

(CEOSA 0901)

# Method Report 3: Method for the Adaptation Economic Assessment

May 2011

**Deliverable 2.2.1 FINAL**

Contractors: Metroeconomica/Paul Watkiss Associates

## **Deliverable 2.2.1: CCRA Method: Method for Adaptation Economic Assessment**

### **Statement of use**

External use

### **Dissemination status**

External

### **Authors**

Alistair Hunt and Paul Watkiss

Hunt, A. and Watkiss, P. (2011). Method for the Adaptation Economic Assessment to accompany the UK Climate Change Risk Assessment (CCRA). Final Report to Department for Environment, Food and Rural Affairs. Submitted by HR Wallingford Ltd, Contract CEOSA 0901. May 2011.

### **Keywords:**

Adaptation, Economics, AEA, CCRA

### **Lead Research contractor:**

HR Wallingford Ltd  
Howbery Park, Wallingford, Oxon, OX108BA  
Tel: +44(0)1491835381

### **Defra project officer:**

Michael Mullen

### **Defra contact details:**

Adapting to Climate Change Programme,  
Department for Environment, Food and Rural Affairs (Defra)  
Area 3A  
Nobel House  
17 Smith Square  
London  
SW1P 3JR

Tel: 020 7238 3000

[www.defra.gov.uk/adaptation](http://www.defra.gov.uk/adaptation)

### **Document History:**

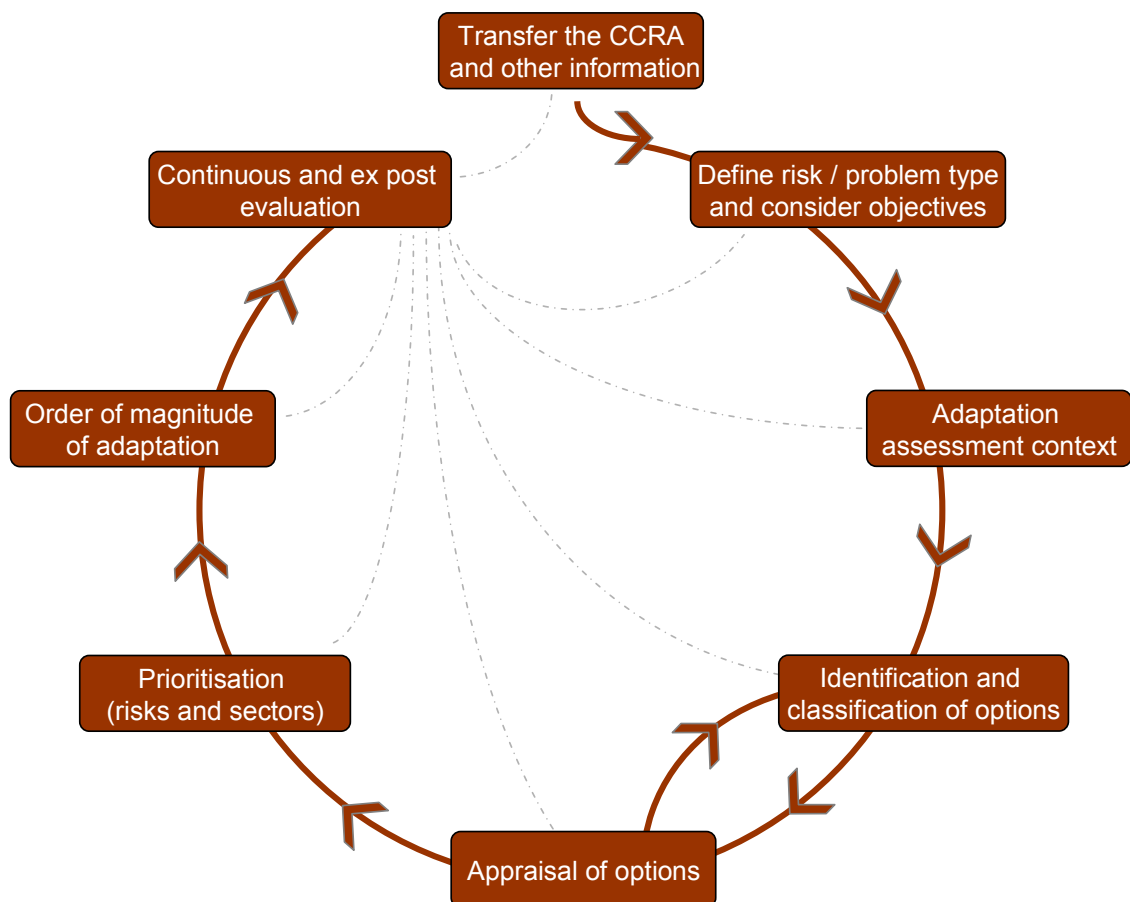
Date	Release	Prepared	Notes
19/1/11	6	Metroeconomica/ Paul Watkiss Associates	Submitted to Defra

# Executive Summary

The Climate Change Act (2008) created a framework to build the UK's ability to adapt to climate change. It requires the Secretary of State to implement a National Adaptation Programme, and to lay before Parliament an assessment of the risks posed to the UK by climate, the Climate Change Risk Assessment (CCRA).

Alongside the first CCRA, an Adaptation Economic Assessment (AEA) is being undertaken to consider potential adaptation responses, and to provide information for the National Adaptation Programme (NAP). The AEA aims to provide information on the costs and benefits of adaptation, the scale of the challenge, the benefits of acting, and to identify priorities. The focus is on what the government needs to do to respond to the risks identified in the CCRA, and how much this will cost.

As part of the CCRA contract and the overall study methodology, a framework has been developed for the AEA. The method was discussed with various stakeholders and amended in light of comments. The resulting method has a number of key innovations that reflect the recent adaptation literature: it explicitly considers uncertainty; it works within an iterative framework consistent with the repeat cycles of the CCRA and the NAP; and it considers the current policy and institutional context including existing adaptation actions. The method is also consistent with Government appraisal guidance and the economic rationale for Government intervention. The proposed method is set out in this document and shown in the figure below.



Watkiss and Hunt, 2010

The steps are summarised below.

**Transferring the information from the CCRA.** The first step transfers the information from the CCRA (and other relevant material) on the risks and opportunities of climate change. It starts with the consideration of current climate risks and vulnerability, then considers the future risks of climate change. It also transfers the information on the role of socio-economic and non-climate factors, as well as cross-sectoral risk information. The aim is to make sure the existing information meets the needs of the AEA.

**Problem, Risk and Objectives.** The second step classifies the individual risks (or problem types) and considers the potential objectives for adaptation for each of these. This provides the initial context for the policy framework.

**Providing the context for an adaptation assessment.** The next step assesses the context for adaptation, undertaking a set of steps normally included as part of an 'adaptation assessment', but amended to match the Government planned appraisal framework and thus to ensure the AEA provides useful input for the NAP. The step includes the consideration of the baseline (including autonomous adaptation), the possible role of Government (the justification for intervention), the assessment of current governance and responsibilities and the analysis of the current levels of adaptive capacity. It also assesses existing plans and preparedness, the policy landscape, the level of investment related to the risk, and the timing and urgency of decisions. At the end of this step, the level of priority for action will be reviewed, providing a prioritisation for subsequent steps. Note that some of these activities will be progressed as part of on-going Defra policy engagement activities.

**Identifying and classifying potential options.** This step identifies potential adaptation options through a process of review and consultation. Additionally, it starts to classify different categories of adaptation, distinguishing between building adaptive capacity and outcome based options, the latter separated into the short and long-term. It also compiles options into adaptation pathways, i.e. towards an iterative (adaptive management) framework to fit the CCRA/NAP cycles.

**Appraising options.** This step collects data on the important attributes needed to assess adaptation, and appraises different options for adaptation for specific risks. It has two stages. The first is a semi-quantitative appraisal which is applied to a large number of risks, using an informal multi-criteria or multi-attribute approach. This recognises that much of risk information from the CCRA is qualitative. The second is a more detailed quantitative economic appraisal, applied to a selection of risks, using a number of alternative approaches that are matched to specific problem types.

**Prioritising adaptation.** This step identifies the priorities for adaptation, with a focus on specific risks and the early policy priorities. It also considers the potential for wider sectoral and cross-sectoral prioritisation.

**Estimating the order of magnitude (of cost) of adaptation.** This step collates the information above, complementing this with a number of other aggregate approaches, to build up the evidence on the costs of adaptation and the potential benefits of action.

**Continuous and Ex post analysis.** This step - which flows throughout the entire process - undertakes a continuous and ex post assessment of the AEA. It collates the information to help assess the effectiveness of the process, and to learn lessons for the CCRA and the NAP and any future national economic assessments of adaptation.

The overall method has been developed for application at the English level (to inform the English NAP), but the method is scalable and transferable, and can be applied at the Devolved Administration level or other aggregation levels.

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# 1 Introduction

## 1.1 Background

As a result of the Climate Change Act (2008), the UK is the first country in the world to have a legally binding, long-term framework to cut carbon emissions.

The Climate Change Act also creates a framework for building the UK's ability to adapt to climate change. The Act requires the Secretary of State to implement a National Adaptation Programme, and to inform this, to lay before Parliament an assessment of the risks posed to the UK by climate to the year 2100, the Climate Change Risk Assessment (CCRA).

Alongside the CCRA, an Adaptation Economic Assessment (AEA) is being undertaken to consider the potential adaptation responses to address these risks, and provide information for the National Adaptation Programme.

As part of the CCRA contract (Contract CEOSA 0901, led by HR Wallingford Ltd) a study methodology has been developed. This includes the method for the AEA, Deliverable 2.2.1, set out in this document.

## 1.2 Objectives of the AEA

The formal objectives for the Adaptation Economic Assessment, as set out in the Defra Study Terms of Reference, are to:

***'To inform the Government about the costs and benefits of adaptation to climate change'***

and:

***- 'to provide an overall indication of the scale of the challenge and potential benefits from acting'; and,***

***- 'given the wide-ranging nature of possible interventions, to identify priority areas for action on a consistent basis'.***

The customer for the AEA is defined as

***'Government at UK, national, and regional<sup>1</sup> levels, but usable and accessible by others who need this information to develop effective plans to address the risks of climate change, particularly those whose actions can contribute to reducing the UK's vulnerabilities, building adaptive capacity, and implementing and evaluating adaptive strategies and measures'.***

The AEA is intended to be a key input to the statutory adaptation policy programme which is defined in the Climate Change Act<sup>2</sup>. This programme is to be developed by Government

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<sup>1</sup> Note the regional geographical focus is changing, due to the policy of the new Government.

<sup>2</sup> The Climate Change Act states that it is the *duty of the Secretary of State to lay programmes before Parliament setting out the objectives of Her Majesty's Government in the United Kingdom in relation to adaptation to climate change.*

following the CCRA. Defra (2010<sup>3</sup>) reports that the 'National Adaptation Programme' *'will address the most pressing climate change risks to the England'* – though it will also include consideration of non-devolved (reserved) matters - and must be laid before parliament after the CCRA (anticipated during 2012) and reviewed every five years. There are also separate adaptation reporting requirements set out for the Devolved Administrations in the Act.

A key aim of the AEA is to provide sufficient information to inform the Government's priorities for action on adaptation and therefore the National Adaptation Programme. However, the AEA itself is not a statutory requirement. The AEA does not have a pre-defined approach or method but has to be conducted in a limited time period to delivery late in 2012 and within finite financial resources.

The TOR also outlines that the AEA should undertake:

*'An identification of the broad types of options for reducing the potential damages from the risks identified in the CCRA, both for sectoral and cross-sectoral risks, and their expected costs and benefits*

*Development of a methodology for prioritising Government action on adaptation given uncertainty and incomplete information*

*An overall estimate of the scale and resources required for adaptation, and the likely benefits from this in reducing the impacts identified in the CCRA'.*

The TOR recognises that *some costs and benefits cannot easily be monetised, and thus the results should be presented in a way that allows consistent comparisons between sectors and regions.*

The ITT also states that the

*'results should be presented in a form that allows spending on adaptation priorities to be compared with spending on other Government priorities'.*

It is stressed that the aim of the AEA is not to provide policy recommendations, i.e. the primary focus is to provide information to decision makers.

Finally, the terms of reference for the AEA, consistent with the CCRA, is primarily orientated towards domestic impacts of climate change in the UK: it does not consider (in any depth) how the effects of climate change at the international level will impact on the UK. However, for some sectors where this may be of primary importance (e.g. agriculture), and thus some consideration will be given to these international effects.

Starting from the objectives above, a method for the AEA has been developed. This document sets out the method and process steps. A pilot study in the health sector provides a worked example.

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<sup>3</sup> The Defra website reports that *the Act requires that a national adaptation programme must be put in place and reviewed every five years to address the most pressing climate change risks to England.*



# 2 Overall Method

## 2.1 Background

The overall framework for the AEA and CCRA was set out in an initial method document (December 2009), and then reviewed, updated and piloted over the first half of 2010.

The CCRA methodology draws on the UKCIP risk framework (UKCIP, 2003) and adopts a scenario-based ‘impact assessment’ (see Carter et al, 2007). Whilst the CCRA has a number of innovative elements to it, notably the exceptional breadth of coverage of risks considered, it has been able to draw on previous national assessment in its methodological development.

For the Adaptation Economic Assessment, there are no such benchmarks. In order to progress the AEA method, the study team prepared a background document (Watkiss and Hunt, 2010) that highlighted the methodological issues in undertaking a national adaptation study such as the AEA, drawing on the existing literature and previous national assessments.

The background document recommended that a different approach was needed from previous national studies for adaptation, which have primarily used the outputs of ‘impact assessments’ directly. It stressed the following methodological issues were key for the AEA:

- The need to explicitly consider uncertainty (climate and other) in the analysis of adaptation, and to move to a framework of robust and flexible options and decision making under uncertainty;
- The need to ground the analysis of adaptation options in the context of current vulnerability, policy and the adaptive capacity of institutions, organisations and society.
- The need to consider adaptation as a process as well as an outcome, and translate this through to the consideration of options.
- The need to focus on planned adaptation (particularly from Government) and on immediate current and near-term actions, in the context of both short- and longer-term risks;
- The need for an iterative approach, so that adaptation is considered as part of current and future CCRA and NAP cycles, i.e. consistent with adaptive management.
- The need to ensure that action is economically rationale and appropriate (justified in the context of government intervention) at national level, allowing for multi-level governance, retaining and encouraging the flexibility and robustness for action at other scales.

It is also stressed that the AEA involves some very challenging aspects from the perspective of government appraisal. First, that the AEA is undertaking analysis across many sectors, involving many cross-sectoral linkages and many Government Departments, and that this involves trade-offs between consistency (in comparing between risks) and consistency with existing sectoral practice.

Second, that the climate risks identified in the CCRA encompassed an extremely broad set of different problem types, with varying characteristics. This makes a consistent and harmonised analysis more challenging. As a simple illustration, the risks to be considered includes a complex mix of the following:

- The existing vulnerability from current climate variability and extremes (including the current adaptation deficit), the latter including major civil emergencies.
- The potential changes from future slow onset changes (e.g. average temperature change, average precipitation, etc.).
- The potential changes in the frequency or severity of extreme events (e.g. the changes in flood return periods, or increases in heavy precipitation event intensity)
- The combined effects of average trends and changing variability acting together,
- Possible major effects, including the exceedence of thresholds and the limits of adaptation.

It is very challenging to address all of these types of risks, for all sectors and with cross-sectoral linkages, within a single unified analysis using a single analytical tool. Indeed, there is no real precedent for this scale of problem and assessment within current Government analysis. Furthermore, these risks are not static: they have a strong temporal dimension and evolve over time. With this in mind, one of the key parts of the methodology has been to incorporate multiple lines of evidence and allow for the testing of approaches and tools, to learn from these applications for future iterations.

The findings from the background document were used to develop the proposed method for the AEA. This proposed a series of steps, extending the existing adaptation and policy frameworks to capture the methodological issues highlighted above.

This method was presented to a series of stakeholder groups and forums. These included the CCRA in-house experts group (and economic sub-group), the steering and funders group, the CCRA forum, and the Adaptation Sub-Committee of the Committee of Climate Change. The comments received from these groups were used to revise and improve the method.

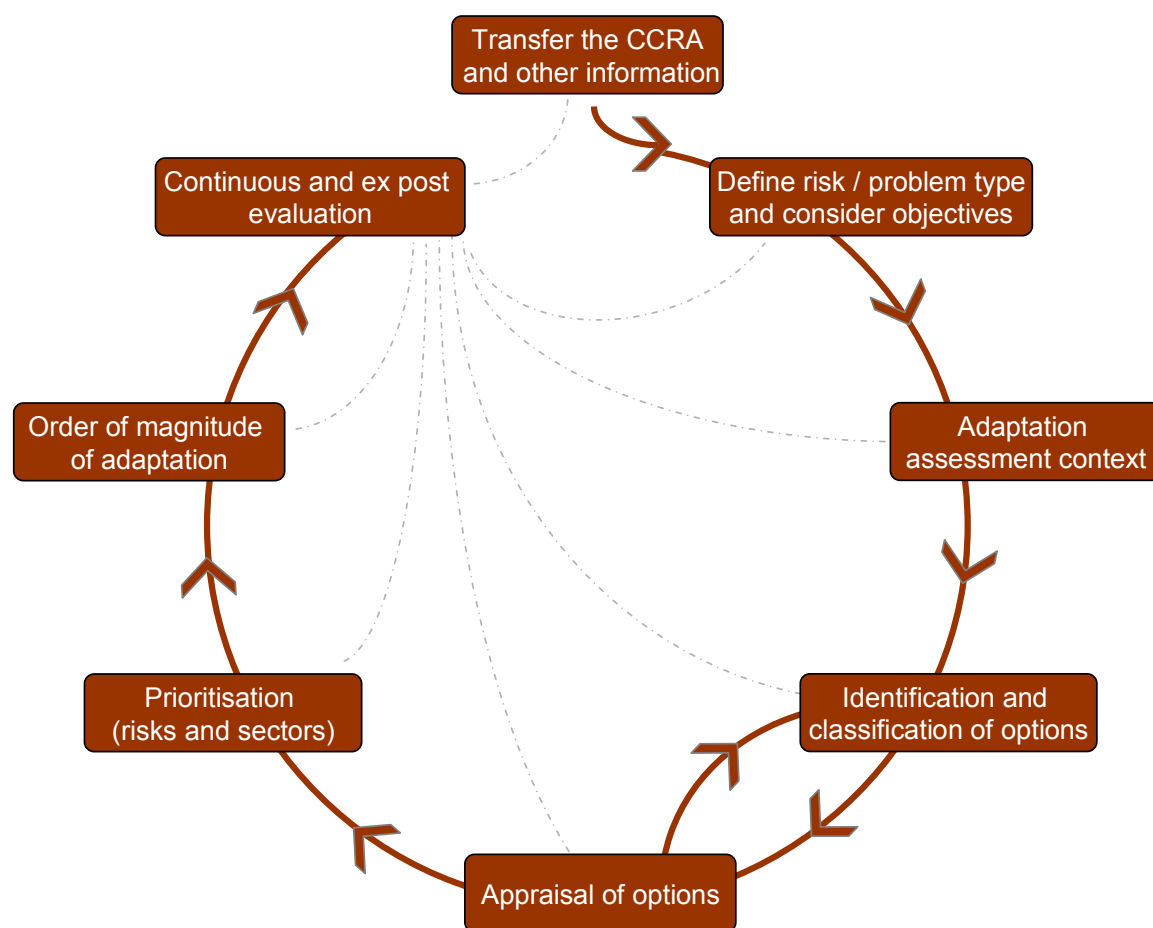
The final step was to pilot the method for a number of risks. This also allowed the consideration of the main CCRA outputs. This led to some revisions of the methodology, to allow the use of the very broad information generated by the CCRA, which for many risks is qualitative or semi-quantitative in nature, i.e. the level of detailed quantitative information that is available from the CCRA also determines the method steps and level of quantification in the AEA.

The lessons from this pilot test were used to revise the method. One of the pilot applications is available as a separate appendix.

The final proposed method is described below.

## 2.2 Method

To address the study objectives, and the issues described above, the study has developed a methodological framework for the AEA, set out in the figure below. This proceeds through a series of steps.



Watkiss and Hunt, 2010

**Figure 1. The Proposed AEA Method and Key Steps**

Each of these broad steps includes a number of major sub-tasks, summarised below.

