Phase 2: Modelling and Analysis

Methodology document

Contents

Introduction

Introduction

This document sets out a desired consistent approach for projects in this programme

- The purpose of this method document is to encourage a consistent approach across the commissioned research projects which will feed into the Well-Adapted UK Report.

- This document covers the desired approach to Phase 2 of the project (modelling and analysis). Phases 1 and 3 are set out in the 'Request for Proposal' (RFP) document. Details of the project specific requirements for implementing this method are also contained within the RFP.

- Where feasible, we would expect suppliers to follow this approach to Phase 2 as closely as possible. For individual research projects, the approach set out here may not be appropriate due to model or data limitations. In some cases, this has already been identified within the project RFP document with an alternative approach suggested. We also welcome suggestions for alternative approaches from suppliers where these are necessary. Any alternative assumptions used in the proposed method should be transparently described and justified.

- In delivering the project, the methodology should be co-developed with the CCC project manager, who should have the opportunity to review all detailed methodological choices and assumptions.

Introduction

We ask suppliers to set out a detailed approach in their bids

In the response to this invitation to tender, we expect suppliers to set out their proposed approach to the Phase 2 tasks outlined on this document, including:

- Where they will follow an alternative approach to that suggested in this methodology document and why an alternative approach has been chosen.
- The metrics they will use to assess hazard, exposure, vulnerability and overall risk (see RFP for project specific details).
- The spatial resolution for each stage of the analysis (see RFP for project specific details).
- The data sources that they will use at each stage of the approach where this is known, anticipating that further data sources may become apparent during the course of the project.
- Where known in advance, the assumptions they will make for each stage of the approach and how they will validate those.
- Where they anticipate there to be data gaps or other challenges in delivering the approach and how they intend to address these.

Description of preferred approach

Description of preferred approach

Phase 2 should cover four core tasks

Task 2.1: Estimate present-day and 'baseline' future risk

A. Analyse the determinants of present and 'baseline' future, using the hazard, exposure and vulnerability framework.

B. Quantify present and 'baseline' future risk, reporting risk in terms of 'impact metrics'.

C. Estimate the total economic-value costs associated with these risks.

D. If appropriate (as indicated by the RFP), assess the distributional impact of these risks.

Task 2.2: Identify and appraise adaptation options

A. Identify a longlist of adaptation options to address risk.

B. Shortlist adaptation options by assessing the costs and benefits of each option.

Task 2.3: Build a scenario of cost-optimal adaptation

A. Build a cost-optimal scenario of adaptation actions deployed by 2030s and by 2050s.

Task 2.4: Conduct sensitivity analysis

A. Use a scenario approach to test the robustness of the analysis to alternative climate and socioeconomic futures.

Task 2.1: Estimate present-day and ‘baseline’ future risk.

Task 2.1: Estimate present-day and 'baseline' future risk.

A. Analyse the determinants of present and 'baseline' future risk using the hazard, exposure and vulnerability framework.

In this step, the supplier should analyse each determinant of present (1991-2020 climatology) and 'baseline' future risk (for the 2030s and 2050s separately), at the spatial resolution described in the RFP for the project. Annex 1 describes how the 'baseline' scenario should be defined.

More details of the specific determinants to be considered within this project are provided within the RFP.

- **Hazard(s).** The supplier should identify relevant hazard metrics, using variables and thresholds agreed with the CCC, to ensure standardisation across projects is maintained where possible. The supplier should analyse how the frequency and severity of hazards is expected to change in future, for different extremity levels (see Annex 2). Suppliers should use the set of climate projections described in Annex 3 for analysis of future baseline hazards.

- **Exposure.** The supplier should identify the relevant people, assets or activities which could be impacted by the hazard. The supplier should analyse how exposure is expected to change over time, in line with the socioeconomic scenarios outlined in Annex 4.

- **Vulnerability.** The supplier should identify characteristics of people, assets or activities which make them particularly vulnerable to experiencing impacts from hazards (for example, factors which make them more sensitive, or which lower their adaptive capacity). Where useful, the supplier can draw on the CCC's collated vulnerability datasets, described in Annex 5. The supplier should spatially analyse these features of vulnerability and how they are expected to change over time, in line with the socioeconomic scenarios outlined in Annex 4.

