levels of adaptation (low impact) (Sayers 2020) under current levels of adaptation (low impact)	Flooding damages	NA	+27%	+34%	+49%
30. Schools at risk	% increase in sites at most significant risk of flooding (Sayers 2020) under current levels of adaptation (low impact)	Flooding damages	NA	+27%	+50%	+77%

Sources: CCC 2015, EA 2023, Climate Risk Indicators, WSP 2020, Sayers 2020, CCRA for Business and Industry 2012

Annex D: Further resources

Climate risk assessment

- The UK Climate Resilience Programme 2023. Climate Risk Indicator explorer
- Met Office. UK Climate Projections 2018 (UKCP18)
- Met Office 2024. Local Authority Climate Explorer
- Environment Agency 2023. Climate Impacts Tool
- Hadley Centre 2021. Effect of potential climate tipping points on UK impacts
- Department for the Environment Food and Rural Affairs 2022. The Third Climate Change Risk Assessment (CCRA3)
- Climate Change Committee 2021. CCRA3 sector briefings

Drafting resilient options

- Climate Change Committee 2021. Independent Assessment of UK Climate Risk
- Department for the Environment Food and Rural Affairs 2023. Third National Adaptation Programme (NAP3)
- Jenkins et al 2021. Adaptation Inventory
- EconADAPT. Adaptation options
- Policy Profession Unit 2024. Climate Adaptation Gateway

Appraising costs and benefits with climate change in the baseline

- Watkiss et al 2021. Monetary Valuation of Risks and Opportunities in CCRA3
- Rising et al 2022. What will climate change cost the UK?
- Office for National Statistics 2024. Impact of hot days on productivity in Great Britain
- Watkiss, P. 2022. The Costs of Adaptation, and the Economic Costs and Benefits of Adaptation in the UK
- The Co-Designing the Assessment of Climate Change Costs (COACCH) 2021. Climate Change Impact Scenario Explorer
- Department for the Environment Food and Rural Affairs 2023. Enabling a Natural Capital Approach (ENCA)
- Environment Agency 2018. Floods of winter 2015 to 2016: estimating the costs
- Sayers et al 2020. Projections of future flood risk

Appraisal under uncertainty

- Tröltzsch et al 2010. The Economics of Climate Change Adaptation
- Government Actuary's Department 2020. Uncertainty toolkit for government analysts
- The Government Finance Function 2013. Orange Book
- Watkiss et al 2013. Real Options Analysis
- Environment Agency 2021. Accounting for adaptive capacity in FCERM options appraisal
- Department for Environment Food and Rural Affairs 2023. Taking an adaptive approach: Thames Estuary 2100

Annex E: Glossary

Term	Definition
Adaptation	The ability of an organisation, asset, or individual to anticipate, prepare for, respond to, and recover from climate related disruption
Adaptive pathways	A flexible strategy for managing climate change involving planning and implementing a series of actions over time, which can be adjusted as new information emerges.
Adaptive capacity	The ability of an organisation, asset, or individual to adjust to climate impacts, take advantage of opportunities and respond to costs
Cascading risk	A situation where climate impacts in one sector trigger or amplify risks in another.
Climate change	Long-term changes in temperature and weather patterns primarily affect driven by anthropogenic (man-made) emissions
Climate Change Committee (CCC)	The Climate Change Committee is an independent non-departmental public body, formed under the Climate Change Act to advise the United Kingdom and devolved governments on tackling and preparing for climate change.
Climate Change Risk Assessment (CCRA)	A report outlines the UK government and devolved administrations' position on the key climate change risks and opportunities that the UK faces today. This is published once every five years, with the latest version (CCRA3) published in 2022.
Climate change scenario	A plausible and simplified representation of future climate change, based on a set of assumptions about future global

	greenhouse gas emissions and the climate's sensitivity to higher emission concentrations
Climate exposure	The presence of organisations, assets, or individuals that could be adversely affected by climate hazards.
Climate hazard	A potentially damaging physical effect driven by climate change, such as extreme weather events.
Climate resilience	The ability to anticipate, prepare for, respond to, or recover from climate related disruption
Climate resilient appraisal	Appraisal that includes at least one climate change scenario in the baseline.
Climate risk	A potential negative impact from climate change resulting from the interplay between hazard, exposure and vulnerability.
Climate risk assessment (CRA)	The process of identifying, analysing and evaluating risks associated with climate change to inform policy development and appraisal.
Climate vulnerability	The extent to which an organisation, asset or individual is sensitive to, or unable to cope with, the adverse effects of climate change
Greenhouse gas emissions	Gases released into the atmosphere that trap heat and contribute to climate change
International Panel on Climate Change (IPCC)	The Intergovernmental Panel on Climate Change (IPCC) is the United Nations' body for assessing the science related to climate change

Lock-in	Climate 'lock-in' refers to decisions taken in the present that increase the degree of future climate risk.
Maladaptation	Adaptation decisions that have adverse or counterproductive side-effects
Nature-Based-Solutions (NBS)	Adaptation measures that utilise nature to increase resilience to climate change.
National Adaptation Programme (NAP)	The National Adaptation Programme (NAP) sets the actions that the UK Government will take to adapt to the challenges of climate change in England.
Real-Options-Analysis	Appraisal technique used to evaluate investment opportunities by considering the value of potential future decisions and flexibility in management.
Representative Concentration Pathway (RCP)	A representation of different greenhouse gas emissions pathways consistent with different levels of future warming. RCP 4.5 and RCP 6.0 are consistent with 2 degrees and 4 degrees of warming respectively.
Tipping points	Climate tipping points are critical thresholds that, when crossed, lead to irreversible changes in the climate system
Triple Dividend of resilience	A conceptual framework that defines the three types of benefits of investments in resilience: avoiding losses from climate change (first dividend), induced economic benefits (second dividend), and social and environmental co-benefits (third dividend).