**Transferring the Information from the CCRA:**

- Assess current, short-term and future climate risks;
- Consider climate sensitivity and vulnerability;
- Assess cross-sectoral risks and linkages;
- Assess non-climate drivers.

**Analysis of Risk, Problem Type and Objectives:**

- Assess and classify the problem type (define the type of risk);
- Consider potential objectives (including cross-sectoral objectives).

**Adaptation Assessment Context:**

- Develop the baseline (including autonomous adaptation and the justification for government intervention);
- Assess current governance and responsibilities;
- Consider the level of adaptive capacity;
- Examine existing plans and preparedness;
- Review the policy, appraisal and investment landscape;
- Assess the timing and urgency of decisions;
- Summarise level of priority and justification for intervention.

**Identification and Analysis of Options:**

- Identify adaptation options;
- Classify options and consider the timing and iteration (adaptation pathways)

**Appraisal of Options:**

- Appraise options (broad approach, multi-attribute analysis);
- Detailed appraisal (detailed quantitative economic appraisal).

**Prioritisation:**

- Prioritise options for risks;
- Consider wider prioritisation across sectors and areas of intervention

**Order of magnitude of Adaptation:**

- Assess aggregate, top-down analysis;
- Assess bottom up and adaptive capacity analysis;
- Consider wider economic analysis (optional).
- Synthesize results.

**Continuous and Ex post analysis:**

- Undertake continuous and ex post assessment of the AEA, to summarise the lessons from the analysis for subsequent cycles.

The figure below shows these additional steps. The figure also serves to demonstrate the linkages between these methodological components. Note that whilst the focus of the assessment is towards addressing risks, the method is sufficiently flexible to allow opportunities arising from climate change to be assessed.

These steps are described in detail in subsequent sections, using examples from the health adaptation pilot study. Whilst the document sometimes refers to 'organisations', these include a very broad definition, i.e. established organisations, businesses and individuals, and may be multiple and informal.

In the method document below, the individual steps are described as follows:

- The purpose, which defines the rationale for undertaking the Step.
- A description of the task, which outlines terms the activities for each step.
- The stakeholder engagement required, i.e. how interested parties will be involved in, and take ownership of, the AEA steps, and the stakeholder consultation, i.e. how interested parties will provide information and feedback to the AEA team.
- The inputs and outputs, i.e. the information needed from previous steps or external sources, and outputs as the measurable products of the step.

It is stressed that while the study aims to provide consistent information, there will invariably be differences in the level of detail and exact analysis between sectors: indeed this reflects the move towards mainstreaming adaptation. It is highlighted that the method outlined is likely to evolve further during the application across the range of sectors. As an example, the approaches may have to be amended to address the specific aspects of the biodiversity and ecosystem services or business sectors.

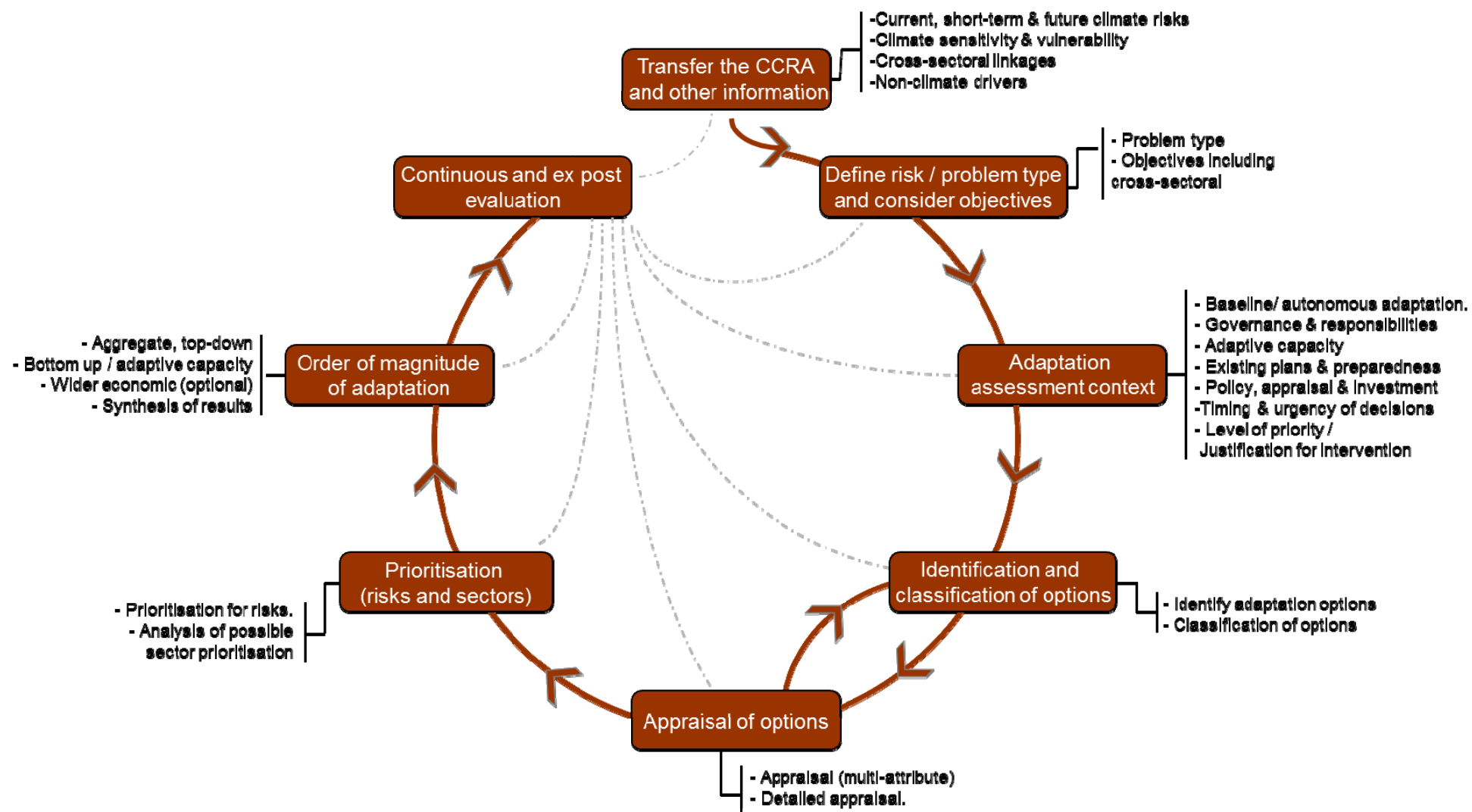


Figure 2. The Proposed AEA Method and Sub-Tasks

## 2.3 The Level of Detail and Prioritisation for the AEA

The CCRA has adopted a tiered approach, with different levels of quantification and analysis for different risks. Under the Tier 1 analysis (the initial assessment) the CCRA identified over 600 potential risks and opportunities from climate change.

Following a selection analysis, around 140 risks (and just under 10 major opportunities) were considered for the Tier 2 analysis (the semi-quantitative risk analysis). These represent the most significant risks to the UK and are the main starting point for the Adaptation Economic Assessment. However, it is highlighted that in some cases, the AEA may want to consider additional risks that were not selected for the Tier 2 analysis in the CCRA, but have been identified as relevant for short-term Government adaptation, e.g. for risks that are of key interest to Departments.

By comparison with previous national adaptation assessments, the number of Tier 2 risks is extremely large. Moreover, each of these risks can be addressed by a large number of adaptation options, which vary and evolve over different time periods.

Given the likely time and resources available for the AEA, it is not possible to apply the full AEA method outlined above to all CCRA Tier 2 risks. The method therefore includes steps that can help prioritise the focus of adaption effort and the analytical work within the AEA.

The exact choice of where to focus is not set out in this document: this is a decision for Defra and associated stakeholders. However, it is possible that the AEA could add most value by focusing less attention on risks that are already well understood and being planned for, and instead consider less explored risks, and/or cross-sectoral dimensions that may not be covered within the current institutional framework and competence.

## 2.4 Stakeholder Consultation and Expert Input

The proposed AEA method relies on expert input and stakeholder consultation. The method that has been developed highlights the need for small expert working groups, with a technical focus but also strong government policy interaction. This is designed to be complementary to the wider stakeholder input and consultation, established within the CCRA. These activities run throughout the entire AEA method, and are described in a number of key intervention points in the following steps.

# 3 Step 1. Transferring the Information from the CCRA and other sources

## Summary

**Purpose:** To transfer the information from the CCRA on climate risks, vulnerability and non-climate risks, as well as from other additional information sources (including the ARPs and other material). To interpret this information to meet the needs of the Adaptation Economic Assessment.

**Method:** Based on review and analysis, policy engagement and correspondence with wider stakeholders and expert opinion.

**Outputs:** A consideration of climate risks for adaptation set in the context of current vulnerability and other drivers.

**Benefits:** This step provides the starting point of the analysis and allows the CCRA evidence base to be explicitly framed in an adaptation decision context. It also provides the starting opportunity for various stakeholders (Departments, etc.) to provide input and guidance to the process and analysis.

The first step in the AEA is to transfer the information from the CCRA, particularly the Tier 2 material on current risks and vulnerability, but also drawing on other relevant information such as the ARPs, the Defra engagement outcomes, various studies and academic research work. The step will also transfer the information on the role of socio-economic and non-climate factors, as well as cross-sectoral risk information, using both the CCRA and other sources. The key aim is to ensure that the data and information available is considered from the perspective of adaptation decision-making, i.e. to make it fit for purpose for the AEA. Note that while the focus is on risks, the analysis will also include opportunities.

Consistent with the overall AEA, this step needs to work with a defined aggregation level. This is matched to the statutory reporting level (see earlier section), and is focused on England, though it also includes non-devolved issues at the UK level (though the approach could also be at the devolved administration level).

As highlighted in the previous section, the CCRA has identified an extremely broad set of risks, including those resulting from current climate variability, future trends and changes in extremes, etc. These risks have a strong temporal dimension and are likely to change over time, in both nature and extent. The challenge for this step is to ensure that this richness is captured, and translated into terms that resonate with those responsible for adaptation decision-making at the national level. In order to do this – and to orientate risks to responses, the step includes four activities: a) analysis and mapping of climate risks; b) consideration and interpretation of vulnerability including particular groups or areas; c) consideration and interpretation of cross-sectoral linkages; and d) identification of major non-climate sectoral drivers.

# 3.1 Interpreting Current, Short-term and Future Climate Risk

## Purpose

The purpose of this step is to interpret the nature and extent of:

- a) current risks
- b) short-term climate risks and;
- c) medium to long-term climate risks.

It describes the nature of the current and future climate risks faced, and organisations and individuals operating affected.

## Description

This step will start by taking the information from the CCRA, but complementing this with other sources. The step will describe the type, immediacy and severity of the selected climate risks. It will be undertaken for all the key risks of relevance to the AEA. The choice of the risks selected for subsequent tasks will be discussed and agreed with Defra and other key stakeholders. Some of the lessons from the pilot study, which was focused on the health sector, are summarised in the box below.

The AEA will initially use the risk 'metrics' and Tier 2 risks (impacts) identified in the CCRA. The step will interpret the quantitative and qualitative information from the CCRA, noting that this may be undertaken at different spatial scales, to make sure it is of most value to sectoral stakeholders. It will also extend the analysis to bring in other relevant sources of information of relevance to adaptation. This includes other activities as part of the Climate Act (including the ARPs), other on-going assessments in Government (including the Departmental Adaptation Plans, Defra ACC activities and policy engagement, and various studies and academic research work.

A key distinction in this review will be to consider current risks first, before identifying future climate risks, for the short-, medium- and separately the long-term. This temporal distinction is critical to the subsequent analysis of the timing of adaptation options. The study will also characterise the nature of the underlying risk, i.e. whether it is from average trends, changes in variability, etc. because this will affect the subsequent consideration of adaptation.

A key issue for this step is to consider the uncertainty in the CCRA and other material. This uncertainty is much wider than the climate projections alone, and also involves the risk nature, the physical impacts and the monetary values, as well as additional uncertainty from future socio-economic factors (see later section).

## Stakeholder Engagement

The CCRA included stakeholder engagement for the consideration of risks, their definition and selection. The analysis for the AEA can continue this process, and also be involved in the additional engagement with Government Departments (the policy engagement process). These steps will help confirm with key stakeholders that the characterisation of risks is appropriate for awareness-raising and other forms of adaptation planning.

## Inputs and Outputs

The principal inputs are the CCRA, spatially disaggregated as far as possible. Additional information from the policy engagement process currently being undertaken with central government departments by Defra, as well as other relevant information sources, will also form important inputs to this task. As a way of orientating risks to responses, the outputs of



this step could include an initial mapping of climate risks and other factors (vulnerability, cross-sectoral and wider socio-economic effects), though it is anticipated that this step would not be associated with formal outputs: it is primarily undertaken to provide the input information for the AEA.

### **Lessons from the Pilot Study: Health Sector Review of Risks**

The Tier 2 CCRA analysis provides a mixture of quantitative, semi-quantitative and qualitative information on risks. This provides the initial information for the AEA. One of the potential risks identified in the Tier 2 health analysis (Hames and Vardoulakis, forthcoming) was the effects of climate change on ozone, and the associated health risks. This has been considered as a worked example in the AEA pilot study.

At this time (May 2011), the CCRA Tier 2 results are not publically available, but the AEA pilot has collected the sort of the information that will be provided by the CCRA and set this in the context of the AEA. The AEA pilot has collated relevant information on current risks, including mortality and morbidity. There is a good existing literature of the risks of ozone currently which indicates around 10,000 deaths brought forward and 20,000 Respiratory Hospital Admissions each year (Stedman and Kent, 2008), if a zero threshold is assumed – though much lower than this with different threshold levels. However, these are not all attributed to the current climate or current climate variability.

The pilot has then considered the short-term risks from climate change (in the 2020s, with a particular focus on next decade). The DH update on climate change and health (Anderson et al, 2008, in Kovats et al, 2008) estimated that for the UK that there could be around 800 additional ozone-related deaths and hospital admissions by 2020 per year due to climate change. With no threshold and the least constraining assumptions this increased up to about 1,500 extra deaths and hospital admissions per annum. Using the current recommended valuation approach of IGCB (2008), this equates to marginal economic impacts of just of £4 to 8 million/year from climate change (noting this is based on a Value of a Life Year Lost approach). The pilot has also reviewed the medium to long-term risk. There are literature studies (e.g. Athanassiadou et al 2010) that give some context for the longer-term increases from climate on ozone (other issues being equal). These indicate increasing risks from the 2020s, but not especially large non-linear increases in risks or possible exceedence of major thresholds. This provides some the context to allow subsequent steps and analysis.

However, a key factor in the review has been that this remains an area where the evidence is low, and there is considerable uncertainty on the exact changes likely (including both positive and negative effects) from climate on air pollution. This uncertainty is key for adaptation in the AEA context, and applies to formation, exposure, physical (health) impacts and valuation. The existing policy framework (e.g. Defra Air Quality Strategy, 2007) did not consider this risk, but it has been considered more recently (Defra, 2010) and was included in the Defra Departmental Adaptation Plan (Defra, 2010b). Note that for this particular risk, the ARPs are not relevant, but for other risks these would be a much more important source of information.

A broader review across the 140 or so Tier 2 risks has shown that most risks in the CCRA have been considered in semi-quantitative terms. This is important in considering the later analytical steps.

## 3.2 Interpreting Climate Sensitivity and Vulnerability

### Purpose

The purpose of this step is to interpret the patterns of climate sensitivity and vulnerability identified in the CCRA and other sources, and to consider where climate risks are likely to matter most, and thus to identify where adaptation decisions could be focused.

### Description

This step will identify climate sensitivity and vulnerability at the most relevant geographical, distributional and sectoral scales for national adaptation decision making. It will use the CCRA outputs (noting these will determine the spatial scale that the AEA can work at). It will also complement the CCRA information with other data sources and studies. This step will also identify any climate risk groupings that are likely to lead to an exacerbation of individual risks, which have previously been mapped separately. Some of the lessons from the pilot study summarised in the box below.

#### **Lessons from the Pilot Study: Vulnerability Assessment**

The CCRA has undertaken a social vulnerability checklist analysis. At this time (May 2011), the Tier 2 results are not publically available, however, the AEA pilot has considered the type of information likely to be provided, and set this in the context of the AEA. This shows a large number of differences in sensitivity and exposure, as well as adaptive capacity, for the climate change and ozone risk.

<b>Vulnerability</b>	<b>Discussion</b>
Geographical	There are strong geographical variations in current ozone, and these continue into the future. These arise between regions of the UK, but also between urban and rural locations. However, there are complex issues on the distribution of ozone, and especially the marginal risks from future climate change (in the context of other background changes).
Vulnerable groups	The evidence for mortality risks, and for respiratory hospital admissions, is primarily in the elderly population, and/or those with existing health conditions, such as respiratory conditions or respiratory illness such as asthma.
Socio-economic factors	There is some evidence from UK studies (King and Stedman 2000; Pye 2001) that air pollution exposure is higher amongst some communities with high social deprivation (i.e. correlation between air pollution and the index of multiple deprivation). However, these effects vary with the pollutant considered, and are more complex for ozone due to formation processes.
Adaptive Capacity	There are some factors thought to be associated with adaptive capacity that relate to ozone risks. This includes whether high risk groups (the elderly) live alone, on access to information, and on the degree of access to health care professional or home health care.
Other	There are a range of other health determinants that possibly increase the outcomes, such as drug-use, low fitness levels, being overweight, et.

Strong geographical and distributional vulnerabilities are apparent. These are likely to influence the nature of adaptation plans, for example leading to a focus on the specific geographical areas of current and short-term vulnerability, and ensuring that adaptation plans adequately target key groups. It is highlighted that the information on vulnerability is often likely to be qualitative in nature.

#### Stakeholder Engagement / Consultation

The CCRA process has included stakeholder engagement on vulnerability. This can be continued as part of the AEA. The analysis should also take note of and be involved in the additional engagement with Government Departments (the policy engagement process), which will help confirm with sectoral stakeholders that vulnerability aspects have been accurately represented, and on the adoption of appropriate scales (geographical, sectoral etc.).

#### Inputs and Outputs

The principal inputs are the vulnerability assessment from the CCRA, and the spatial and sectoral characterisations of climate risks (including geographical or group disaggregation). A wide range of additional sources are likely to provide valuable inputs.

Based on these climate risk characterisations, the main output will be an initial indication as to where and when adaptation responses are most likely to be needed. This information will be primarily collated for subsequent tasks, thus it does not require a separate output.

## 3.3 Identification of Cross-Sectoral Risks

#### Purpose

The purpose of this step is to identify where the climate risks and sensitivities collated in the previous steps have cross-sectoral dimensions. It will draw in the cross-sectoral linkages between risks, though the consideration of the CCRA cross sectoral analysis and systematic mapping. In doing so, it will identify where risks have a strong cross-sectoral dimension, but also facilitate the identification of adaptation options that have cross-sectoral and ancillary benefits, i.e. so building synergies and reducing conflicts.

#### Description

The step will use the outputs from the systematic mapping and cross sectoral analysis in the CCRA to identify linkages between risks (and metrics). It will also complement this with other information sources. It will build up a list of relevant linkages that need to be taken into account in the subsequent analysis of adaptation.

#### Stakeholder Engagement / Consultation

There is a role for stakeholders in specifying and clarifying cross-sectoral linkages. There is also on-going consultation between Defra ACC and officials in Central Government departments and this will be used to help identify appropriate relevant documentation and other information.

#### Inputs and Outputs

The CCRA inputs will provide the main inputs, including the systematic mapping. The CCRA policy risk assessment and the consultation between Defra ACC and officials in Central Government departments will also provide inputs, as well as the wider literature.

The outputs will include a list of cross-sectoral risks, though this information will be primarily collated for subsequent tasks, thus it will not involve a separate output.

### **Lessons from the Pilot Study: Cross-Sectoral Assessment**

The CCRA has considered cross-sectoral elements and undertaken a systematic mapping. At this time (May 2011), the CCRA Tier 2 results are not publically available, but the AEA pilot has collected the sort of the information that would be provided by the CCRA and set this in the context of the AEA.

As an example, the pilot shows that ozone has cross-sectoral impacts that are additional to health. These include impacts on the agricultural sector, the damage of some materials and as impacts on natural and semi-natural ecosystems. These cross-sectoral risks are important in considering the overall problem, but also in analysing the benefits of any ozone adaptation measures that address underlying formation.