Hazard, exposure and vulnerability will all vary spatially across the UK. Spatial variation in all factors should be presented at LSOA (2021) scale and relevant spatial scale for key decision makers (as guided by the RFP).

The supplier should use these analyses of hazard, exposure and vulnerability as key inputs in Task 2.1.B (risk assessment). The final scope of risk determinants will be agreed with the CCC project manager.

Bids should specify the approach suppliers will take to identifying and analysing these determinants of risk, including any challenges this may present or assumptions that may be needed.

Task 2.1: Estimate present-day and 'baseline' future risk

B. Quantify present and 'baseline' future risks, reporting risks in terms of 'impact metrics'

In this step, the supplier should estimate present-day and 'baseline' future risks, drawing on the analysis of hazard, exposure and vulnerability undertaken in Task 2.1.A using appropriate risk modelling tools.

The supplier should report risks in terms of summary 'impact metric(s)'. These metrics should be those which could form the basis for outcomes-based resilience standards, for example duration of power outages is the metric that forms the basis of the Electricity System Restoration Standard.

In general, we are interested in impact metrics relevant to the possible determination of resilience standards in the following categories of the Government Resilience Framework:

- Prevent: proactive prevention of the risk occurring
- Mitigate: limiting the scale and extent of impacts when the risk occurs
- Recover: limiting the duration and long-term consequences of impacts that occur

The RFP for each project includes more details of possible impact metrics, and we ask suppliers to confirm in the bid response which impact metric(s) they propose to use.

Where possible, the supplier should quantify impact metrics using multiple hazard extremity levels (see Annex 2) incorporating these together to calculate expected average annual impact. Spatial variation across the UK should be presented at LSOA (2021) scale and relevant spatial scale for key decision makers (as guided by the RFP).

Bidders should set out the details of the tools, methodological approaches and proposed 'impact metrics' as part of their responses. Significant detail should be provided on the modelling tools that integrate the aspects of hazard, exposure and vulnerability from Task 2.1.A into risk metrics. They should also clearly identify if/how they intend to use hazard information from multiple severity levels.

Task 2.1: Estimate present-day and 'baseline' future risk

C. Estimate the total economic value costs associated with risks.

In this step, the supplier should monetise the risks estimated in 2.1.B to estimate, as far as possible, the total economic value costs (net of any benefits and including the costs of impacts in non-market sectors) associated with present and 'baseline' future risks.

Where possible and appropriate, 'costs' associated with the expected Government emergency response to realised impacts in the baseline future should be considered as part of this task (including their interaction with reducing direct costs), but any inclusion of response costs should be agreed with the CCC during the project.

The estimation of 'whole-economy' costs should consider direct and indirect costs and benefits (reported year-by-year) arising from climate impacts as guided by the RFP. We advise using HMT's Green Book for monetising non-market impacts. Further costing guidance is presented in Annex 6.

Suppliers should indicate in their bid response which direct and indirect costs and benefits they expect to be able to value and the intended methodology approaches to allow them to do so.

Task 2.1: Estimate present-day and 'baseline' future risk.

D. If appropriate (as indicated by the RFP), assess the distributional impact of these risks.

The RFP describes whether this step is required for this project and, where it is required, provides more details on which distributional impacts should be assessed.

If required, the supplier should analyse how risks are distributed across different groups. For example, the supplier might consider how risks are distributed:

- Among people with protected characteristics (as defined by the Equality Act) or other socioeconomic characteristics (for example, income level or occupation).
- Across different geographical areas.
- Across different economic sectors.

In the bid response the supplier should set out an appropriate quantitative approach for assessing distributional impacts. The supplier should also describe how these distributional impacts can be communicated (for example, presenting impacts relevant to the population average). If a quantitative approach is not feasible, the CCC would also consider qualitative analysis.

Task 2.2: Identify and appraise adaptation options

Task 2.2: Identify and appraise adaptation options

A. Identify longlist of adaptation options to address risks.

B. Shortlist adaptation options by assessing their costs and benefits.

A. Identify longlist of adaptation options to address risks.

In this step, the supplier should develop a longlist of adaptation options which can be used to manage the risks analysed in Task 2.1. This longlist should be developed through literature review and in collaboration with the CCC and project steering group (see Phase 1 described in the RFP). Types of adaptation options could include physical (including nature-based or engineered), social and behavioural, or institutional solutions.

B. Shortlist adaptation options by assessing their costs and benefits.

For each long-listed adaptation option, the supplier should collate information on:

- The expected risk-reduction benefits of the adaptation action (compared to the 'baseline' risks estimated in Task 2.1)
- The expected investment requirements and operational costs to implement the action and how these would change over time.
- Any expected co-benefits and/or trade-offs (see Annex 7 for a list of areas to consider).
- Energy use (where material) including the pattern of demand across time in particular its relationship to the relevant climate hazard.
- Any relevant information on the feasibility of and capacity for implementation and expected deployment times.
- The maximum scale that the adaptation option could be deployed at.

Based on this information suppliers should take a proportionate approach to shortlisting adaptation options aligned with their approach to building adaptation scenarios in Taks 2.3. These approaches should be set out in the bid. The shortlist should be agreed with the CCC and project steering group.

In bids, the supplier should set out how they will handle evidence gaps or uncertainty while analysing cost or benefits of adaptation options, and how this will be transparently communicated in final products. They should also set of their intended approaches to long-listing and short-listing options and intended data sources that will be used.

Task 2.3: Build a scenario of cost-effective adaptation

Task 2.3: Build a scenario of cost-optimal adaptation

A. Build a cost-optimal scenario of adaptation actions deployed by the 2030s and by the 2050s.

From the short-listed adaptation actions in Task 2.2B the supplier should build a 'cost-optimal' scenario of adaptation (minimising total net costs) that could be deployed by the 2030s and by the 2050s respectively.

For models that are not inherently cost-optimising models, the supplier can consider different approaches (as below) for developing this scenario. A proposed approach should be agreed with the CCC project manager:

- **Iterative cost-minimisation.** The supplier could run the risk model used in Task 2.1.B iteratively, each time increasing the deployment of short-listed adaptation options (following a rank ordering of options based on their net costs – Annex 8, including co-benefits – Annex 9, and wider feasibility considerations), until the calculated marginal cost of risk reduction exceeds the marginal benefits of avoided climate risks.

- **Scenario approach.** The supplier could develop multiple packages of adaptation actions at different levels of ambition and quantify the whole-society costs and benefits of each package. The preferred package would be the one with the highest cost-benefit ratio.

For this cost-optimal adaptation scenario, **total adaptation investment required** (by the 2030s and by 2050s) and the **residual level of climate risk** (by the 2030s and by the 2050s - using the impact metrics of Task 2.1.B) should be reported. The level of residual risks might vary by geographical area or for different types of assets or activities and the approach to managing this should be agreed with the CCC project manager.

Bid should set of proposed details of the intended approach to building the cost-optimal adaptation scenario and how they intend to be able to calculate the associated investment costs. Where Government has an articulated 'risk appetite' this should be considered within the proposed approach to cost-optimal adaptation and sensitivity to the nature of these assumptions explored. Approaches to this should be set out in the bid and agreed with the CCC.