The pilot also reports that ozone pre-cursor species are highly cross-sectoral in nature. The principal driver for any increasing risks related to ozone therefore arises from emissions from energy-use, industry, etc. This also means that any adaptation responses that address the primary risk will have to be much wider, i.e. beyond health related options alone, and thus need to be seen in a cross-sectoral perspective.

## **3.4 Interpreting Non-Climate Drivers**

### Purpose

The purpose of this step is to interpret the significant non-climate drivers and socio-economic factors that are likely to affect the extent of climate risks, considering the context of future adaptation decisions (noting adaptation responses are influenced by the future socio-economic scenario).

The aim is to use the information from the CCRA – and other sources - to bring an appreciation of how non-climate driver influence future climate risks, and bring these into the overall decision-making context. The step will assess the relative importance of climate risks compared to other influences across different sectoral risk contexts. This separation is essential because of the different uncertainty levels (to the future socio-economic vs. climate component) and because it implies potentially different forms of adaptation decision making and responses.

### Description

The step will use the outputs from the CCRA analysis of socio-economic scenarios and futures, which will provide analysis of the non-climate future impacts to the key risks (and metrics). This is anticipated to include a mixture of some quantitative and qualitative information. It will also consider other sources of information on future socio-economic drivers. This information will be considered to identify the principal factors – whether economic, social, cultural or other – that are currently found to influence the determination and achievement of sectoral objectives, and to check the factors likely to be important influencing future time periods.

Using the CCRA outputs, and other sources, it will establish the importance of future socio-economic signals, compared to climate signals, in quantitative terms as far as possible. Examples of non-climate health drivers are given below from the pilot.

### Stakeholder Engagement/ Consultation

There is a role for stakeholders in specifying and clarifying socio-economic drivers. There is also on-going consultation between Defra ACC and officials in Central Government

departments and this will be used to help identify appropriate relevant documentation and other information.

### Inputs and Outputs

Inputs include the analysis of socio-economic scenarios undertaken in the CCRA, as well as other inputs (e.g. from the policy engagement process) and the wider literature.

Outputs include a framing of other socio-economic risks and influences. This information will be primarily collated for subsequent tasks, thus it will not involve a separate output.

### **Lessons from the Pilot Study: non-climatic drivers**

The CCRA has considered how socio-economic factors and drivers are likely to affect risks, and undertaken some semi-qualitative/quantitative analysis of key drivers for some Tier 2 risks. At this time (May 2011), the CCRA Tier 2 results are not publically available, but the AEA pilot has collected the sort of the information that will be provided by the CCRA and set this in the context of the AEA.

A number of current and future socio-economic trends will have a large impact on future health risks, and will also influence the appropriate adaptation responses, not least in the choice between measures that are hazard based or vulnerability based. Perhaps more importantly, future socio-economic trends will determine future emissions of ozone pre-cursors, which will have an even greater influence on the levels of relative risk. The interpretation of future risks are also complicated by changes in wider government health policy, as well as the way in which future economic growth will determine vulnerability, impacts and adaptation responses.

Driver	Implications
Background pollution levels (precursors)	Key driver in future ozone concentrations, noting changes in pre-cursor and ozone concentrations from emissions in the UK, Europe and globally. Strong linkages with GHG mitigation, as this will drive future emissions of many pre-cursors.
Population	Population growth projected for the UK will increase the population at risk. This increases the number of people exposed.
Age distribution	An ageing population would increase population sensitivity to these impacts, as they primarily occur in the older population. Also there are effects of ageing of the UK population more generally on health and social care services.
Health care and status	Future health care policy will have an impact on baseline rates, as will factors such as underlying health status.
Land-use change	This has potential impact on ozone concentrations.
Economic growth	Growth in per capita income may reduce impacts, if underlying health status improves with income, or as cleaner technologies get developed.
Behavioural patterns	More time spent more time in leisure and outdoor activities, may increase exposure to ground-level ozone.

These socio-economic drivers are important and need to be considered in translating risks from the CCRA context for adaptation. They will affect the level of future risks, but also provide an additional orientation for tackling future risk from alternative (socio-economic) options. An analysis of the broader CCRA outputs reveals that much of the socio-economic assessment is qualitative in nature (though there are quantitative assessments for some key risks, for some key factors).

# 4 Step 2. Define Problem Type, Classify Risk, Consider Objectives

## Summary

**Purpose:** To classify the type of risk and define the problem type. To consider the potential objectives for adaptation.

**Method:** This step has two elements. First, based on the information from the previous task, to categorise the type of risk and from this to define the type of problem - the first step in a policy cycle. Second, to review and map existing sectoral and cross-sectoral objectives. Where these do not exist, to investigate possible objectives for planned adaptation through review and policy engagement.

**Outputs:** The classification of CCRA information into risk types. An analysis of potential objectives for adaptation.

**Benefits:** This step moves the assessment from a scientific based analysis to frame it within standard Government policy appraisal processes. This will ensure the results from the AEA are suitable for subsequent Government deliberations on adaptation, i.e. for the NAP. It also provides a way to classify the types of risks to match subsequent analysis methods. The step then provides a first analysis of potential adaptation objectives, including wider sectoral and cross-sectoral objectives.

At this point in the analysis, there will exist an overall summary of the immediacy and severity of selected risks from the CCRA (from Step 1), as well as any major opportunities, placed into a decision context of adaptation. This summary will also include consideration of vulnerability, cross-sectoral risks and wider socio-economic factors.

Consistent with government policy frameworks (e.g. HMT, 2007), and in previous adaptation frameworks (UKCIP, 2003), one of the next steps is to define the problem and consider objectives for adaptation.

This step therefore provides analysis and characterisation of risks into individual problem types. It will classify the nature of the risk, the relevant time periods, the cross-sectoral elements, the possible thresholds or limits of adaptation, etc. This also will allow the clustering of some risks across the range of CCRA results, allowing a way of focusing down to a smaller number of related risks that can subsequently be considered together.

The step also considers the potential objectives for adaptation, including existing broader sector and relevant cross sectoral objectives. Again, this is consistent with the one of the earlier steps in a standard policy appraisal cycle.

It is highlighted that the identification of adaptation objectives involves some challenges, and that the objective chosen will alter the desired level of adaptation, the costs and benefits of

adaptation, and the residual damages (after adaptation). To illustrate, the objective of adaptation can be (UNFCCC, 2009; Parry et al, 2009):

- To avoid all damages or return levels of welfare back to pre-climate levels (noting this is often impossible because of residual damages).
- To maintain current levels of risk or reduce them cost-effectively within budgets or to pre-defined acceptable levels. The latter can often be set on the basis of tolerable risks, or seek to achieve common standards (e.g. risk exposure) for all, and thus often has a strong equity aspect (ensuring no groups are exposed to unacceptable risks).
- To reduce levels to the economically rational level, ensuring benefits are equal to or greater than costs, noting that this will mean some degree of residual impacts.

In practice, objectives will vary between studies and stakeholders and there will be trade-offs between doing everything possible (avoiding the problem, irrespective of costs) versus living with the risks (see Horrocks et al, 2006). How the objectives are determined – and the level at which they are set - determine the appraisal and level of adaptation.

It is stressed that it is not the role of the AEA to set adaptation objectives: this is a task for Government decision-making. However, it is possible to use existing sectoral objectives as a starting point, whilst adopting alternative assumptions relating to near-term adaptation decision-making contexts. It is also extremely useful to consider broader sectoral objectives to provide current Government context, and cross-sectoral objectives to allow a cross-sectoral perspective in later steps.

#### Purpose

This step will classify each of the types of risks identified in the CCRA. It will consider the potential problem type and consider how best to analyse these in later sections. The step will also consider potential adaptation objectives by reviewing and map existing objectives, including risk specific objectives, broader existing sectoral objectives and any relevant cross-sectoral objectives.

The information will help subsequent steps identify where and when – in sectoral and spatial terms - adaptation responses are most likely to be needed. Note that while the focus is on risks, the analysis will also include opportunities.

#### Description

A key focus of the study is to consider adaptation within a Government policy appraisal framework. The first part of such a framework is to define the problem and from this to set high level objectives. To progress this, this step will classify the risks, i.e. differentiating between the types of risks, e.g. whether slow onset, variability, potential threshold and limits of adaptation, etc. It will then define the type of problem, e.g. what is the key policy issue (noting that this will vary between risks that are well defined versus those that are more uncertain). This will also be important in considering the types of approaches that might be needed in later steps, particularly in any detailed appraisal.

This step will also allow some clustering of risks across the range of CCRA results, where there are many common aspects (for risk levels and adaptation, such as in the floods area, which crossed across most CCRA sectors).

The next part of the step will be to consider the potential objectives for adaptation (i.e. for risk reduction). The step will review any existing sector objectives, particularly where there are existing pre-defined objectives or risk thresholds related to specific Tier 3 risks. As an example, in some sectors (e.g. floods or the health pilot example of ozone, see box below) there are well defined objectives which provide a strong framework for analysis, whilst in other areas the study will need to consider potentially different objectives. A strong feature of



this step will be the policy engagement process, i.e. to discuss risks and potential objectives with Government departments.

The review will also consider broader sectoral objectives (e.g. at the Department level, including strategic objectives and national sectoral objectives), as well as relevant cross-sectoral objectives. It will take the existing information from the Policy Risk Assessment of the CCRA, and the current Defra ACC policy engagement exercise, noting that this will be an evolving step as new Government strategic objectives emerge. It is envisaged that these objectives will be both process- and outcome-based. This will allow a mapping of climate risks (from Step 1) against these objectives. The step will also consider identify other, sub-national, sectoral or social objectives through the sectoral stakeholder groups. Examples are given from the health pilot in the box below.

It will also start to examine the current approach for appraisal within government. This will allow a portrait of the relevant decision context(s) within the sector. It will also provide an initial indication of the time-frames which dominate sectoral activities and further facilitate a more detailed mapping of stakeholders. Together, this information will help to orientate the AEA in line with sectoral actors and their objectives, and identify likely synergies or conflicts between wider sectoral objectives and climate risks.

The step will also repeat this analysis for relevant cross-sectoral objectives, again to help identify potential synergies/opportunities and conflicts in sectoral and cross-sectoral responses.

#### Stakeholder Engagement/Consultation

The policy engagement process (the on-going consultation between Defra ACC and officials in Central Government departments) will be key to consideration of objectives, especially for broader sectoral and cross-sectoral objectives. There is also a key role for stakeholders in specifying and clarifying specific risks across these broader sectoral and cross-sectoral objectives. The first round of stakeholder workshops will be used to consult on potential objectives.

#### Inputs and Outputs

The inputs will be the CCRA information and in particular the previous Departmental Adaptation plans, new Departmental documentation, and the consultation with Departmental officials.

The output will be the categorisation of risk types, the definition of risks, and the consideration of potential objectives (risk specific and broader context). This information will be primarily collated for subsequent tasks, thus it will not involve a separate output.



### Lessons from the Pilot Study: Risk Type and Objectives

This first part of this step considers the risks in terms of the type of problem (a typology of the problem type). An example is shown for the pilot risk of ozone below.

Risk description	Problem Type
Mortality and morbidity from ozone	Increased mortality (deaths brought forward) and morbidity (respiratory hospital admission), plus some possibility of long-term chronic mortality and other less severe morbidity.
Timing	Current issue (existing ozone and health issue) though unclear the level that can be currently attributed to climate variability and extremes. Short-term potential increases.
Nature of risks and thresholds	Possibly increasing risks over time. Ozone sometimes considered as a <u>threshold</u> pollutant, i.e. threshold above which health impacts arise, and thus scientifically set 'safe' levels.
Risks of lock-in or loss of option value	Low, though NOx and VOCs pollution abatement expenditures may be reduced if incorporated in replacement investment in industrial technologies rather than retro-fitting.
Linked sector risks	Ozone impacts on vegetation (agriculture, natural and managed ecosystems). Also thought to have some impacts on materials (see introductory sector).
Cross sector risks or linkages	Low for risk itself, though agriculture and natural vegetation at risk. However, adaptation response has a strong cross sectoral linkage as it can involve emission reduction in pre-cursor emitting sectors (energy and industry).

The immediate risk – of ozone on health – is an existing problem, with risks primarily concerned with the short-term, and some cross-sectoral linkages. It is associated with some threshold issues, but these are dominated by other factors. A comparison of this risk against others from the CCRA Tier 2 analysis has shown a wide variation in characteristics (different risk types), which is linked to later stages and methodological analysis. It also has shown that some risks are cross-sectoral in nature (e.g. flooding), but also that other risks that fall largely within one domain (e.g. ozone and health in public health) will often require cross-sectoral adaptation responses (e.g. tackling ozone pre-cursors involves potential consideration across many sectors).

The second part of this step considers any existing or possible future objectives. The analysis has reviewed the existing objectives for ozone. There is an existing architecture of ozone related legislation. These are primarily set from European Commission legislation, transposed into UK legislation, but there are also statutory duties that cascade down to local authorities (see later institutional landscape). In many cases the UK is bound by these objectives, however, the UK Government's and devolved administrations' primary objective (Defra, 2007) is to ensure that all citizens should have access to outdoor air without significant risk to their health, where this is economically and technically feasible. However, in considering which options to take forward as part of the UK AQS to move towards these objectives, Defra primarily used cost-benefit analysis (IGCB, 2008) for health based analysis. Note there is also an additional set of objectives (and legislation) in relation to emissions which affect ozone pre-cursor emissions. There are also very strong linkages with GHG emission objectives and the effect of these on ozone precursors.

In the context of short-term adaptation policy, the adaptation objectives for this risk would probably be based around the existing targets and ozone objectives, though it is also possible that economic efficiency could be relevant in cases where the costs of measures did not exceed the monetised benefits.

# 5 Step 3. The Adaptation Assessment Context

## Summary

**Purpose:** To undertake the early steps of an ‘adaptation assessment’ at national scale, providing the key information that affects adaptation decisions, including identification of institutions and organisations, responsibility, adaptive capacity, existing adaptation policies, the level of preparedness, and the timing and urgency of decisions.

**Method:** Based on literature review, stakeholder engagement with key organisations, and correspondence with wider stakeholders and expert opinion.

**Outputs:** Identification of the key adaptation gaps and priorities for early adaptation action, as well as the priority areas for Government intervention. Information for the baseline analysis of appraisal and identification of the rationale for intervention.

**Benefits:** This step provides the baseline for policy appraisal. The step is intended to increase the relevance of the output of the AEA to policy makers, as well as provide the context to allow consideration of immediate and short-term adaptation priorities. It will also identify where planned Government adaptation is needed and is justified, i.e. in the context of the NAP. By considering existing policy and information, it will also show where there are major gaps and allow the AEA to add most value.

This section of the analysis explores the context for adaptation, considering the governance, competence and responsibility, adaptive capacity and level of preparedness, etc. This information is usually included in an ‘*adaptation assessment*’ (see the typology of Carter et al, 2007).

Importantly, the AEA proposes to undertake this adaptation assessment analysis within the Government public policy context, in order to be of most relevance to the NAP. Therefore the step collates the additional information that is needed for a Government appraisal framework, i.e. to consider the baseline (including the ‘with policies’ scenario and any existing adaptation plans), to examine the justification for intervention, and to consider the urgency (timing) of any decisions or actions, especially in the context of CCRA cycles. This will help to orientate the AEA in line with the needs of relevant policy makers and also provide the input to subsequent tasks particularly the identification and appraisal of options. At the end of this step, the AEA will be able to make a further prioritisation of risks for subsequent analysis.

Consistent with the overall AEA, and particularly for this step, the method needs to work with a defined aggregation and governance level. This is matched to the statutory reporting level and is focused on England, though it also includes non-devolved issues at the UK level.

For each of the selected risks considered in the AEA at this stage, this step will describe:

- The baseline conditions, including the level of autonomous (i.e. private) adaptation and the possible role for government to intervene.
- The institutional and governance landscape, including who has the responsibility for identified risks?

- The existing levels of adaptive capacity.
- The current preparedness, including existing adaptation plans and measures, and whether these are sufficient to manage the risks,
- The current Government policy landscape, and the level of investment (public spending) that might be vulnerable to risks in the future.
- The timing and urgency of decisions.

It is highlighted that many of these activities will be part of the on-going process of policy engagement undertaken by Defra with other Government department.

## 5.1 Baseline (including Autonomous Adaptation)

### Purpose

The purpose of this step is to assess the baseline of future climate risks in the absence of further Government intervention, and to identify the rationale for Government action for risks, noting this includes many different forms of intervention. This includes a strong focus on different forms of autonomous adaptation.

### Description

A key issue in looking for the role of Government planned adaptation is to assess what would happen in the absence of action. This can be considered under a category of autonomous adaptation, i.e. the potential reduction in risk that would occur even without planned action. However, autonomous adaptation is very generally defined (see box below) and is subject to different interpretations.

**Autonomous adaptation** (IPCC, 2007) – *Adaptation that does not constitute a conscious response to climatic stimuli but is triggered by ecological changes in natural systems and by market or welfare changes in human systems.*

However, there are a number of issues in defining and interpreting this definition.

First, there is a wide interpretation of what is – and what is not - autonomous adaptation. While natural physiological acclimatisation and reactive autonomous behavioural and technological changes at the individual and household level are widely accepted as autonomous, there is much less agreement on other aspects.

Second, there are some issues with this definition of autonomous adaptation, for example, as UNFCCC (2009) highlights, while autonomous adaptation does not require a policy intervention, it still requires conscious action on the part of those individuals or private companies that take it (which contradicts the definition above).

Finally, the traditional attribution of all private sector actions as being autonomous is problematic, especially for the UK, which has many privatised sectors or activities, which are under national planned control in other countries, and which are controlled and managed through a planned government regulatory environment.

This step is effectively part of the baseline analysis, i.e. to assess the do nothing scenario or without policies scenario (what would happen in the absence of planned adaptation). Examples are given below from the health pilot.

Within the CCRA, it has not been possible to adopt a single unified definition of autonomous adaptation and apply this consistency to all sectors. Indeed, previous national impact assessments have often mixed impacts and autonomous adaptation when reporting results. Instead, the CCRA has aimed to be explicit about the level of non-government planned adaptation (in relation to risk). This step will facilitate the transfer of the assumptions made for the AEA context.

For each risk, this step will first delineate adaptation actions that could be taken by individual or private actors (noting these may themselves be dependent on public actions, including e.g. the regulatory regime, the private-public linkages, etc.). It will also consider if autonomous adaptation may itself lead to market failures (including externalities) or perverse outcomes, which need to be made explicit and considered (because of the potential role for Government to correct these e.g. by providing appropriate market signals). Whilst it will not be possible to re-analyse CCRA results with different autonomous adaptation assumptions, this task will be able to identify the potential types of autonomous adaptation, how influential they might be, and to categorise the rationale for government intervention.

At the end of the step, the main risks to be considered will have been categorised in terms of the likely baseline (within Government planned policies) and assessed in terms of the possible intervention for Government. This will link through to the identification of adaptation options in later steps.

#### Stakeholder Engagement / Consultation

The policy engagement process (the on-going consultation between Defra ACC and officials in Central Government departments) will be important for the consideration of possible baselines and the rationale for intervention. It is also envisaged that the first round of adaptation sector workshops could review the assumptions adopted regarding baselines and autonomous adaptation.

#### Inputs and Outputs

The inputs will be the assessment of autonomous adaptation in the CCRA, both in qualitative and where available, in quantitative terms, as well as discussions from the policy engagement process.

The outputs of this step will be a preliminary mapping of responsibilities between private and public actors within sectors, and an analysis of the baseline and rationale for Government intervention. This information will be primarily collated for subsequent tasks, thus it will not involve a separate output.

### **Lessons from the Pilot Study: Autonomous Adaptation**

As highlighted above, there are many different forms of autonomous adaptation. These will change the risks of climate change in the absence of government intervention, and thus can be considered part of the do nothing scenario (or without planned adaptation counterfactual). For the health pilot example, the analysis has shown that ozone is already tackled through Government planned level policy and that this is an area with low levels of autonomous adaptation. For ozone and health, individuals have potential to reduce risks individually by exposure, but as ozone is invisible, this is dependent on sufficient information on concentration levels and knowledge of safe levels. Further, individuals have little potential to manage ozone concentrations, as ozone is a trans-regional and trans-boundary pollutant (i.e. ozone pre-cursors). There is also unlikely to be any autonomous private sector adaptation.

It is stressed that this contrasts strongly with other risks, even in the health sector, where autonomous adaptation is extremely important. For example, heat related risks involve physiological acclimatisation, autonomous (household) behaviour, and technical (household) adaptation, whilst other risks will involve much higher levels of market adaptation induced by changes in relative prices, economic resources, etc. as well as international effects. The pilot has also revealed that the widely used definition of 'private sector' adaptation being autonomous is problematic for UK analysis, because of the large degree of privatised activities, but also because of the nature of the public-private sector including financing through PFI and PPP arrangements.

A wider comparison across the CCRA Tier 2 outputs has also shown that the analysis of autonomous adaptation does vary. It also shows that much of the potential information in this area will be qualitative in nature.

## **5.2 Current Governance and Responsibilities**

### Purpose

This step will identify current governance including institutional responsibilities for responding to climate risk. The purpose is to identify – for each risk/sector – the pattern of responsibilities (and competence) that currently exist for responding to climate risks, including the split between public and private organisations. This will allow the AEA team to identify the current organisations who have competence and responsibility, and who make decisions relating to climate risks, and to engage directly with these organisations in determining adaptation design. The institutional and governance architecture also influences the potential for adaptation options. The public-private categorisation will help to ensure that the AEA is orientated towards climate risks that require public policy.

### Description

For each climate risk, or group of risks, the key organisations and other sectoral actors will be mapped according to the role(s) they currently have for climate variability, as well as for wider relevant socio-economic aspects. This will build upon the split of responsibilities between public and private actors, identified in the previous step, by specifying individual organisations and other actors. It will also build on the information captured in the CCRA stakeholder engagement process. A summary from the health pilot is in the box below.

### Lessons from the Pilot Study: Mapping of Institutions and Responsibilities

The ozone pilot has investigated the complexity of the institutional and governance system, including current responsibility for risks, through a mapping exercise. The Department of Health leads the health and social care sector, which includes the NHS. The previous Departmental Adaptation Plan (DH, 2010) set out organisational governance in relation to climate change risks. It also set out the partnerships related to climate change, i.e. NHS Sustainable Development Unit, the Health Protection Agency (HPA), other national organisations, international organisations (World Health Organization (WHO)). Note that many of these structures have recently changed or are the subject of current review. However, the lead government department for ozone is Defra, and there it has a range of existing policy responsibilities including statutory duties, for ozone control and reporting. In the context of ozone and health, there is strong cross- sectoral link between the two departments through the Inter-Departmental Group on Costs and Benefits (particularly relevant in the context of economic assessment), and through the DH Committee on the Medical Effects of Air Pollutant (COMEAP), and a much wider linked institutional landscape, involving many others.

The institutional mapping of organisations and responsibilities has also shown a landscape that cascades from European right down to local level. Ozone is a trans-boundary pollutant, and national level pollutant, so it requires co-ordinated national level (and even European level) action. However, the responsibilities involve many different aggregation levels and therefore multi-level governance. These are important at looking at the existing framework and actions on which to consider any adaptation.

A summary of some of the institutions and responsibilities are included below, which include multiple governance and aggregation levels.

Policy / responsibility	Implications
European (EU) Air Quality legislation	2008 ambient air quality directive (2008/50/EC) including ozone precursor. There are also European emissions legislations, and target ozone concentration values in other legislation.
UK Air Quality Strategy	UK Government Air Quality Strategy 2007. Air Quality Standards Regulations 2010, which also incorporates the 4th air quality daughter directive (2004/107/EC) that sets targets for levels in outdoor air of certain toxic heavy metals and polycyclic aromatic hydrocarbons.
Information and Alert thresholds	Information and Alert Thresholds for ozone.
Monitoring and reporting	The UK monitors and models air quality to assess compliance with the air quality limit and target values in the EU legislation above, reported to the commission (and subject to action in cases of non-compliance).
Local authorities	Local authorities in the UK have statutory duties for managing local air quality under Part IV of the Environment Act 1995 (review and assessment and Action Planning).

The nature of risks, and the adaptation response, is influenced by this policy landscape. These are essential to consider in the baseline for planned adaptation. They also demonstrate the cross-departmental responsibility for risks and adaptation.

The step will draw on the Defra ACC policy engagement exercise to obtain information on responsibility in Government and outside. This will also be supplemented through wider engagement through the sector workshops. Relevant organisations can be a) identified; b) categorised, (i.e. primary, secondary or key), and; c) assessed in terms of their interest in, and potential influence on, the design of responses to climate risks. A detailed description of a formal stakeholder analysis is given in Metroeconomica (2004). In broad terms, this step

will assess the extent that organisations/actors have complementary or conflicting objective(s) – and means to achieving these objectives - in responding to climate risks.

#### Stakeholder Engagement / Consultation

There is on-going consultation between Defra ACC and officials in Central Government departments and this will be used to help identify appropriate responsibility. The mapping of organisations and organisational responsibilities could also be supplemented through the first round of adaptation sector workshops, and possibly through broader engagement processes and bilateral discussion. The organisational mapping of responsibilities will be compiled by the team on a sectoral and cross-sectoral basis.

#### Inputs and Outputs

The principal inputs to this step will be the documentation of the policy environment compiled as part of the CCRA, the inputs from step 2 on policy and objectives, and the Defra ACC policy engagement exercise

The output will be the (cross-) sectoral mapping of organisational responsibilities in undertaking responses to climate risks. This information will be primarily collated for subsequent tasks, thus it will not involve a separate output.

## 5.3 Adaptive Capacity

#### Purpose

This step will identify the current level of adaptive capacity, including: i) learning and; ii) incorporation of climate risks in decision-making tools at the organisation and other level and vulnerable areas. The purpose is to help assess the current ability to respond to climate risks. This assessment will inform subsequent focus, i.e. where resources should be targeted towards adaptation objectives, e.g. investment in capacity, or where appropriate adaptive capacity is in place to make specific adaptation options to directly reduce levels of climate risks.

#### Description

The definition of adaptive capacity is included in the list of key terms at the end of this document. This definition is slightly contentious and subject to different interpretations, especially in the context of the UK.

In recognising these issues, this step takes account of several lines of evidence on adaptive capacity.

The first step is to transfer the findings of the PACT work on adaptive capacity from the CCRA, i.e. at the organisation level. This will be based on the four sectors within the CCRA, plus the additional health sector pilot. In other sectors, a higher level of adaptive capacity will be made based on existing information, such as self-assessment or the carbon disclosure projects. This information will also be complemented by other sources, e.g. the NAO self-assessment exercise and other relevant material from the DAPs.

The resulting information will present an assessment of the likely quality of any adaptation actions that may take place in the sector, i.e. in the absence of adaptation intervention(s). The metric for this assessment is qualitative – e.g. high, medium or low levels of decision making and potential for mal-adaptation.

The incorporation of this information will be built into subsequent tasks, e.g. the inclusion of adaptive capacity options, the analysis of the costs of building adaptive capacity, and the appraisal of adaptive capacity options.



## PACT

The PACT review accounts for adaptive capacity in relation to:

- a) Duration (long term decisions that extend into periods of increased climate uncertainty – e.g. over 30+ years need higher capacity than decisions with short time scales of 0-3 years;
- b) Reversibility (upgrading the capacity of storm drains is cheap at the time of installation but very expensive once in the ground; this therefore requires high capacity);
- c) Climate consequences (the choice of paint for the interior of a building is of relatively little consequence and so needs lower capacity), and;
- d) Potential to constrain or enable other decisions (regulations can block or enable responses by organisations, particularly by those of lower capacity).

This review will be complemented by an assessment of the capacity in industry level organisations that help and assistance that can potentially be (or is already) given to individual organisations in taking climate-relevant decisions. In addition, a review of a small number of actual adaptation actions that are being taken in the five selected sectors will assess how any gaps are filled in practice

The resulting sectoral reports will present an assessment of the likely quality of any adaptation actions that may take place in the sector, i.e. in the absence of some adaptation intervention(s). The metric for this assessment is qualitative – e.g. high, medium or low risk of poor decision making. The assessment will also suggest adaptation actions where an improvement is judged to be most likely to assist outcomes. A higher level assessment of adaptive capacity across the 11 sectors defined in the CCRA will also be undertaken, adopting the same summary metric utilised in the more detailed sectoral reports.

The second element will relate to the individual or household level, and for disperse private sector actors which are likely to undertake high levels of autonomous adaptation (e.g. farmers). In some areas, there is existing work on the current level of capacity of these actors for current risks (e.g. in the flood sector or the in farming sector). This step will draw this information together and identify gaps. Similarly, the aggregation of these groups, at the societal level, also leads to an additional aspect of adaptive capacity in terms of wealth and income levels, as more affluent societies, or groups within societies, may have higher adaptive capacity as they are less limited by resource constraints on adaptation. This task will consider the existing information that has relevance here, considering the current social deprivation information, as well as economic projections and income distributions, to consider how these may affect adaptive capacity.

### Stakeholder Engagement / Consultation

The PACT assessment is engaging organisations within each of a number of priority sectors, which has included the health sector. Data from the PACT applications will allow the team to present characterisations of the levels of preparedness within, and across, sectors and so will facilitate further discussion. The on-going consultation between Defra ACC and officials in Central Government departments will inform the treatment of adaptive capacity.

### Inputs and Outputs

The principal input to this step will be the PACT analysis and the UK-wide adaptive capacity analysis undertaken as part of the CCRA, though it will also include the DAP information, engagement with various organisations, and wider literature sources (e.g. on non-organisational capacity).



The main output from this Step will be the assessment of adaptive capacity levels across the sectors. This information will be primarily collated for subsequent tasks, thus it will not involve a separate output.

#### **Lessons from the Pilot Study: Adaptive Capacity**

There is some existing information from the DH DAP (2010) on the level of adaptive capacity in Government for health and climate change, based on the National Audit Office review (and reporting to the Environmental Audit Committee), which required DH to self-assess itself against five key themes on a five position scale. This showed a relative low level. The DH scored mostly at the level of '*getting started*', though with people and process at the next highest level of '*awareness and understanding*'.

The CCRA has undertaken a more detailed analysis of organisation adaptive capacity in the health sector (Ballard, forthcoming). This provides the necessary starting information for the Adaptation Economic Assessment. At this time (May 2011) the CCRA PACT results are not publically available, but they will provide information on the relative level of capacity within the health sector for different types of adaptation (structural and organisational), and a relative comparison against other sectors.

For the specific ozone risk, there are additional factors of adaptive capacity that need to be captured. A key factor here relates to individuals. This includes factors for high risk groups (the elderly) particularly in access to and awareness of information, but also the broader access to health care professional or home health care. More generally, the pilot has shown that there is a good awareness and level of capacity in relation to the baseline risk of ozone and health. However, the awareness of climate change on ozone is at a fairly low level, reflecting the uncertainty in the evidence. There is also an issue of the awareness and commitment of front-line health practitioners, and even the awareness of those with responsibility for controlling ozone (national through to local authorities) varies. This leads to a significant number of adaptation options that build capacity for this risk, as well as the later discussion of health- and other options for addressing climate related ozone risks.

## **5.4 Existing Plans and Preparedness**

### Purpose

This step will identify existing plans and preparedness for tackling existing climate variability and future climate change, including existing adaptation options. The step will establish the current baseline of direct adaptation responses to climate risks in England (and non-devolved matters) and, in doing so, identify potential gaps for public adaptation policy.

### Description

In this Step, the team will undertake a review of existing measures to address current climate risks and future climate change. The focus will be on those options that are implemented by public sector action directly, or determined or influenced by public sector action (e.g. via a regulatory regime, through information, etc.). It will include a detailed review of the DAPs undertaken by the previous Government, the current Defra ACC policy engagement and take account of Departmental actions under the Government. It will also incorporate the ARPs at present being produced across a number of sectors. An example is given below in the box below from the health pilot.

### Lessons from the Pilot Study: Preparedness and existing options

The consideration of existing plans and preparedness is critical because the UK is already implementing adaptation responses, against a background of a strong policy baseline of action for underlying risks. As an illustration, the health pilot on ozone has shown a very significant policy landscape that is already addressing ozone risks.

Plan/Policy	Implications
European Air Quality Policy (2005: 2010) and Emissions Legislation.	Series of policies that reduce emissions and/or reduce/set targets for air pollution concentrations. Includes Clean Air For Europe, Thematic Strategy on Air Pollution, Directive 2008/50/E, UNECE Gothenburg Protocol, forthcoming Emission Ceiling Directive, existing and future emission standards for vehicles, etc.
UK Air Quality Strategy (2007)	Sets out plan to achieve EU and National air quality strategies, targets, limit values, etc. Transposition of European policy across all air quality and emissions legislation.
Information and Alert thresholds	Information and Alert Thresholds for ozone (see objectives). In cases where either the information threshold or the alert threshold for ozone is exceeded the details set out in paragraphs 3 to 6 of the Air Quality Standards Regulations, as a minimum, must be made available to the public
Local authorities	Local authorities are required to carry out regular reviews and assessments of air quality in their area against standards and objectives prescribed in regulations for the purpose of local air quality management (LAQM) before undertaking Action Planning (Air Quality Action Plans) if air quality is found to breach the regulations.

In addition, there is a strong linkage with mitigation policy, because action to reduce greenhouse gas emissions often has many benefits in reducing ancillary air pollutants, which includes ozone pre-cursors. Given the level of emission reductions planned in the UK, this will have a material effect, though some of the exact outcomes will be complex. Note that similar effects will arise in Europe, as a result of European policy. A key point here is that there is an existing cycle of air quality policy. One of the most important issues for adaptation (in the context of the NAP) is to identify the opportunities for incorporating climate change into the existing policy framework, i.e. the mostly timely and appropriate consideration is to work within the existing policy cycle. This is in itself influenced by the European Commission.

Finally, in relation to specific climate change adaptation policies, the Defra DAP (Defra, 2010b) highlighted the complexities of atmospheric chemistry and climate modelling mean improving our evidence base will be important in shaping future actions in relation to climate change adaptation. It also set out the following actions.

- *By 2011, we will use the UK Climate Projections to carry out air quality modelling studies to evaluate the impacts of future climate on air pollutant concentrations.*
- *Over the next 2 years we will carry out a review of the available evidence on how climate change will alter both social and environmental responses to air pollution to inform future research and policy development.*

The aim of the task will be to compile an inventory of adaptation options already implemented, or planned to be implemented. This step has a strong link to the consideration of adaptation, as it forms the baseline 'with policies' scenario that is part of standard government appraisal. This is particularly important because much of the baseline information on climate risks in the UK, including many sectors and risks assessed in the CCRA Tier 2 analysis, do not account for the existing policies in place (implemented or planned/announced). This is a key issue given the shorter-term focus of the AEA and the NAP. As well as ensuring that existing measures are accounted for (so that the appraisal does not consider options that are already implemented), the future risks of climate change

need to be adjusted downwards in line with existing policies, as does the effectiveness of future adaptation measures (as the unit and overall effectiveness of additional marginal options will be lower). However, it is very difficult to quantify the effectiveness of existing adaptation measures in reducing risks, not least because of complex attribution issues, and much of this assessment is likely to be qualitative in nature.

It is also highlighted that there are complex issues related to the implementation of plans at different governance and aggregation levels. For many risks, there are already actions being undertaken at different aggregation levels (national through to local) and across different organisational levels (national government, private sector, etc.). The initial focus of this task will be national, but with a consideration of these multi-level aspects.

#### Stakeholder Engagement / Consultation

The identification of existing relevant preparedness, policy, plans and adaptation responses will be linked to the on-going consultation between Defra ACC and officials in Central Government departments. This will be supplemented through discussion with other key organisations. The consideration of existing options and plans could also be informed by the stakeholder consultation undertaken in the first round of AEA workshops, though supplemented by other sectoral documentation.

#### Inputs and Outputs

The main inputs to this Step will be the review of the policy landscape carried out within the CCRA, the DAPs, the consultation between Defra ACC and officials in Central Government departments, and information from the sectoral ARPs that becomes available in the course of the AEA.

The main output will be a sectoral overview of currently undertaken or planned adaptation option implementation and a resulting gap analysis that highlights where option implementation is not planned but where there is the potential need. This information will be primarily collated for subsequent tasks, thus it will not involve a separate output.

## 5.5 Policy, Appraisal and Investment Landscape

#### Purpose

This step will consider the wider policy landscape associated with the risk. This will also include the decision making domain, i.e. the current decision criteria and appraisal techniques utilised in the sectors where public policy-relevant adaptation action is being considered (allowing the team to consider the adequacy of existing appraisal processes in the context of projected climate change). Related to this policy dialogue, the step will also assess public spending in the context of Investment and Financial Flow information (focusing on the Government level) and the implications for prioritisation and later costing steps.

#### Description

This step will examine the existing policy baseline and future commitments and how these could affect risk and adaptation.

It will look at the existing decision-making approaches (and criteria) for appraisal of future options at the risk or sectoral level, i.e. how decisions are currently taken for resource commitments and policy, including current/planned adaptation options, reflecting the fact that these will influence the analysis and prioritisation of options. The Team will also identify which data has been, or is being, used in regulatory impact assessment (appraisal)

processes. These tasks will be undertaken by adopting bilateral communications with the relevant stakeholders.

This step will allow the AEA team to assess the adequacy of existing appraisal processes in the context of projected climate change. It will use the Defra ACC policy engagement exercise to obtain information on departmental spending plans, current approach to appraisal, and other policy aspects.

It will also undertake an analysis of the levels of spending in the sector, particularly infrastructure, starting with the PESA (public expenditure statistical analysis) and then through to Departmental Plans, to assess the level of capital investment that is climate sensitive, with long-life times, helping to identify priority areas of focus. This builds on an emerging area of adaptation economics that undertakes Investment and Financial Flow analysis (see box below). Where possible, future plans (next spending period, or commitments) will also be assessed using a high level investment and financial flow assessment. The information from this task provides one of the main evidence lines on the future costs of adaptation (for the later step on the order of magnitude).

### **Investment and Financial Flow Analysis**

Investment and financial flow (I&FF) studies typically consider how much it might cost to enhance the resilience of future investments or financial flows. Both aggregated and detailed approaches are possible. At the aggregated level, studies typically assess the sensitivity of future investments, estimating the proportion (as a %) at risk from climate change and estimating the increase in investment needed, as % increase or 'mark-up', to increase resilience (often termed, incorrectly, 'climate proofing'). More recent detailed studies undertake investment and financial flow analysis at a national sector level, i.e. as in the UNDP IFF studies (2010), looking at climate risks and undertaking detailed costing of the additional marginal costs needed for building resilience.

The level of detail will be determined by the availability of data, and the level of public to private information available.

The lessons from the health pilot for this step are summarised below.

### Stakeholder Engagement / Consultation

There is on-going consultation between Defra ACC and officials in Central Government departments and this will be used to help identify appropriate spending plans, appraisal approaches and decision making processes, and policy aspects. Additional stakeholder engagement will be through bi-lateral discussion with relevant departments. The Step will also allow a dialogue on the most appropriate appraisal techniques within the climate change context, given data constraints etc.

### Inputs and Outputs

The key inputs will be from the consultation process between Defra ACC and officials in Central Government departments, and from supporting documents.

The output from this Step will include a review of existing appraisal criteria and recommendations on the potential for use in the adaptation domain, and the compilation of the spending profile and likely vulnerability to climate change. This information will be primarily collated for subsequent tasks, thus it will not involve a separate output.

### **Lessons from the Pilot Study: Policy and investment landscape**

It is useful to examine the institutional context for decision making within a sector, to enable consideration of sectoral adaptation policy. Policy appraisal of air quality policy in Defra primarily uses cost-benefit analysis for health improvements, combining this with a form of MCA when considering additional benefits to ecosystems (in terms of critical loads or other target exceedences) and Monte Carlo analysis to look at uncertainty. The methodology for this appraisal is well established through the IGCB. These methods have been applied for previous national and even packages of local level plans and would also be the key starting point for future appraisal, though some minor adjustments may be warranted to address some of the uncertainty aspects of climate change and ozone.

Alongside this, the pilot has undertaken a review of major investment. The focus was to assess the potential vulnerability of current budgets. This has focused on major infrastructure investments that have long life-times, and are thus potentially vulnerable to future climate change. The pilot has been working through the PESA (public expenditure) and DH and Defra Departmental reports, to start to undertake an initial investment and financial flow. However, in this case, ozone primarily affects human health, and there is less of an investment risk for this impact. This contrasts with other risks considered in the pilot, which have shown potential high concerns as part of the I&FF analysis.