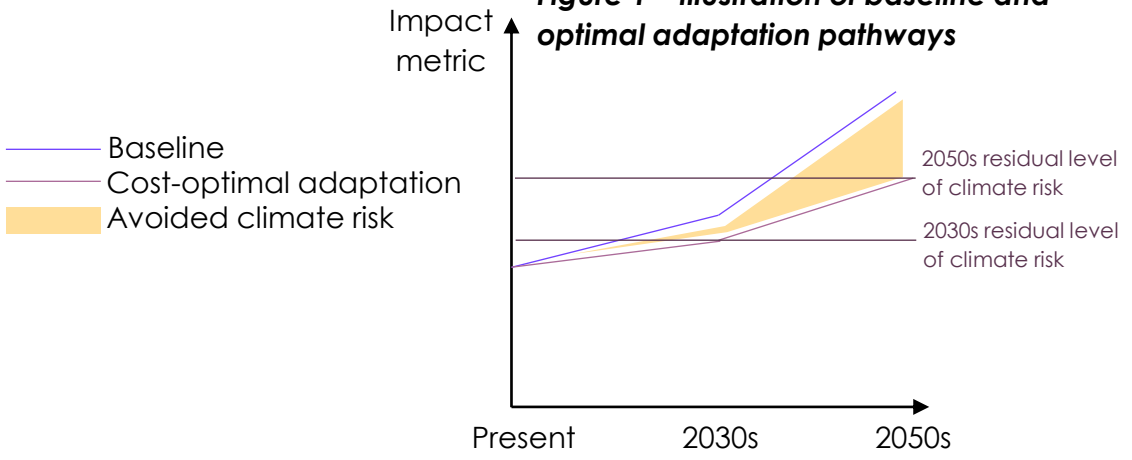

Figure 1 – Illustration of baseline and optimal adaptation pathways

Task 2.4: Conduct sensitivity scenarios to examine uncertainty

Task 2.4: Conduct sensitivity scenarios to examine uncertainty

A. Use a scenario approach to test the robustness of the analysis to alternative climate and socioeconomic futures.

In this Task, the supplier should test the robustness of all analysis to alternative climate and socioeconomic futures. This could be conducted as a separate Task or completed alongside the rest of the analysis.

The supplier should repeat the analysis undertaken in Tasks 2.1, 2.2 and 2.3 for different sensitivity scenarios, reporting the baseline risks, the investment needed for the new cost-optimal adaptation scenario under the sensitivity scenario and the associated residual impacts.

The sensitivity scenarios are:

- **High climate hazards.** Higher global warming levels are expected to impact the frequency and/or severity of climate hazards. The approach the supplier should take for this sensitivity is described in Annex 10.
- **High exposure and vulnerability.** The supplier should develop a scenario, in consultation with the CCC, where people, assets or activities are more exposed or have higher levels of vulnerability. Annex 10 proposes some indicators which may be relevant in developing this scenario.
- **Reasonable worst case (optional).** The supplier could consider a scenario with both high global warming levels and high exposure and vulnerability(aligned to the two previous sensitivities) occurring together.

Bids should clearly set out the ability to deliver these sensitivity scenarios and the details of the intended high exposure and vulnerability variant – including its associated data sources.

Technical annexes

Annex 1: the 'baseline' future scenario is where no additional adaptation action is taken

Definition of the 'baseline' scenario

- The 'baseline' scenario is a future scenario defined for 2030s (2030-2039 average) and 2050s (2050-2059 average) where no additional adaptation actions are taken relative to present-day.
- In this future scenario, the UK experiences changes in climate hazards (Annex 2 and 3), socioeconomic variables (Annex 4) and other anticipated changes in the relevant system.
- Under this scenario, existing adaptation assets are maintained up to the end of their planned lifetime, and then replaced like-for-like.
- For some research projects, it may be appropriate to model an additional / alternative 'planned action baseline' future which includes actions which could support adaptation that have already been committed to. The RFP will indicate where this is required.
- For example, considering the risk of flooding to the built environment, the 'baseline' future would be where:
  - the frequency/ severity of flooding increases in line with the climate scenario set out in Annexes 2 and 3
  - the population would grow in different regions in line with the population scenarios described in Annex 4
  - characteristics of built environment assets would change in line with current policy and trends associated with Annex 4 scenarios
  - existing flood defences are maintained, and then replaced like-for-like at end of life.
  - there is no additional investment in flood adaptation beyond present-day levels

Annex 2: the supplier should model risks associated with hazard events of different extremity levels

Description of proposed extremity levels

- The supplier should ideally analyse hazards at a range of different extremity levels (for the time periods identified in Annex 1) to cover a variety of severity levels across the probability distribution and allow a more complete estimate of expected annual impacts.

- There are four standardised extremity levels we encourage suppliers to use where possible to inform their calculation of expected annual impacts: these being annual probability of exceedance of **5%, 1%, 0.5% and 0.2%** (where possible). The hazard levels associated with these are likely to vary spatially.