The wider consideration of future investment has also identified some challenges for this task, which links through to the order of magnitude step later. For the health sector, this is complicated because of the private finance initiative (PFI) and public-private partnerships (PPPs), and this has made it difficult to capture the full information on the future investments at risk.

## **5.6 Timing and Urgency of Decisions**

### Purpose

This task will identify the temporal pattern of risks and responses, including the urgency of decisions. The purpose is to undertake an initial prioritisation of adaptation responses based on urgency of action.

### Description

This Step will involve undertaking a sectoral and cross-sectoral survey of risks and adaptation decisions, set against short, medium or long term consequences. In order to structure the Step, the following questions will be considered for each risk:

- The time period before the risk becomes serious, i.e. whether risks are already present, whether they are within the immediate policy or investment cycle, or whether they will only become acute later (e.g. within a few decades). If the risk is outside the lifetime of upcoming decisions, then it has lower priority.
- The opportunity to act, i.e. whether actions are possible within the next few years (that would affect the level of adaptation). If opportunities arise much later, yet still prior to risks becoming more important, there is less immediate rationale for action.
- The time available for implementation, i.e. whether decisions take long time periods to plan and implement. If actions can be taken and implemented quickly there is less priority for early decisions.

- The duration of action and reversibility, i.e. whether decisions have a long life time, are very expensive, or impossible to reverse (e.g. spatial planning). Note that decisions which are easy to reverse and low cost may be themselves good examples of no regret adaptive management.
- The potential for learning, i.e. if the opportunity or threat is in a new area and offers insight, including learning processes, then it may be advantageous to prioritise, to stimulate the capacity to learn.
- Appropriate capacity is in place, i.e. if this exists or can be introduced quickly, it is likely to be associated with better adaptation. Conversely, if there is not the capacity to make decisions, then may not be a priority area for adaptation.

#### Stakeholder Engagement / Consultation

The process will require stakeholder engagement, to help assess the urgency of decisions. Subsequent rounds of consultation between Defra ACC and officials in Central Government departments will be used to help discuss appropriate priorities.

#### Inputs and Outputs

The inputs will be the review of adaptive capacity (including PACT), and other information based on the earlier steps.

The main output will be an ordering of adaptation action based on this urgency mapping. This information will be primarily collated for subsequent tasks, thus it will not involve a separate output.

#### **Lessons from the Pilot Study: Urgency of decisions**

The health pilot has considered the urgency of the decisions for the ozone and health risks, summarised below.

<b>Timing/Urgency</b>	<b>Assessment for Risk</b>
The time period before the risk becomes serious	Existing risk (but low climate attribution). Potential for short-term increase (2020) within immediate policy review 'window'.
The opportunity to act	Good opportunity through revision of air quality policy and strategy, though given longer-term nature of more severe risks, there is the potential to act in later cycles.
The time available (or required) for implementation	Most decisions short-term (i.e. within 10 years) and relatively quick to implement.
The duration of action and reversibility	Mixed. Some low cost options, though some technical measures likely to be more expensive. However, very few actions will be irreversible.
The potential for learning	Underlying area of policy (air pollution control) well established, but potential for learning with respect to the specific marginal risk attributable to climate change. Key issue is that underlying research is needed to allow later informed action.
Appropriate capacity is in place	High level of underlying capacity (air quality regulatory groups, etc.) but low levels in relation to ozone and climate change.

A quick comparison with other risks has shown strong differences when compared to other CCRA risks, even in the health sector, which have scored much more highly in terms of the urgency of the decision. This forms an important component in prioritisation.

## 5.7 Summary: Level of Priority and Justification for Intervention

### Purpose

This step will assess the level of priority for different risks in relation to adaptation, in the context of the current and future CCRA cycles, and in terms of the justification for Government intervention. It will help in prioritising which risks can be assessed broadly, and those which are likely to be priority areas for more detailed appraisal.

### Description

Following the completion of the steps above, the AEA team will understand the baseline (without planned adaptation), where capacity exists, the existing level of preparedness, and the institutional context for action. This will have highlighted the gaps for further analysis and for policy intervention. It will also summarise the justification for Government intervention across different risks, consistent with Green Book guidance. This will include the extent to which market failures exist, or where there is a need for the public sector. This will be informed by the classification systems developed by Cimato and Mullan (2010) and Berkout (2007). This will include a re-analysis of the earlier baseline/autonomous adaptation analysis.

This information will enable a prioritisation of adaptation action to identify:

- Where current risk and short-term risk warrant attention;
- Where early decisions have relevance and where there is the risk of lock-in: long-term, long life-time investment (infrastructure);
- Where there are potential major effects in longer term, or possible thresholds, and where early strategic decisions may be valuable;
- Where there are high public investment levels in climate sensitive infrastructure ;
- Where there are possible market failures from autonomous adaptation.

This will allow resources in the rest of the AEA to be targeted to the decision contexts where the implications for public sector intervention are greatest, and where the need for analysis is most critical in the current CCRA cycle and the first National Adaptation Programme. In particular, it will form the basis for identifying – in discussion with Defra and other stakeholders – the areas of analysis that might warrant more detailed economic appraisal.

### Stakeholder Engagement / Consultation

The process will require stakeholder engagement, to help assess the priority, including key inputs and discussion through the policy engagement process. Subsequent rounds of consultation between Defra ACC and officials in Central Government departments will be used to help discuss appropriate priorities. The identification of key adaptation decisions could also be discussed during the first adaptation sector workshops.

### Inputs and Outputs

The main inputs will be the earlier steps complemented by the discussion relative priorities. The outputs will include a categorisation of the priority risks / adaptation gaps and help in focusing subsequent method steps.

At this point, the information from the first three steps of the methodology could be summarised into an interim report, which assesses in detail the risks and adaptation assessment for the prioritised risks, in order to consider the main risks being taken forward for subsequent analysis. One of the key aspects of this task will be a summary of the policy



context information for a large number of disparate risks. The pilot has drawn up potential templates that would provide such information at this point.

### Lessons from the Pilot Study: Prioritisation

The health pilot has considered the climate change and ozone risk. In general, this is an area that warrants public sector intervention. The previous steps show that this is an area of very low levels of autonomous adaptation and that the risk has elements of public goods (air quality). Moreover, the regional and trans-boundary pollution requires co-ordinated national level action.

The review across other steps reveals this is an area of current Government responsibility, with multiple levels of governance and responsibility from national down to local authority. There is good adaptive capacity in place on the existing risk (ozone) but much less in relation to the climate change factors. It also shows that there are an extremely large number of policies that are targeting the existing problem of ozone, from European down to local authority level, though none of this actively builds in climate change - thus there is a potential gap – however, there is a very wide-ranging set of policy (both air quality and GHG) that will materially affect future concentrations, and there are a number of existing Defra research initiatives for this risk that are already planned.. A key issue is that there is an existing policy cycle for air quality policy, set by European and National level and this provides the opportunity to incorporate climate change issues into air quality policy.

The information on the timing and urgency of decisions, and the level of investment indicates much lower risks. There is no large financial investment stream that is at risk of climate change associated with this risk; but there are some financial investments that could be affected by some adaptation options or decisions which may not deliver the anticipated benefits if this risk turns out to be large. There is an existing policy and appraisal process in place, which forms the basis for any subsequent analysis (including in the AEA) though some extensions may be needed to address some uncertainty.

Criteria	Assessment for Risk
Current risk and short-term risk warrant attention	✓ yes, though scale of impacts and economic costs are modest compared to other risks
Early decisions have relevance and there is the risk of lock-in: long-term, long life-time investment (infrastructure)	✗ low in terms of long life time of investment (infrastructure), but some issues in relation to investment in new technological processes or technology/options. Noted that some early decisions for capacity building and evidence are needed
Potential major effects in longer term so that early strategic decisions are valuable	✗ levels anticipated for 2080s are still relatively modest.
High public investment levels in climate sensitive infrastructure	✗ no
Possible market failures from autonomous adaptation	✗ no

Compared to other risks, there is less justification for urgent large-scale action, and less priority for assessing this risk in detail (as part of the detailed economic appraisal), especially given uncertainty of the impact. However, there are some essential early adaptation steps, with the priority to improve this evidence base - to allow more informed analysis and decisions in the next cycle. A quick comparison with other risks has shown strong differences when compared to other CCRA risks, even in the health sector. This demonstrates it should be possible to assign relative priorities to different risks to inform later sections.



# 6 Step 4. Identification and Classification of Adaptation Options

## Summary

**Purpose:** To identify and classify the potential options available for dealing with key priority risks / adaptation gaps identified.

**Method:** Based on literature review, expert opinion, stakeholder engagement with key organisations and stakeholders participation through workshops, this task will draw up a list of adaptation options for subsequent appraisal. It will also categorise (classify) these options, allowing packages of options (adaptation pathways) for risks over time in the context of CCRA/NAP cycles. The task will also collate data on the options for subsequent appraisal.

**Outputs:** Identification of the key adaptation options, classified in relation to specific temporal risks, with data on options.

**Benefits:** This step will provide a list of adaptation options for each of the main priority risks identified. This will form a useful set of information in itself as well as providing information for later tasks. By separating out the options according to their potential timing, it will also provide a useful focus on which options are likely to be more relevant in the short-term and thus a priority for consideration as part of the NAP for England.

The previous steps above allow an initial prioritisation to be undertaken through gap analysis and the urgency of decision. This step – consistent with previous frameworks and the overall method statement for the CCRA / AEA – identifies potential adaptation options.

The key difference to previous national studies is that the adaptation options will be considered against specific, temporally differentiated risks, towards an adaptive management framework, and will be classified in terms of potential types of responses.

## 6.1 Identifying Adaptation Options

### Purpose

This task will identify an initial list of potential adaptation options for specific risks, based on literature review, desk analysis and consultation. This level of assessment will be undertaken for all of the priority risks / adaptation gaps identified at the end of the process above.

### Description

There are a large number of potential adaptation options available to address any given risk. These involve process based and outcome based options, 'soft' and 'hard' measures etc. They may also take a number of forms including, but not limited to: infrastructure investments; financial incentives; autonomous and regulated price adjustments; voluntary behavioural change, and undertaking management decision-making processes that incorporate climate change risks. Various adaptation options also vary strongly between

aggregation levels and governance and according to different socio-economic futures (see discussion in earlier sections).

The task will undertake a literature review to collate a list of adaptation options for each risk. It will also collect any relevant information on the options, costs, benefits or other aspects. It will draw on previous studies (academic literature, grey literature, other national studies, databases of adaptation options, etc.). It is also proposed to use the first round of adaptation workshops to discuss and expand the list of options, including analysis of existing applications, ex post data, etc. In some sectors, such as flood management, the bulk of this evidence base is likely to exist already and will be relatively straightforward to assemble. In other sectors or less well known risk areas, the evidence base is less likely to be developed and so will require a greater level of sustained engagement.

In contrast to many generic studies of adaptation, the task will then place these options within the context of the earlier baseline analysis (from Step 3). First, it will compare the list of options and plans against those already implemented, including the DAPs, linking back to the adaptation assessment (step 3. 4). Second, it will also bring in the potential options for adaptive capacity identified in the PACT assessment, i.e. at the organisation level. This will be complemented by a wider consideration of adaptive capacity options (e.g. research, information, knowledge, learning, facilitation and exchange of data, etc.). Finally, a key part of this step will be to consider options from a cross-sectoral perspective, ensuring that cross-sectoral options (and data relating to these) are captured). An example from the health pilot is given below. The AEA Team will document the information on potential adaptation responses using the categories described above and submit these for stakeholder consultation.

#### Stakeholder Engagement / Consultation

The identification of adaptation responses will draw on stakeholder engagement, at both sectoral and cross-sectoral levels. There is likely to be an initial meeting with the expert (sectoral) working groups. There will be extensive engagement with UKCIP and Defra ACC and officials in Central Government departments. This will be supplemented through discussion with other key organisations. A major stakeholder engagement exercise is also anticipated in the first round of AEA sector workshops to provide inputs on adaptation options.

#### Inputs and Outputs

The key inputs will be previous studies and literature, expert elicitation, discussion with academics and expert groups, UKCIP, Government departments, the PACT result findings, and stakeholder workshops.

The principal output will be the documented list of adaptation actions, with references of any existing examples and data sources.

## Lessons from the Pilot Study: Identification of options

The study has undertaken a detailed literature review to build up a database of adaptation options for climate change and ozone. This has reviewed the health based climate change literature, previous national studies (e.g. DH, 2001; DH 2008; ECCE, 2005; Ebi, 2006; SIAM, 2002; SCCV, 2007; NRC, 2004: 2007, Defra, 2010 etc), and also the underlying air quality policy literature and studies, noting the latter is far more extensive. These are summarised below, with an initial categorisation into adaptive capacity options and more outcome based options, the latter split between health-based and air quality based options.

## Selection of Options for Adaptation to Climate Change and Ozone

Adaptive Capacity	Health Based Interventions	Air Quality/Emission Based Interventions
<p>Improved research of interaction between climate change and ozone, including precursors.</p> <p>Improved models/modelling for predicting the impact of climate change on air quality (ozone), including validation.</p> <p>Underlying research on ozone and health, including consequence functions, thresholds, population groups affected, etc. Note could include epidemiological studies aimed at evaluating the impact of ozone and climate change.</p> <p>Research on socio-economic factors and modifiers, as well as distributional and vulnerability aspects and adaptive capacity.</p> <p>Air quality modelling studies to evaluate the impacts of future climate on air pollutant concentrations (note in current Defra DAP).</p> <p>Improved air quality monitoring for ozone and data surveillance.</p> <p>Improved epidemiological system for the observation of the effects of atmospheric pollution and climate.</p> <p>Review of evidence on climate change and social and environmental responses (in DAP)</p> <p>Integration of climate change in air quality policy and action plans.</p>	<p>Establishing surveillance and monitoring systems including appropriate information on meteorology, environment, health and socio-demography, for the early detection of changes and in order to obtain data for further study.</p> <p>Public awareness campaigns*</p> <p>Health education and promotion*</p> <p>Home-based prevention advice*</p> <p>Targeting of vulnerable groups, e.g. through partner organisations, carers, etc.</p> <p>Ozone (episode/elevated) warning systems / alerts (enhanced scheme that more targeted than current national system)</p> <p>Strengthening of emergency medical services and planning.*</p> <p>Behavioural change: adjust activities.</p>	<p>Largely based around existing measures for ozone.</p> <p>Emergency ozone control (triggered by episodes/events), e.g. vehicle restrictions.</p> <p>Reduction of ozone pre-cursor emissions (source control) in general:</p> <ul style="list-style-type: none"> <li>-Vehicle emission standards</li> <li>-Industrial pollution controls</li> <li>-Energy efficiency</li> <li>-Renewables/low emission electricity/heating</li> <li>-Transport control measures / public transport</li> </ul> <p>Etc.</p> <p>Note can be in the form of legislative measures to establish air quality standards and emission reductions, market based instruments, voluntary schemes, etc.</p> <p>Note that options vary in aggregation level from national policy (e.g. AQS Defra, 2007) through to local level (action plans)</p> <p>Promotion of, and common active participation, along with planning and action processes (including sustainable development).</p> <p>Strategies in the transport, town planning and industrial sectors.</p>

\*note many of these could be considered capacity building.

## 6.2 Classification of Adaptation Options

Following the identification of options, this step of the AEA will further classify different categories of adaptation, distinguishing between building adaptive capacity and outcome based options, the latter separated into short and long-term considerations. The driver is to compile initial adaptation pathways which collate options over time and allow the consideration of uncertainty within an iterative (adaptive management) approach that responds to current and future risks.

### Purpose

This task will categorise the adaptation options, linking them to the specific type of time defined risks, and in terms of a simplified typology of adaptation that allows decision making under uncertainty, and links with the iterative approach of the CCRA and NAP.

### Description

This step will classify the list of adaptation options, assigning them to the specific temporal risks and adaptation gaps. Each option will be considered against the type of specific time defined risks (noting that some options will be applicable in more than one time period) and noting that these will include a mix of risks in relation to slow onset, changes in variability and extremes, limits, etc. This allows an early consideration of whether options are more or less applicable for different levels of risk. While there are many adaptation typologies, the study will use a very simple categorisation which lends itself to the temporal dimension above, i.e. considering options in terms of:

- Adaptive capacity options, primarily focused on the near-term.
- Short-term measures, which may include benefits in addressing current climate variability as well as longer term change, and is likely to include the types of options classified as no regrets, win-win or low cost.
- Medium-long term measures, which may need early action due to the long-term nature of the exposure of investment (lifetime of infrastructure), the length of the decision process, and the need for planning to keep later options open (particularly for major or irreversible effects in the long-term).
- Medium-long term measures that don't require early action.

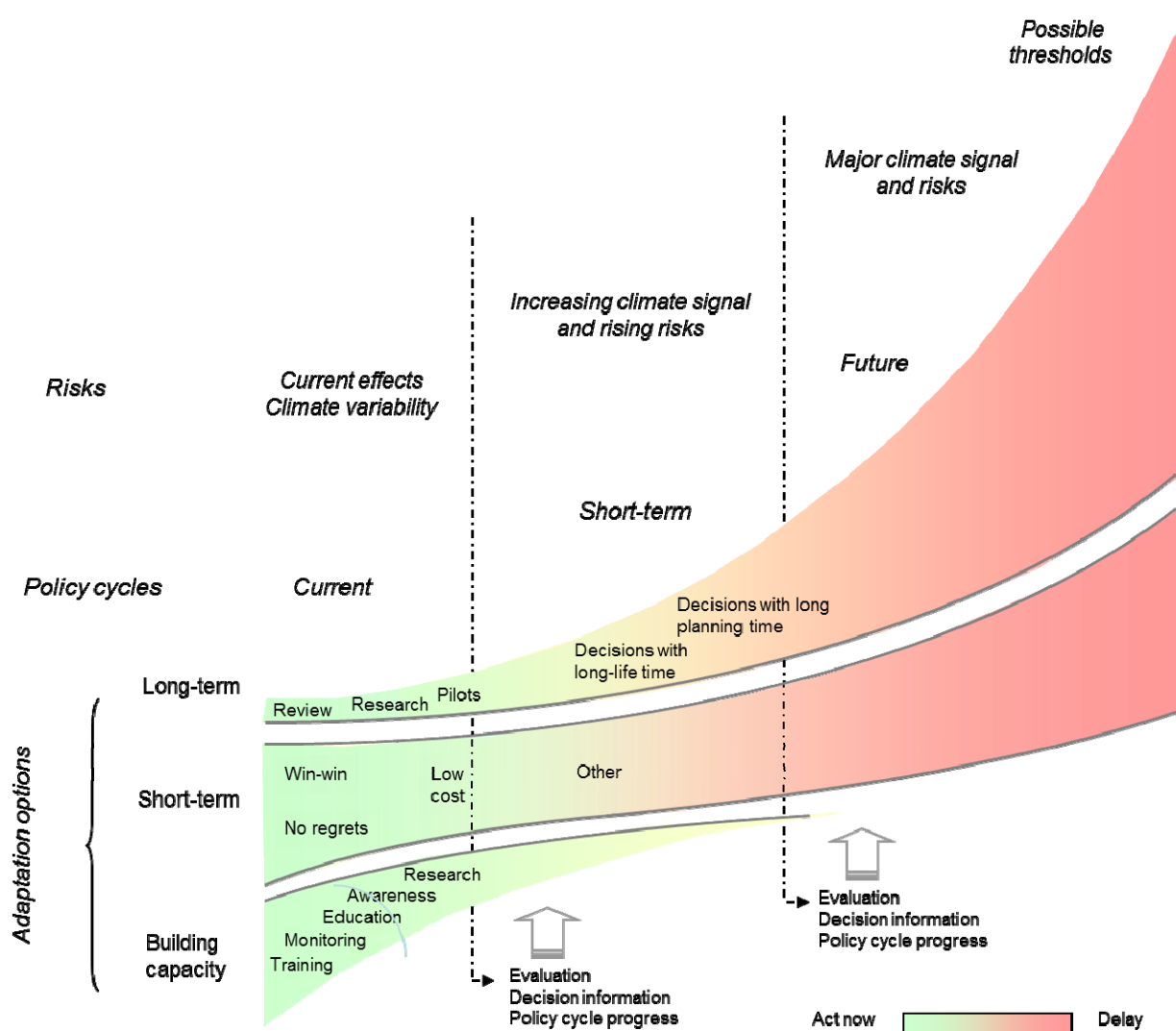
In simple terms, this classifies adaptation options into a three by three matrix, splitting the type of options, and the timing of application, which allows options to be mapped to changing risks over time (noting some inter-dependencies, discussed later).

Adaptation \ Risks			
	Current and immediate risks	Short-term risks	Long-term risks
Long-term options			
Short-term options			
Adaptive capacity			

Act now  Delay

The options are then classified into an **adaptation pathway (or pathways)** that address the evolving nature of many risks over time, and the cyclical nature of the CCRA and the NAP, which are repeated every few years. It also starts to allow the consideration of inter-dependencies and linkages between options, to allow iteration over future policy cycles and timescales in relation to the level of future risks. This ensures that the AEA works within an adaptive management framework, i.e. of decision making under uncertainty.

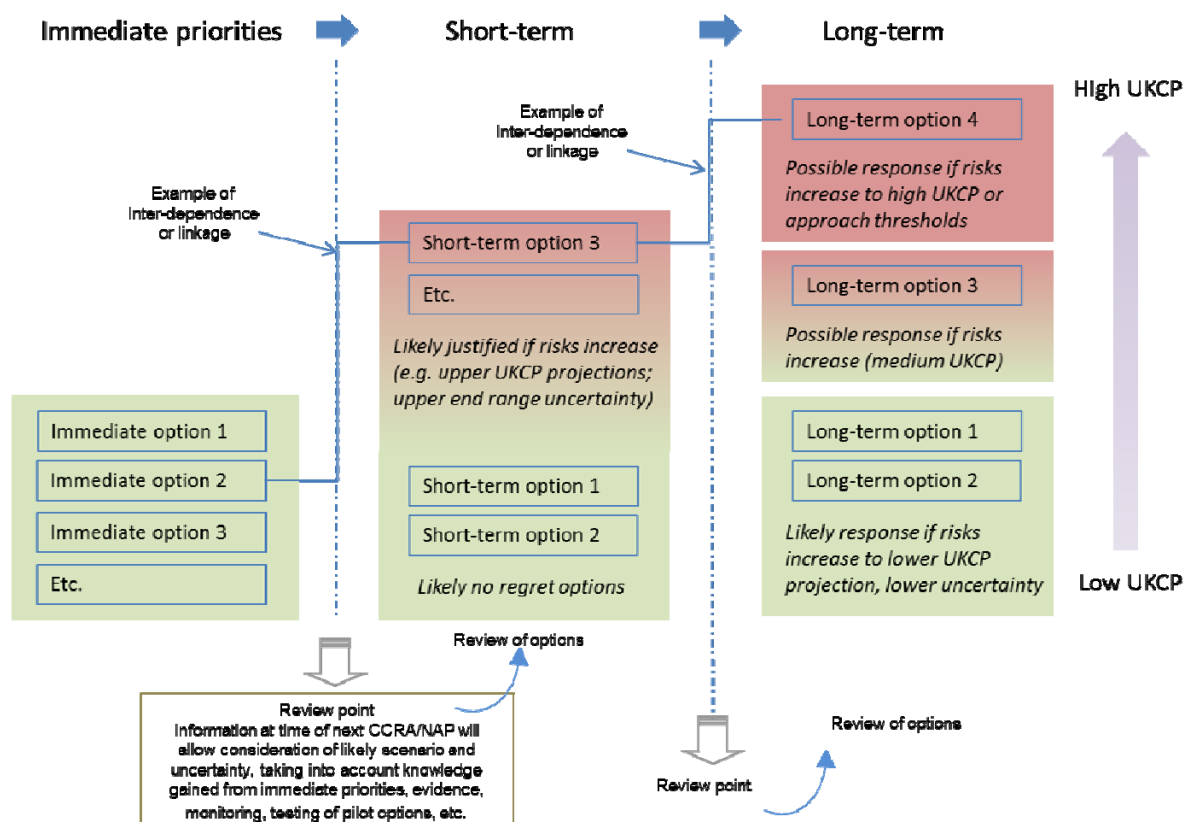
A general example of an adaptation pathway is shown below, with a specific example from the health pilot in the box. The figure illustrates the pathways concept. The starting point is the 'risks' (at the top of the figure), which will potentially increase over time, but to a greater or lesser extent depending on the future scenarios and projections. These are then placed in the context of the sequential cycle of the CCRA and the NAP (policy cycles). Together these provide the basis for an iterative cycle that allows subsequent information to be included to help redirect and inform adaptation over time. The diagram also shows the flow of adaptation options over time. On the left - in green - are the early priorities for. These are primarily focused on capacity building, no regret options and early planning for long-term decisions.



Watkiss, 2010

**Figure 3. Example of an adaptation pathway, reflecting different options over time as part of an iterative framework**

Over time, other options can be introduced once better information is available, noting that many of the options in later periods will involve higher costs or more radical solutions, and may only be applicable if future risks are high. Note that the shape of each adaptation pathway will vary with each specific risk, for example, with a different balance between short- or long-term measures. Indeed, recognising these differences, the varying level of preparedness, etc. is a key part of the framework.

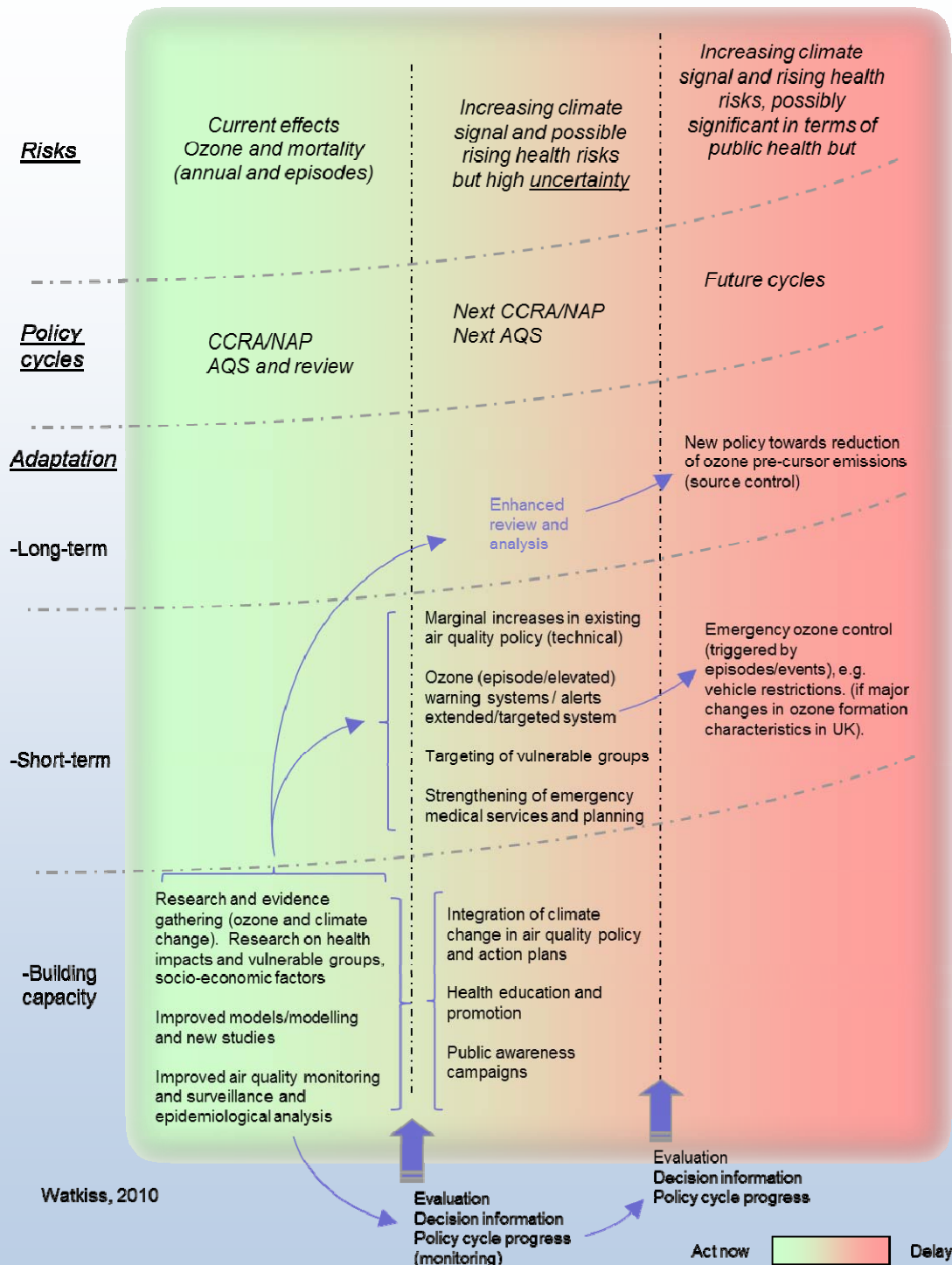


## Stakeholder Engagement / Consultation

## Inputs and Outputs

## Lessons from the Pilot Study: Classification of options and adaptation pathways

The health pilot has considered an illustrative adaptation pathway for ozone and health.



This classifies the options in light of the CCRA / air quality policy cycles, and the increasing risks over time. It also starts to show the potential flow of options over time and the decisions points for iteration: these relate to the adaptation options that might be relevant in later time periods, which will vary with the level of risk (and uncertainty) that is anticipated. It also allows for early actions that are still need to keep later options open and the timing of policy responses.



# 7 Step 5. Appraisal of Adaptation Options

## Summary

**Purpose:** To undertake an appraisal of potential adaptation options, related to sectoral and cross-sectoral climate risks.

**Method:** Based on the data on specific options/pathways, and using expert elicitation, to appraise the options for each of the priority climate risks / adaptation gaps.

The appraisal will be undertaken in two phases, working within the time and resources likely to be available, as well as the level of information that is available for CCRA risks (many of which are considered in a semi-quantitative analysis).

The first phase will apply a broad approach to assess a number of potential options for a large number of risks. This will allow consideration of both quantitative and qualitative risk based information. The second phase will focus down with more detailed quantitative economic appraisal, looking at a number of specific high priority risks and applying a range of different approaches to help inform future methods and guidance, as well as providing direct appraisal outputs.

**Outputs:** Ranking of the adaptation options for priority risks. It will also include the detailed appraisal results, and information and lessons for future appraisal and transferability.

**Benefits:** This step will provide a first ranking of adaptation options, i.e. allowing the identification of the most promising options. The detailed economic appraisal will provide a source of input for the National Adaptation Programme.

This step will appraise the adaptation options identified for each of the priority risks / adaptation gaps in the previous task.

It is highlighted that the appraisal method used in the AEA is heavily influenced by the type of information available from the CCRA (Tier 2 risks). The application of the Government economic appraisal framework to the AEA requires detailed quantified data on risks or impacts, and is also resource intensive. However, much of the CCRA Tier 2 information is primarily semi-quantitative in nature<sup>4</sup>, and this influences the appraisal process possible.

To address this, the AEA method splits the appraisal process into two phases – the first phase to allow an initial appraisal for a large number of risks working with a range of quantitative and qualitative data - and the second focusing down into priority areas with more detailed economic appraisal.

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<sup>4</sup> Of the 140 or so Tier 2 CCRA risks, only around one third provide quantified outputs (where consequence functions have been used to provide physical impact estimates) for the climate projections. There is also considerable variation between sectors, reflecting the underlying knowledge. For some sectors, e.g. for floods, water, and some health risks, there is detailed quantified information. In other sectors, e.g. marine, business, energy, there is mostly semi-quantitative or qualitative data only, much of which relates to intermediate climate outputs or exposure/burden, rather than impacts.



The first task undertakes a broad ranking of the adaptation options. This can be applied to a large number of climate risks. Given the semi-quantitative nature of much of the CCRA input information, this initial step will use a multi-attribute approach (an informal multi-criteria analysis). This will make explicit – as far as possible - the costs and benefits associated with individual options or pathways to capture the economic perspective. However, it will also allow a comparison of a number of criteria, expressed in monetary and non-monetary terms (and quantitative and qualitative information), which are associated with ‘good’ adaptation. The approach makes the trade-offs between, e.g. economic efficiency and robustness, explicit. It can be applied within – and potentially across sector(s).

However, it is also recognised that for some priority risks, more detailed appraisal will be needed, and thus the second part of this task includes a further analytical step to provide a more detailed economic appraisal for priority areas. This second phase is structured to be compatible with a standard impact assessment (economic appraisal) framework (e.g. HMT, 2007). However, as highlighted in the methodological background paper, the analysis of adaptation involves a number of challenges, including the significant uncertainties to be addressed, the inter-dependencies involved between responses, the strong cross-sectoral nature of many risks, and the long time periods involved. A number of the methodological challenges are described in the box below, along with a description of how the proposed approach addresses these.

While none of these challenges are individually unique, they do make the analysis more complex. Indeed, the existing appraisal guidance in Government has already issued supplementary guidance that recognises these issues and includes additional analysis methods for adaptation (HMT, 2009).

This detailed appraisal step therefore allows – and indeed encourages - the use of a number of different approaches, including the supplementary guidance and other relevant appraisal techniques for adaptation. The most appropriate method to adopt is selected based on a review of the type of risk and the attributes of the problem, i.e. different risk types will necessitate different approaches. However, there is a common theme in addressing uncertainty through identifying:

- No regret/win-win options that are justifiable under existing climate;
- Options that either facilitate more effective responses in the future through their flexible design, or allow such responses to be implemented;
- Options that allow learning to be undertaken and incorporated in decision-making;
- Options which are robust to the projected range of uncertainties (climate and non-climate).

### **Lessons from the Pilot Study: Methodological Challenges.**

The background document has considered the methodological challenges of adaptation for appraisal (e.g. Watkiss et al, 2007; UNFCCC, 2009, etc.) and considered how to address these. A summary is included below.

There are difficult issues in developing baselines for adaptation appraisal, in terms of the impact of existing policies on current risks and the role of autonomous adaptation (developing the do nothing, with policies scenario. The adaptation assessment step provides the information to consider this, through quantitative, sensitivity analysis or qualitative consideration.

There are key issues related to uncertainty, including across the climate projections, the future socio-economic signals, vulnerability, the level of acclimatisation, impacts etc. These translate through to the analysis of adaptation benefits (the reduction in risk from specific options) and the residual impacts after adaptation. The classification of adaptation options into short- and longer-term options, and the iterative pathways framework used, helps address this uncertainty by focusing on those options that are robust and identifying different future options that may be more or less relevant as information on risks evolves over CCRA cycles.

There is a need to consider geographical aggregation, which affects the analysis of risks, but also the resolution and appropriateness of adaptation responses. The AEA is capturing these through the vulnerability task. There are also challenging issues with temporal scales and dynamic linkages, which are being addressed through the adaptation pathways, allowing for the separation of risks in different time periods.

There are cross sectoral aspects with strong linkages for risks and adaptation. These wider effects – even if not directly quantifiable – can be addressed in the multi-attribute framework. In many cases, there may be ancillary effects from actions, both positive and negative, which are also included in the multi-attribute appraisal approach, and will also be explored in the more detailed appraisal cases.

There are a wide range of soft (non-technical) options, that are difficult to appraise in quantitative terms, but which are highly relevant for adaptation. The separation of these options in the framework (from technical options) allows the consideration and prioritisation of them separately, and the criteria based approach (and detailed examples which will include such options) will provide a way to make sure they are given equal treatment in the appraisal.

There are complex issues on separating the roles of public and private sectors, and responses. The early adaptation assessment will have investigated these issues and options will be focused on the justification for intervention for planned government adaptation directly, to enable and facilitate good private sector adaptation, or look at how to address autonomous mal-adaptation.

There is an issue of prioritising options in terms of distributional effects and equity, in terms of options to address the risk (where there are potentially strong distributional consequences of risks) but also wider sectoral or cross-sectoral priorities. A separate distributional category is therefore included in the criteria.

Finally, there are challenging issues of attribution, trying to examine the degree to which options will address future climate risks versus existing risks of climate change (and thus how to attribute costs and benefits). Similarly, on how to attribute future benefits that address the marginal impacts of climate change versus more general benefits (including those that arise from future socio-economic change). The earlier consideration of current risks will help this, along with the specific baseline analysis.

# 7.1 Appraise Adaptation Options: broad appraisal of many risks

## Purpose

To appraise the potential adaptation options or pathways, providing a ranking of the adaptation options, and identifying possible priorities for the early action.

## Description

The previous steps serve to identify a first screening of priorities for adaptation action, set within an iterative framework. This step appraises the specific options to address priorities.

Due to the large number of potential risks to be considered, the level of information available from the CCRA (often qualitative or semi-quantitative), and the methodological issues highlighted above, this task will use a multi-attribute analysis – i.e. an informal multi-criteria analysis - to allow a risk-based prioritisation of options (or packages of options). Note that consistent with Government appraisal, one of the options will be a do-nothing scenario. The task will also have a strong focus on the collation of cost data, which will subsequently inform the “order of magnitude” step in the aggregate step described later.

The method proposes that the appraisal ranking will be undertaken by small sector expert working groups (expert elicitation). These groups will be comprised of the AEA core team, sector experts and policy representatives. It is anticipated that a round of expert meetings (one per sector) would be held to undertake this appraisal. Prior to undertaking the appraisal exercise, the sectoral working groups will need to ensure that there is:

- Common understanding of terms;
- Comparability of actions;
- Sufficient data existing to inform meaningful comparisons and subsequent ranking.

Following discussion during the method development stage, it is envisaged that the appraisal will adopt the following criteria:

- Costs (indicative, including ancillary & cross-sectoral effects);
- Effectiveness/Benefits (indicative, including ancillary & cross-sectoral effects);
- *Net Benefits (Benefits minus Costs)\**
- Urgency of decision in current policy cycle/given length of lead time to implementation;
- Flexibility/reversibility;
- Distributional effects;
- Acceptability/Feasibility

\*It should be clear that due to their lack of independence, where it is possible to derive an indicative estimate of net benefits, the “Costs” and “Effectiveness/Benefits” criteria will not be adopted together. However, “Costs” may be adopted alone in order to acknowledge the importance of a criteria that recognises budget constraints.

In addition, the following criteria will be adopted as far as is possible:

- Robustness of effectiveness against uncertain futures;
- Ability to keep other future options open.

The weighting and ranking of the individual criteria will be considered by the sectoral expert groups. This process of ranking will be undertaken within the time-frames and iteration cycles identified in step 4, e.g. so that options are ranked within defined risk / policy cycles. This allows a prioritisation of short-term immediate options to be taken separately to a

prioritisation of options relevant for the medium term and the long-term. This also allows an analysis of the options against the different risks over time and across the alternative scenarios.

In order to further capture this uncertainty, the range attached to a number of the attributes (e.g. costs, benefits, distributional effects) will be defined. The appraisal can then use these ranges as sensitivities. It is envisaged that the interpretation of the UKCP09 scenarios (and distributions) will be central in defining these ranges. It is also highlighted that the ability to cope with uncertainty is addressed explicitly in the “robustness” and “keeping options open” attributes – these attributes reflecting two alternative ways of responding to uncertainty.

An illustrative example of the ranking process is provided in the box below, based on the pilot exercise.

To ensure the data is available for this appraisal step, the task will collect data on the attributes of the potential options. The quantity and quality of information available is likely to vary with each risk and option. Within the resource constraints of the appraisal, a priority will be given to estimation of the costs and effectiveness/monetary benefits of options. This will draw on evidence from present-day resource costs attached to adaptation options, including the reporting of option implementation in other regions or countries, as well as from discussion with relevant stakeholders. The information on benefits will be based on a similar approach, where possible scaling-up of unit benefits from specific sub-regional adaptation options. Where possible, data on ancillary costs and benefits will also be incorporated in the cost and benefit estimates.

Whilst it is likely that the exercise will be relatively “rough and ready”, each group will be responsible for recording and compiling documentary support of details of the process including:

- Data collation, and an evaluation of its quality;
- Weighting of criteria;
- Ranking of options/pathways;

This record of data and process will subsequently be available to wider stakeholder groups.

The outputs will be a ranked list of options, separated by time period, summarizing how they perform against the criteria. The structure of this output is designed to be comparable to the use of Appraisal Summary Tables, as adopted in other central government appraisal documentation, such as that in the Department for Transport webtag guidance.<sup>5</sup> These rankings will then be used to collate the ranked options within the iterative approach and the adaptation pathways (i.e. looking at combinations of options), checking for dependencies, i.e. to reflect the decisions and priorities for different time periods.