- We accept that the use of all these levels may be practically challenging, so we encourage suppliers to propose proportional alternative approaches where this is not possible

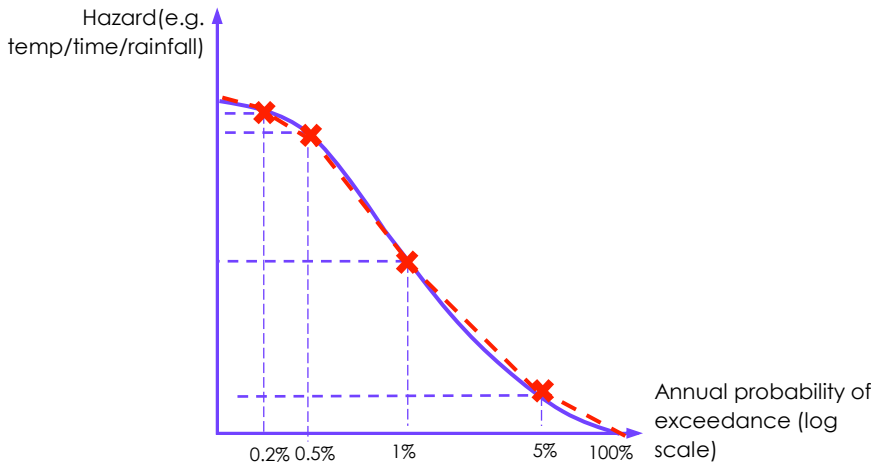

Figure 2 – Illustration of probability exceedance distributions

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Annex 3: the analysis should apply a global warming level approach to UKCP18 projections for analysing the changing profile of hazards

Analysis of global warming levels

- For CCRA4, and consistent with the IPCC 6th assessment report (AR6) we will use a **Global Warming Level** (GWL) approach, sampling UK hazards from the most relevant UKCP18 products at the specified GWL levels.

- Table 3 provides a summary of the climate futures that we would like the core analysis to align to for both the 2030s and 2050s analysis periods.

- The CCC can provide time-slice data for when the UKCP18 variant reaches specific GWL thresholds to aid contractors identifying the correct climate data for the project and wider guidance on accessing the relevant climate hazard information aligned to this framing.

	Future climate conditions: Core analysis	
Future time periods	2030s	2050s
Global warming levels (relative to pre-industrial)	1.5ºC	2ºC
UK climate	Median ensemble member of UKCP18 @ 1.5ºC	Median ensemble member of UKCP18 @ 2ºC
Severity of UK hazards	As per Annex 2	As per Annex 2

Table 3 – Climate framing for the future time periods for the central analysis

Annex 4: the analysis should also use a set of socioeconomic projections which are consistent across all research projects

Description of socioeconomic projections

In the core analysis, suppliers should make use of the following socioeconomic projections, which can be provided by the CCC:

- Population – the ONS principal population projection (2020-based interim national population projections)

- GDP – the central GDP scenario from the OBR (March 2023 variant)

Alignment with other standard Government projection sources for other relevant socio-economic variables is desirable wherever possible and bids should be clear on what sources they would intend to use for projections of other socio-economics variables.

Annex 5: Vulnerability datasets

- CCC has separately commissioned collation of UK-wide data on indicators of societal vulnerability at consistent spatial resolution (LSOA level).
- Data included:
  - Household/population characteristics (e.g. age, sex, gender, income etc.)
  - Business and workforce characteristics (e.g. business size, number of outdoor workers)
  - Indicators of community adaptative capacity (e.g. single occupant households, internet connectivity)
- Data should be available in spreadsheet and GIS-enabled formats by end-July 2024 and can be provided to the suppliers where relevant for this project.

Annex 6: suppliers should draw on Green Book guidance to estimate whole-economy costs and benefits

A – Key principles in monetising costs and benefits

- **Social costs (or benefits)**. The supplier should estimate the year-by-year costs and benefits that accrue to the UK economy considered as a single entity, without considering transfers between actors within the economy.

- **Total economic value.** The supplier should estimate the total economic value associated with costs and benefits. When analysing risk (Tasks 2.1.B, 2.3 and 2.4), suppliers should consider both direct and indirect impacts of hazards. When assessing the benefits of adaptation actions (Task 2.3), suppliers should consider co-benefits and trade-offs. The approach to estimating total economic value should be proportionate and agreed with the CCC project manager.

Annex 6: suppliers should draw on Green Book guidance to estimate whole-economy costs and benefits

B – Detailed description of the approach

- **Net present value.** Suppliers should **report year-by-year costs and benefits** for the outputs of Task 2.1C and 2.3. However, to calculate the cost-optimal adaptation scenario in Task 2.3, net present value (NPV) cost are required.