The outputs of this stage are a ranked list of options, set in line with the adaptation pathways, summarizing how they perform against the criteria. In the example (in the box), the adaptation pathway is relatively simple since the early capacity building activities are complementary to each other and link sequentially – and the options for the short-term can be rapidly filtered on the basis of existing information on likely costs and benefits. For other risks, a more complex pattern will emerge, with issues of interdependence and a degree of exclusivity between certain options. However, these can be tracked and presented through the method above.

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<sup>5</sup> <http://www.dft.gov.uk/webtag/documents/project-manager/unit2.7.2.php>

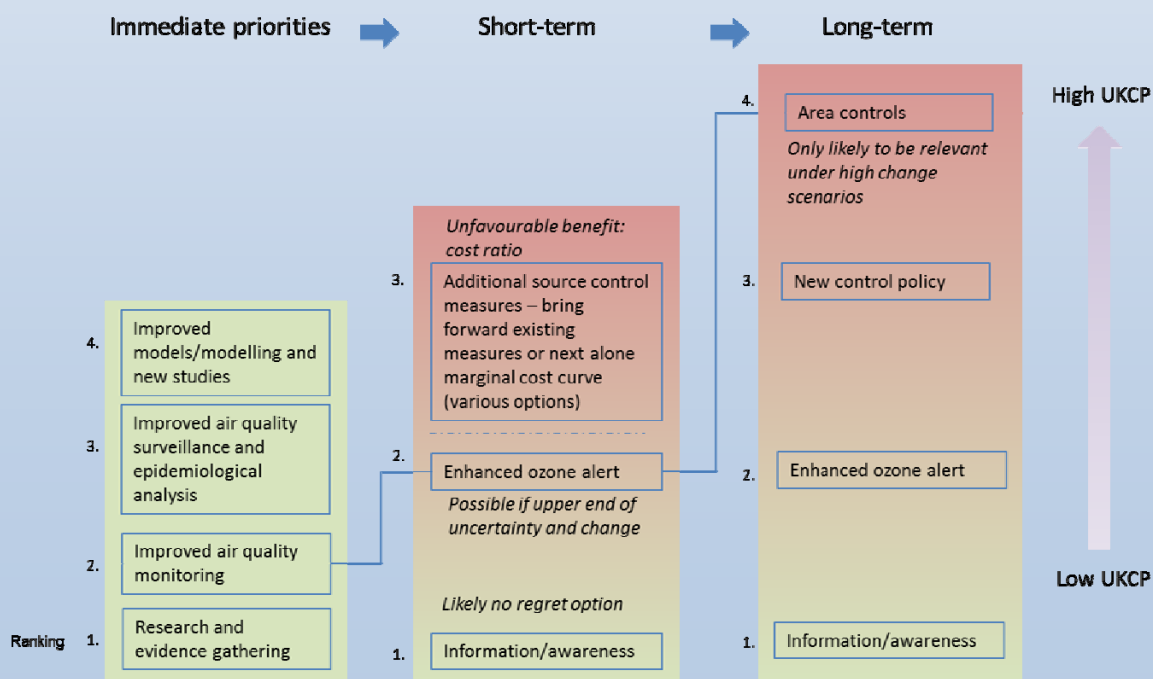
## Lessons from the Pilot Study

An illustrative example from the appraisal of options is summarised below.

Adaptation option	Costs	Benefits	Net Benefits	Urgency
<b>Building Capacity</b>				
<b>Evidence and research</b>				
Research and evidence (ozone + climate change)	Low.	Improves benefits/ reduce costs later	Yes but hard to measure	Very high
Improved models/modelling and new studies	Low	As above	As above	High
Research on health impacts, vulnerable groups, socio-economics	Low	As above	As above	Medium – high
Improvement of mortality records/ epidemiology	Low	As above	As above	Medium - high
Improved air quality monitoring and surveillance	Low-medium. Vary with coverage	As above	As above	Medium - high
<b>Information, training, etc.</b>				
Health education and promotion	Low	Medium	Yes (High)	Medium – high
Information provision	Low	Medium	Yes (Medium)	Medium – high
Awareness raising (public)	Low	Medium	Yes (Medium)	Medium – high
<b>Current/Short-term</b>				
Ozone alert systems (extended and targeted)	Low. - Medium Vary coverage	High, but depends on effectiveness	Yes (High)	Medium
Marginal technical control policy	Medium. Cost of control policy	Variable. Vary with level projections.	Variable. Not low/med UKCP	Medium

See pilot for details and additional columns.

An intermediate ranking of options is then produced across different time periods (not shown). These ranked options are then collated within the iterative framework of risks as in the illustrative example below.



### Stakeholder Engagement / Consultation

A key element of the stakeholder engagement will be expert elicitation to help undertake the appraisal analysis.

The ranked list of options will be the focus of the second round of AEA stakeholder workshops. These workshops will serve to discuss the appraisal based on expert elicitation. Note this engagement may take a different form to the first stakeholder meetings, i.e. it may involve a smaller number of larger meetings, or it may have an orientation around themes, for example, to encourage the cross-sectoral perspectives and avoid being constrained by sectoral thinking e.g. with regard to project/policy appraisal methods.

### Inputs and Outputs

The principal outputs of this step will be:

- a) an initial ranking of the adaptation options against specific individual or grouped climate change risks;
- b) an identification of possible priorities for near-term adaptation actions. The output of the results of the appraisal – as a ranked list of the options – will be produced (as a milestone), but at this stage, there will be no formal report.
- c) collation of the aggregate costs implied by implementation of the highest ranked adaptation options.

## 7.2 Detailed Appraisal of Priority Areas (Quantitative & Economic)

The second part of this task is to progress to a more detailed economic appraisal of priority risks and the associated adaptation options. This builds on the information identified in previous Method components, notably the identification of options and the broad appraisal task, above. The aim will be to generate more refined estimates of adaptation costs and benefits associated with a small number of risks.

### Purpose

This step will undertake detailed economic appraisal for selected high priority contexts, where for example:

- a) the rankings that result from the broad appraisal produce an unclear outcome that may be better informed through further investigation;
- b) the potential cost implication for the UK public sector is judged to be significant;
- c) where use of alternative analytical techniques are thought likely to result in potentially sizeable cost savings.

The number of priorities will be shaped by the level of interest, and associated resource availability. This more detailed economic appraisal is designed to have two benefits. First, the exercise is designed to extend the coverage of appraisal tools to adaptation decision contexts, e.g. cross-sectoral contexts, which have not adopted formal economic appraisal methods. Second, the exercise should provide exemplars of practical applications of alternative techniques, and allow a testing of the appropriateness of such techniques in varying sectoral and cross-sectoral contexts. It is hoped that the exercise will also facilitate a comparison of how the approach used affects the outcomes of the appraisal. This is important to test and learn for future CCRA/NAP cycles.

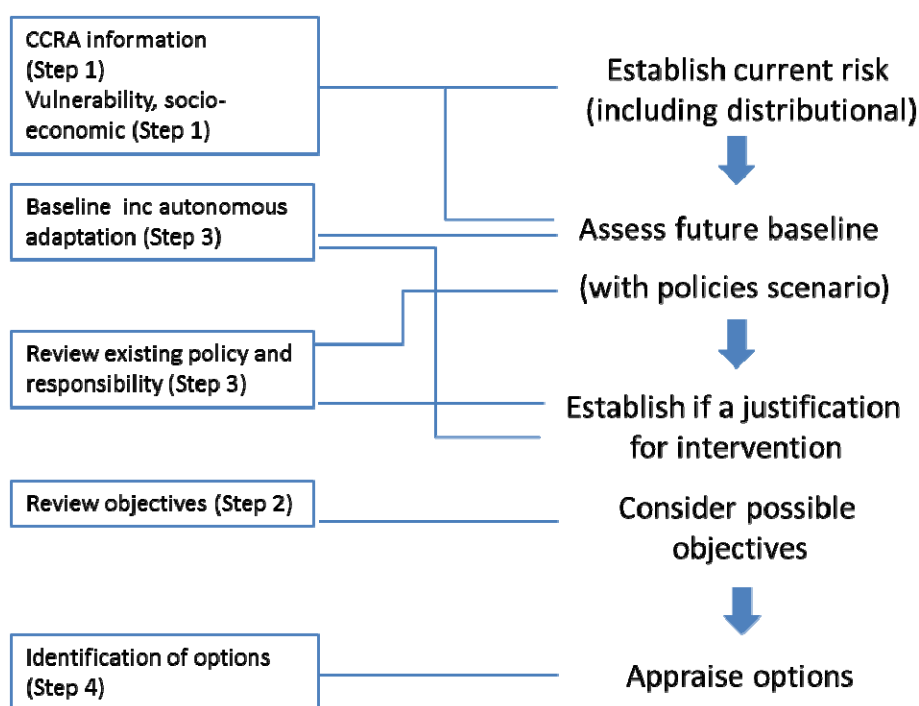
### Description

For selected risks identified in the CCRA, economic appraisal will be undertaken using alternative decision support tools. This will form part of the more detailed quantitative

analysis (e.g. what was formerly Tier 3 in the CCRA structure). It is anticipated that these appraisals will be undertaken in – or across - different sectors and will allow a strengthening of the economic justification for adaptation prioritisation. It is intended that this analysis will supplement and build on the MCA-like analysis to be carried out around the Tier 2 risks in the previous section.

The analysis is likely to be focussed on climate risks that are judged to have impacts on social welfare of regional and/or national importance, and where existing assessments of the costs and benefits are judged to be potentially insufficient to allow defensible decision making related to public policy. Reflecting, the stated purpose of this exercise, it is also envisaged that the applications may be undertaken in a cross-sectoral context, where climate risks lead to identification of adaptation options that require cross-Departmental co-ordination. As such, the choice of risks to be addressed will be informed by the process and outputs of the preceding task within this step. The data required to undertake this task will be derived and collated by the AEA Team, in conjunction with members of the relevant sectoral working groups.

One element is to ensure consistency with the existing appraisal guidance, as outlined in HMT (2007) and the impact assessment guidance. This involves some analytical steps that will need to be undertaken in the detailed appraisal step. The previous steps in this method will have generated the inputs for such a framework, as shown below.



**Figure 6. Linkages between previous steps and the detailed appraisal**

For the subsequent detailed appraisal of options, a range of potential decision support tools are described in existing guidance documentation. Principal documents for public sector appraisal include: The Green Book, (HMT, 2003: 2007)<sup>6</sup> and Supplementary Guidance (HMT, 2009), The Magenta Book (2011)<sup>7</sup> and Orange Book (2004)<sup>8</sup>, as well as hazard-specific risk management, e.g. The Flooding and Coastal Erosion Management Appraisal

<sup>6</sup> [http://www.hm-treasury.gov.uk/data\\_greenbook\\_index.htm](http://www.hm-treasury.gov.uk/data_greenbook_index.htm)

<sup>7</sup> [http://www.hm-treasury.gov.uk/data\\_magentabook\\_index.htm](http://www.hm-treasury.gov.uk/data_magentabook_index.htm)

<sup>8</sup> [http://www.hm-treasury.gov.uk/orange\\_book.htm](http://www.hm-treasury.gov.uk/orange_book.htm)

Guidance (2010).<sup>9</sup> Further guidance developed in the UK context is provided in Metroeconomica (2004), Willows and Connell (eds.) (2003) and Ranger et. al. (2010).

A summary list of principal decision support tools likely to be adopted in this appraisal step is presented in the table below. Whilst a range of tools are presented, it is emphasised that these methods are not mutually exclusive. For example, the principles of CBA are fundamental to both Real Options Analysis (ROA) and Portfolio Analysis (PA). Similarly, the dynamic, learning-based element of ROA may be incorporated in PA, such that the portfolio of adaptation options evolves over time as more is learnt about the extent of climate sensitivities.

A key distinction to note, however, is that whilst a number of methods, such as those based on CBA, ideally require probabilistic climate risk estimates, others including RDM and RBR instead require more knowledge of policy makers' degree of risk aversion. Thus, when selecting a tool for use in appraisal it will be important to assess the degree of confidence on the treatment of uncertainty in the UKCP09, and other, climate projections. Such a trade-off is described in Ranger et. al. (2010).

Because of the focus here on public sector appraisal contexts, the detailed analysis will principally utilise tools that are recommended in the guidance issued by central government departments, most notably the Green Book and its Supplementary Guidance. However, alternative, less-established, techniques – including those documented in the table below – may be useful to test in some contexts. For example, if it is judged that little new information on climate variable probabilities is likely to become available in the time-frame available for capital expenditure decisions, techniques alternative to CBA and ROA may be tested.

For each decision support tool listed, the table below includes references that give particularly clear examples or illustrations of the tool being used in practice. These examples will be used as starting points, or templates. For example, ROA has most notably been used in the flood context in the Thames Estuary<sup>10</sup>. This experience is evaluated in a number of references, including the Green Book Supplementary Guidance. However, it should be emphasised that the level of resources available to the AEA may not allow the level of analysis undertaken in the original study; in this case, the appraisal is likely to need to rely on more proxy data but ensure that sensitivity analysis explores the implications of not being able to use the best data.

#### Stakeholder Engagement / Consultation

It is anticipated that stakeholder engagement in the selected sectors will provide sufficient data to enable an assessment of the likely costs and benefits associated with alternative responses, under current climate variability and future projected climate change, and their use in alternative decision support tools. A key element of the stakeholder engagement will be expert elicitation to help undertake the appraisal analysis.

#### Inputs and Outputs

Inputs will come from earlier steps in the AEA, literature review, expert elicitation and stakeholder consultation collated in the previous steps of the AEA Method.

The principal outputs will be a detailed ranking of adaptation options, with an economic appraisal report. An ancillary output will be some lessons from the application of different approaches for different risks in a specific policy appraisal context. This will be produced in a form that it is directly relevant as an input to the National Adaptation Programme, i.e. providing information that will be directly useful for any subsequent impact assessment.

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<sup>9</sup> <http://publications.environment-agency.gov.uk/pdf/GEHO0310BSDB-e-e.pdf>

<sup>10</sup> <http://www.environment-agency.gov.uk/homeandleisure/floods/104695.aspx>



## Decision Support Tools and Relevant Uses

Decision Support Tool	Brief Description	Usefulness & limitations in climate adaptation context	Principal References
Social Cost-Benefit Analysis (CBA)	CBA values all relevant costs and benefits to government and society of all options, and estimates the net benefits/costs in monetary terms. CBA aims to directly compare costs and benefits, allowing comparisons within and across sectors	Most useful when: -Climate risk probabilities known -Climate sensitivity likely to be small compared to total costs/benefits -Good quality data exists for major cost/benefit components	The Green Book (2003) Metroeconomica (2004) Granger et. al. (2010)
Social Cost-Effectiveness Analysis (CEA)	CEA compares the costs of alternative ways of producing the same or similar outputs, identifying least-cost outcomes.	Most useful when: -As for CBA; -Agreement on sectoral social objective (e.g. minimise loss of life years from heat-related causes).	Watkiss et. al. (2009) Metroeconomica (2004)
Real Options Analysis (ROA)	ROA extends the principles of CBA to allow for learning about the nature/extent of climate change and its impact on the adaptation option(s) being considered. This is incorporated by estimation of the value associated with providing information that reduces the uncertainty relating to climate risks.	Most useful when: -As for CBA; -Learning related to climate sensitivities is likely within decision time-frame; -Adaptation context includes possibility of need for investment in long lifetime, climate-sensitive, assets.	Green Book Supplementary Guidance (2009);
Portfolio Analysis (PA)	PA allows an explicit trade-off to be made between the return – measured e.g. in net benefit terms (from CBA) – and the uncertainty of that return – measured by the variance – of alternative combinations (portfolios) of adaptation options, under alternative climate change projections.	Most useful when: -As for CBA; -A number of adaptation actions are likely to be complementary in reducing climate risks.	Crowe and Parker (2008)
Robust Decision Making (RDM)	RDM quantifies the trade-offs implied by adopting adaptation options that address possible vulnerabilities under future uncertainty, compared with other criteria such as economic efficiency	Most useful when: -Probability distributions of alternative climate, socio-economic and vulnerability futures can be constructed, and data for their characterisation is available.	Groves and Lempert (2007)
Risk-Based Rules (RBR)	Ranking, (ordinal or cardinal), guided by risk attitude of decision-maker. Includes e.g. Maximin and Minimax Regret rules.	Most useful when: -Climate risk probabilities not well established, or do not exist; -Degree of social risk appetite agreed.	Willows and Connell (eds.) (2003) Ranger et. al. (2010)

# 8 Step 6. Prioritisation of Adaptation Options

## Summary

**Purpose:** Given the wide-ranging nature of possible interventions, this step identifies priority areas for adaptation on a consistent basis.

**Method:** Based on the information gathered in the previous steps, this step will prioritise adaptation options for specific risks, looking over time, and investigate the potential for prioritisation of options within sectors and for specific themes.

**Outputs:** Priority areas for public policy in relation to climate change adaptation. The output will be the documentation of priority areas for action for each of the key risks/adaptation gaps, and the forms of adaptation that may be best suited to addressing these risks.

**Benefits:** This step will provide the prioritized adaptation options, which will form the main evidence input from the CCRA – AEA work into the NAP.

Given the wide-ranging nature of possible interventions, an idealised output from the AEA is one that identifies priority areas for all possible risks on a consistent basis. Whilst this ideal may not be realised in practice, this step is designed to explore the potential for prioritisation on the basis of the data and stakeholder engagement processes available to the AEA.

This step will draw the information together from the previous tasks and use this to identify priority areas. In considering this task, it is highlighted that the objectives of the AEA are to provide information on adaptation, not to make recommendations. Therefore, the aim of this task is not to come up with a list of recommendations for the National Adaptation Programme. Instead, the aim is to identify the likely priority areas for action based on the evidence gathered,

This prioritisation may be undertaken at different levels, i.e.:

- The identification of priorities for each specific climate risk;
- The identification of priorities within a sector;
- The identification of priorities across sectors within a theme, e.g. the priorities for building adaptive capacity across all sectors.
- The identification of priorities across all risks, sectors and themes.

Within the AEA, the focus of effort will be on the first two of these. The requirements for the latter two prioritisation levels are likely to be beyond the remit of the AEA, particularly as prioritisation across sectors is likely to be associated with policy recommendations, which will be drawn up subsequently by Government in development of the NAP.

## 8.1 Prioritisation (by Risk)

### Purpose

This step will identify priority areas for action on a consistent basis for each risk over time.

### Description

The output of the Appraisal Step (Step 5) within the AEA will constitute the main basis for risk-based prioritisation. The informal MCA ranking exercise will identify the ranked adaptation options/option pathways on the basis of a range of criteria, and also consider this output in terms of the urgency of implementation, given current knowledge on climate change risks.

This step will extend the appraisal and collate information on the priority actions for each risk in a way that allows an adaptation pathway to indicate how risks may be addressed iteratively over time. It may also be able to identify policy priorities on the basis of the urgency of decision-making required and the needs of cross-sectoral co-ordination.

### Stakeholder Engagement / Consultation

As part of the wider consultation, the prioritisation of options will be discussed in the second round of stakeholder engagement.

### Inputs and Outputs

The inputs will be the previous steps, primarily the appraisal step.

The output will be priority areas for action for each of the key risks/adaptation gaps.

## 8.2 Prioritisation by Sector and/or Theme

### Purpose

The purpose of this step is to prioritise across different climate change risks, on a sectoral or thematic basis, in order to inform the National Adaptation Programme.

### Description

Given that the nature of climate change adaptation is determined by specific risks, the most straightforward level of prioritisation is likely to be at the individual risk level (outlined above). However, resource allocation across Government requires that prioritisation is also attempted on a sectoral and cross-sectoral basis.

The potential for the prioritisation within the AEA will be determined principally by the existence of common metrics within sectors, and across sectors. For example, health-based outcomes of adaptation options may be expressed as quality adjusted life years (QALYs), which can be used in prioritisation of adaptation options across risks within the health sector. Alternatively, where CBA has been used in the Appraisal step, the common metric could be monetary, (e.g. net present values), and such an approach may facilitate comparison and prioritisation of options across sectors.

The task will collate data from previous steps of the AEA and progress an initial prioritisation by sector. This will be reported for each sector, or for other comparable clustering of risks.

#### Stakeholder Engagement / Consultation

The second round of stakeholder workshops will be used to consider the relative priorities.

#### Inputs and Outputs

The inputs will be the previous steps, primarily the appraisal step.

The output will be priority areas for action for a number of case studies at the sectoral and theme level.