- The supplier should estimate the net present value of costs and benefits by applying the appropriate social discount rate. In line with Government guidance, these are:

  – 3.5% as standard, tapering to 1% (see Table 1)

  – 1.5% for health interventions

  – 10% for official development assistance

- **Base price year.** The supplier should use 2023 as the base price year. The CCC can provide GDP deflator data if required.

- **Exchange rates.** The supplier should use the Bank of England or Office for Budget Responsibility for exchange rate conversion

Period of years	0-30	31-75	76-125	126-200	201-300	301+
Standard social discount rate	3.5%	3%	2.5%	2%	1.5%	1%

Table 1 – Social discount rates

Annex 7: suppliers should consider a range of co-benefits and trade-offs when assessing adaptation actions

List of proposed considerations

- **Feasibility considerations**
  - Capacity of relevant actors to implement
  - Alignment with existing policies
  - Technological readiness and deployment timescales
- **Economic considerations**
  - Sectoral gross value added
  - Employment and incomes
  - Property or asset values
- **Social considerations**
  - Population health
  - Population wellbeing
  - Distributional impacts
- **Environmental considerations**
  - Interactions with other climate hazards
  - Greenhouse gas emissions
  - Biodiversity
- **Other**
  - Maladaptation risk (defined as agreed with the CCC)

Annex 8: suppliers should follow a consistent approach when estimating the costs of adaptation actions

A – Detailed description of approach

- Suppliers should estimate the year-by-year expenditure on adaptation which is **additional to the 'baseline'** scenario. This includes:
  - The full cost of actions where the primary benefit is adaptation.
  - The additional cost of making assets or activities climate-resilient.
- Suppliers should include the following types of expenditure:
  - **Capital expenditure** – expenditure that creates an asset with a lifetime greater than 1 year (for example, buildings, infrastructure or equipment).
  - **Operating expenditure** – ongoing expenditure required to deploy and operate assets. For example, maintaining flood defences, electricity for air conditioning.
- Suppliers should include costs of production, distribution and retailing.
- Suppliers should not include:
  - Impacts on upstream investment in the supply chain.
  - Upstream strategy development costs.
  - Financing costs.
  - Taxes or subsidies, for example VAT.
  - Intangible costs, for example R&D.

Annex 8: suppliers should follow a consistent approach when estimating the costs of adaptation actions

B – Detailed description of approach (continued)

- Suppliers should **report year-by-year costs and benefits** for the outputs of Task 2.3.However, to calculate the cost-optimal adaptation scenario, net present value (NPV) cost are required.
- There may be significant **uncertainty and optimism bias** (the costs of large projects are often underestimated).
  - A best-guess central cost should be landed on for adaptation interventions where possible.
  - Where there is significant uncertainty, suppliers should present a range between:
    - A lower bound (a reasonable estimate of the minimum cost of the intervention).
    - An upper bound (a reasonable estimate of the maximum cost of the intervention).
  - For large projects, where there is potential for optimism bias, this should be adjusted for to provide a more realistic assessment of potential costs and expected returns on investments.
  - Costs of actions on roads, rail, bridges/tunnels, buildings, IT projects, land and property purchases should have optimism bias adjustments applied consistent with this HMT guidance.
- Suppliers should take into account **opportunities for future cost reduction** in their assessment of cost.

Annex 9: the CCC has compiled guidance for monetising the co-benefits of adaptation actions

List of useful resources

A. General

- The Green Book

B. Social impacts

- Green Book supplementary health guidance
- Wellbeing appraisal tables and guidance
- Economic and social costs of crime
- Culture and heritage capital evidence bank

C. Environmental impacts

- Defra's Enabling a Natural Capital Approach (ENCA) Guidance.
- University of Exeter's Outdoor Recreation Valuation Tool
- National Water Environment Benefits Survey
- Defra toolkit

Annex 10: the supplier should use consistent methods in developing sensitivity scenarios

Description of projections which should be used in sensitivity scenarios

- There are two differences in climate scenarios between the core analysis and the **high climate hazard sensitivity**:
  - there are higher levels of global emissions, such that the indicative global warming level for each time period becomes: **2.0ºC in 2030s; 2.5ºC in 2050s**
  - the supplier should take the **upper** UKCP18 ensemble member for the relevant global warming level to identify UK climate fields.
- The following could inform a **high socioeconomic vulnerability sensitivity**:
  - ONS high population projection
  - the high GDP scenario from the OBR