# 9 Step 7. Order of Magnitude of Adaptation

## Summary

**Purpose:** To provide an overall indication of the scale of the challenge and potential benefits from adaptation to climate change.

**Method:** Using a combination of evidence lines and approaches, this step will build up an estimate of the order of magnitude of adaptation costs for England, over the short- and longer-term, the level of resulting benefits, and the residual impacts.

**Outputs:** Aggregated estimates of the scale of costs and potential benefits of adaptation.

**Benefits:** This step will provide the headline estimates of the costs (and benefits) of adaptation. This information will provide key inputs to the NAP, i.e. providing the underlying economic justification for action and the potential level of costs and benefits. This will also help communicate the scale of adaptation across Government, i.e. to all stakeholders.

The study objectives set out the need to provide an overall indication of the scale of the challenge for adaptation for the England (to help inform the NAP) – and where possible for the UK. While the main focus in this step is on identifying the costs of adaptation, it will also consider the potential benefits of acting. In addition, it will consider the residual impacts after adaptation (as adaptation reduces but does not completely removal all impacts). This is important in considering the overall costs, i.e. the need to consider the sum of adaptation costs and residual damage costs, as shown in the discussion in the box below.

It should be noted that adaptation actions are targeted to address the ‘gross’ effects of climate change and socio-economic change. Clearly, however, some adaptation action might have occurred in the absence of climate change. In principle it is possible to differentiate the marginal adaptation attributable to marginal climate change. Since a principle aim of this step is to identify the costs associated with adaptation to climate change, the question of attribution will be clearly discussed and presented when reporting the results from this task to ensure transparency.

The step will estimate the potential costs and benefits by using a combination of top down and bottom up approaches. This recognises that the methods and approaches for estimating the economics of adaptation are still evolving, and that multiple lines of evidence is likely to bring insight into a complex area, where there is relatively little experience. The step includes a number of specific sub-tasks.

- “Top-down” estimation approaches including a combination of
  - a) aggregate economic sector models and results, which are primarily based around technical or engineered options. These are available for some sectors (e.g. floods using existing sector models), or can be derived from the existing studies based on unit cost assumptions. Such information will be synthesized from existing studies, and if possible, based on the available impact assessment data from the CCRA. It may also be possible to draw in research evidence to this

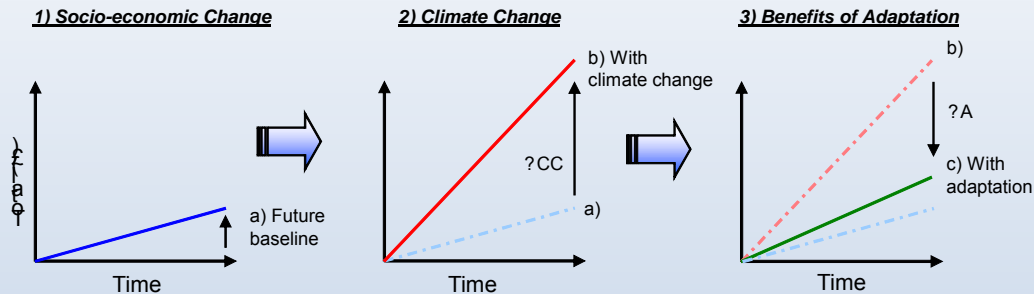
step, for example, including the national level results on the costs (and benefits) of adaptation from other projects.

- b) Investment & Financial Flow (I&FF) based assessment. This primarily requires projections of sectoral climate-sensitive capital investments, along with assumptions regarding the additional expenditure that would be needed to reduce future climate sensitivity. This may be informed by existing sectoral-wide analysis.
- A “Bottom-up” estimation approach that compiles the cost estimates derived in earlier steps and complements these (e.g. through synthesis) with existing micro-level sectoral analysis in relation to climate risks.

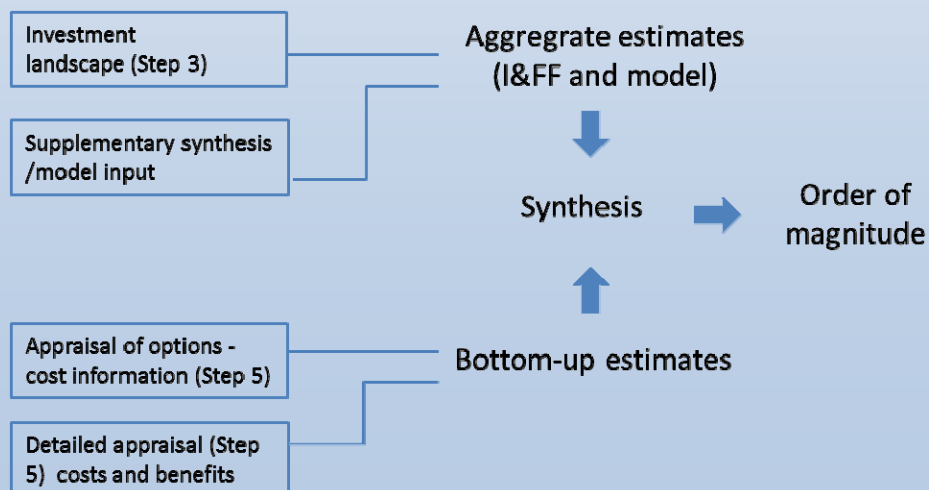
### The framework for assessing the order of magnitude

A high level framework for adaptation costs and benefits existing, shown in the stylised figure below (based on Boyd and Hunt, 2006, and also reproduced in the Stern review). This shows the economic costs (vertical axis) against time (horizontal axis) and outlines three steps for assessing adaptation costs and benefits:

1. The economic costs are estimated for future baseline conditions, i.e. for socio-economic change (noting these changes will occur even in the absence of climate change).
2. The additional impact of climate change is added ( $\Delta CC$ ) to give the total effects of socio-economic change and climate change together, noting that only the marginal (or net) increase above the baseline is due to climate change – this point is important otherwise the analysis overstates the impacts that occur from future climate change.
3. Adaptation reduces the impacts downwards. The reduction ( $\Delta A$ ) provides the economic benefits of adaptation and this can be compared against the costs of adaptation. Note that there are still residual impacts (economic cost) as long as adaptation reduces impacts, but it does not remove them completely.



The information to work with this framework is partly generated in earlier steps, see below.



## 9.1 Top Down and Aggregate Approaches

### Purpose

To provide 'top-down' or aggregate estimates of the costs of adaptation and the potential benefits from acting. This will help inform public policy budget allocations.

### Description

This step will investigate the use of approaches to investigate the aggregate costs of adaptation.

First, it will undertake a high level Investment and Financial Flow analysis. This will draw on the earlier task in the adaptation assessment context (in Step 3), considering the information from Government budgets and investment plans, and bench-marking the sensitivity of current and future investments to climate variability and future climate change. It will use specific sector based mark-ups to estimate the potential costs of adaptation for enhancing climate resilience. This will draw on current sectoral risk studies, further informed by targeted stakeholder inputs.

Second, it will draw on the outputs of existing sectoral models that assess the costs – and where available the benefits of adaptation and residual impacts - to derive estimates of the potential order of magnitude costs for England (and where possible for the UK). For example, using a synthesis of existing estimates, aggregated sector models, for different time periods.

### Stakeholder Engagement / Consultation

The analysis will be undertaken in collaboration with the policy engagement tasks and with Government departments (budgets), as well as in discussion with sectoral modellers.

### Inputs: Outputs

The main inputs will be the PESA and departmental plans, as well as modelling inputs.

The output will be estimates of the aggregate sectoral adaptation cost estimates, and some indicative information on the benefits and residual impacts.

## 9.2 Bottom-up Information and Adaptive Capacity

### Purpose

To provide bottom-up estimates of the costs of adaptation and the potential benefits from acting, including the estimated costs of building adaptive capacity.

### Description

This step will use the information from previous steps on costs of specific adaptation options/option pathways, particularly from the appraisal analysis. For each climate change risk considered in the appraisal, this task will collate the costs associated with the prioritised adaptation options. This process will be undertaken in such a way that the risk of double-counting is minimised, by first ensuring that the costs of alternative adaptation options to respond to a given risk are not aggregated, and second by ensuring that the costs of implementing single options that respond to different risks are not included more than once.

The cost/benefit aggregates will be produced at the level of risks (specific or clustered) and will also be presented on a grouped basis, including sectors. The focus of this evidence base will be on cost estimates produced for the immediate and near-term time periods.

#### Stakeholder Engagement / Consultation

The adaptation cost estimates for individual sectors will be discussed with to sectoral stakeholders for information and for verification.

The estimates of adaptation costs will be discussed with a number of stakeholders, possibly through a specific economics workshop.

#### Inputs; Outputs

The main inputs will be the appraisal step above, including the costs of adaptive capacity (including case study) and the costs of options.

The output will be the bottom-down estimates of the adaptation costs.

## 9.3 Wider Economic Costs (optional)

This is an optional task as part of the AEA method.

#### Purpose

To use the information from the steps above and feed these into some form of wider economic modelling analysis, possibly through the use of a computable general equilibrium model (CGE).

#### Description

The analysis above captures the direct primary effects from climate change on production or consumption. However, there are an additional set of indirect impacts that will occur that reflect changes in production or consumption in one or more sectors across the whole economy, through effects on relative prices, including factor prices, i.e. from climate change impacts and adaptation affecting sectors or regions that are different from those initially impacted, and the feedbacks between sectors. This includes cross sectoral effects where changes in one sector have knock on or multiplier effects to another. In some cases, it may result in “non-marginal” effects, which change the prices in that market by changing the underlying demand and supply conditions. Finally (and potentially arising from both the previous elements), there will be macro-economic effects from larger changes that impact at a national level in terms of GDP, employment, etc.

This optional step will consider the potential to assess these indirect costs – for impacts – and for adaptation. These indirect costs require some modelling of sectoral interdependencies, but can be undertaken using a partial equilibrium (sector level to global models for e.g. agriculture) or general equilibrium approach (using computable general equilibrium models).

## 9.4 Synthesis

#### Purpose

This task will compile the information from the evidence lines above and synthesize to provide an overall indication of the scale of the challenge and potential benefits from acting.



The task will help to raise awareness on the resource implications of climate adaptation in England.

#### Description

This task will bring together the information from the top-down and bottom-up estimates above. The information will be synthesised to give aggregate resource estimates of climate adaptation for short-term budgetary planning purposes. It will identify the scale of resource required from public finance under climate change, focusing on climate risks directly occurring in England.

For each risk/risk cluster, cost ranges will be produced in order to represent the uncertainty associated with the individual estimation procedures, both within and between each evidence lines. Alongside these values, a commentary will be provided on the level of confidence, together with a judgement as to the relative emphasis on alternative estimates or on defined data ranges.

#### Stakeholder Engagement / Consultation

The adaptation cost estimates for individual sectors, and the methods used to generate them, will be discussed with sectoral stakeholders for information and for verification.

#### Inputs; Outputs

The inputs will be the steps above.

The outputs will be a synthesis of the top-down and bottom-up approaches, together with a commentary that explains differences and commonalities between the sets of estimates. The outputs will be an aggregated indication of the scale of the challenge and potential benefits from acting.

# 10 Step 8. Continuous and Ex Post Assessment

## Summary

**Purpose:** To undertake an ongoing and ex post assessment of the AEA.

**Method:** This step - which flows throughout the entire process - will undertake an ongoing and ex post assessment of the AEA. It will collate the information to help assess the effectiveness of the process, and to learn lessons for the CCRA and the NAP and any future national economic assessments of adaptation.

**Outputs:** Analysis of the key adaptation options.

**Benefits:** This step will provide an essential summary of the steps, lessons, and process of the AEA, to help inform future cycles. It will ensure the institutional memory associated with the analysis will be written down, to facilitate future assessments. It will also help identify key issues for the next CCRA, i.e. to enable the linkage between the next CCRA and next NAP.

A key part of the method framework proposed is to learn lessons for future CCRA/NAP cycles. While this is often considered a key part of national assessments, there is very little published material, which makes it difficult to transfer these lessons to future assessments, especially given that these may involve new teams.

The method therefore explicitly includes an ex post assessment of the AEA, to summarise the lessons from the analysis, and write these up for subsequent cycles. However, as well as undertaking this analysis at the end of the process, information from other studies indicates that it is even more useful to document these lessons as the study progresses, i.e. while the information is fresh, allowing iterations as the study progress as well as lessons for the future, hence the inclusion of continuous as well as ex post assessment.

## 10.1 Continuous and Ex Post Assessment

### Purpose

The purpose of this Step is to evaluate:

- a) whether the process of climate adaptation decision-making is sufficient to undertake the initial prioritisation of adaptation action, and;
- b) whether the actions themselves, if implemented, are effective in limiting climate risks.

### Description

The evaluation of the AEA process, including the way in which it facilitates sectoral adaptation decision-making, will be undertaken by Defra and its partner organisations on an on-going basis, during and following the AEA. This review process will inform the design of the 2nd CCRA, and subsequent CCRA cycles to be undertaken from 2015 on a 5-year basis.

More immediately, the AEA will provide an input to the National Adaptation Programme; its success will therefore be measured, in part, according to the extent to which it fulfils this role.

The AEA is designed to facilitate and improve sectoral decision-making. Evaluation of this aspect will be undertaken in subsequent CCRA cycles, and will include an ex post evaluation of decisions – and associated resource commitments – that are identified as being made as a result of the AEA. To facilitate this evaluation, the AEA Team will maintain sectoral-based logs of decision processes that are observed. Ideally, adaptation-related decisions themselves, reported by stakeholder consultees, should also be reported as part of the post-AEA process.

An additional form of ex-post evaluation is the monitoring of adaptation using adaptation indicators. Previously there has been some progress on process based indicators with the N188 local authority indicators. However, national-level indicators are likely to emerge as part of the AEA, and may subsequently be implemented.

#### Stakeholder Engagement

Stakeholder engagement will be integral to the AEA process, and in the sectoral decision-making that it is designed to encourage. The value of the AEA will be assessed according to the extent that sectoral stakeholder decision-making is judged to be improved.

#### Stakeholder Consultation

Stakeholder consultation will primarily be undertaken in the process of deriving national-scale adaptation indicators, and in their verification.

#### Inputs: Outputs

The principal inputs to this Step will be the collective outputs of the preceding Steps of the AEA.

The outputs will be a summary of lessons from the continuous and ex post analysis, including an externally published summary. This will assess the effectiveness of the AEA process, and inform future national economic assessments of adaptation. Other outputs will include the sectoral-based logs of adaptation decision processes, and the record of their associated consequences. The collation of local and national-level adaptation indicators will also constitute an output.

# 11 Stakeholder Engagement and Expert Elicitation

The AEA anticipates a number of areas of expert and stakeholder engagement. These are extremely important in helping to progress the analysis, but also allow the study to benefit from the extremely wide knowledge base in the UK. It will also allow the outputs of the AEA to be subject to wider consultation. A number of key areas are highlighted.

First, the method recommends the use of expert working groups. These will focus initially on a 'synthesis' of information on early steps (1 – 4), i.e. the identifying the existing literature, considering the adaptation assessment context, and in particular, identifying options and identifying data to allow appraisal of these options. It also anticipated that these groups would undertake the initial appraisal of options. These groups are envisaged to be sectorally centred, at least initially, but involve relevant cross-sectoral representation.

Second, there is the continuation of the CCRA stakeholder engagement/consultation. The external stakeholder engagement is proposed to have two rounds of consultation. The first of these is anticipated to provide additional context on the adaptation assessment, provide input and comment on adaptation options to be considered, and to help in identify relevant sources of information. It is proposed these discussions take place on a risk/sector basis and follow the same format as the CCRA workshops. The second set of workshops is anticipated to focus on the appraisal results and discussion of priorities, including cross-sectoral aspects. At this stage, it is recommended that this might move away from a sectoral structure towards value-based tasks, and involve a broader group of cross-sector stakeholders.

Finally, running alongside the expert and consultation exercise is a policy engagement task, which is being led by Defra, but provides much of the information for the policy context and discussion with various Departments. This task will allow discussion on a number of the AEA inputs, but also on the policy priorities for adaptation across central government departments.

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# Key Terms and Definitions

A key issue for this study is the definitions of key terms. The most widely cited definitions are those in the IPCC TAR and AR4. However, there is a wide diversity of definitions, especially in the adaptation context. Levina and Tirkpak (2006) reviewed the definitions and meanings in use for a wide range of terms for adaptation, and found that the wording and meaning of definitions vary widely. The key terms used in the paper are defined below, reporting the IPCC and alternative definitions. The CCRA definitions are also included, and the study has used these as a general rule.

## **Adaptation**

The IPCC (WGII: glossary, 2007) defines adaptation as:

*Adaptation Adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities. Various types of adaptation can be distinguished, including anticipatory, autonomous and planned adaptation:*

- *Anticipatory adaptation – Adaptation that takes place before impacts of climate change are observed. Also referred to as proactive adaptation.*
- *Autonomous adaptation – Adaptation that does not constitute a conscious response to climatic stimuli but is triggered by ecological changes in natural systems and by market or welfare changes in human systems. Also referred to as spontaneous adaptation.*
- *Planned adaptation – Adaptation that is the result of a deliberate policy decision, based on an awareness that conditions have changed or are about to change and that action is required to return to, maintain, or achieve a desired state*

However, there are some issues with this definition of autonomous adaptation. For example, UNFCCC (2009) highlights that while autonomous adaptation does not require a policy intervention, it still requires conscious action on the part of those individuals or private companies that take it. Moreover the traditional attribution of autonomous adaptation to the private sector is problematic – the UK has many privatised sectors, which would be under national planned control in other countries.

The CCRA glossary also notes that *The inclusion of the word ‘conscious’ in this IPCC definition is a problem for the CCRA and we treat this as anticipated adaptation that is not part of a planned adaptation programme. It may include behavioural changes by people who are fully aware of climate change issues.*

The Defra Adapting to Climate Change<sup>11</sup> glossary defines adaptation as:

*Adaptation means changing our behaviour to respond to both the projected and current impacts of climate change.*

It also provides a more detailed definition, largely based on the IPCC, but includes a separate inclusion of reactive and anticipatory adaptation:

*Reactive adaptation is adaptation that takes place in response to the consequences of a particular event.*

*Anticipatory adaptation is that which takes place before impacts of climate change are observed.*

The UK Climate Impact Programme (UKCIP, 2003) defines adaptation as

*The process or outcome of a process that leads to a reduction in harm or risk of harm, or realisation of benefits associated with climate variability and climate change.*

As highlighted by Levine and Tirkpak, the various definitions do imply different interpretations of what adaptation includes.

## **Adaptive Capacity**

The IPCC (WGII: glossary, 2007) defines adaptive capacity (in relation to climate change impacts) as:

*The ability of a system to adjust to climate change (including climate variability and extremes) to moderate potential damages, to take advantage of opportunities, or to cope with the consequences.*

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<sup>11</sup> <http://www.defra.gov.uk/environment/climate/documents/interim2/glossary.pdf>

Ballard, 2009, modified from the IPCC to support project focus on management of future risks, proposes:

*The ability of a system to design or implement effective adaptation strategies to adjust to information about potential climate change (including climate variability and extremes), to moderate potential damages, to take advantage of opportunities, or to cope with the consequences*

The Defra glossary uses the IPCC definition. It adds a further definition for building adaptive capacity (sourcing UKCIP) as

*Developing the institutional capacity to respond effectively to climate change. This means compiling the requisite information and creating the regulatory, institutional and managerial conditions that are needed before adaptation actions can be undertaken.*

The CCRA defines as:

*The ability of a system to design or implement effective adaptation strategies to adjust to information about potential climate change (including climate variability and extremes), to moderate potential damages, to take advantage of opportunities, or to cope with the consequences (modified from the IPCC to support project focus on management of future risks), Ballard (2009). As such this does not include the adaptive capacity of biophysical systems.*

Levine and Tirpak highlight varying definitions of adaptive capacity. They report the UNDP, 2005, as a further definition as:

*Adaptive capacity – Is the property of a system to adjust its characteristics or behaviour, in order to expand its coping range under existing climate variability, or future climate conditions. The expression of adaptive capacity as actions that lead to adaptation can serve to enhance a system's coping capacity and increase its coping range thereby reducing its vulnerability to climate hazards. The adaptive capacity inherent in a system represents the set of resources available for adaptation, as well as the ability or capacity of that system to use these resources effectively in the pursuit of adaptation. It is possible to differentiate between adaptive potential, a theoretical upper boundary of responses based on global expertise and anticipated developments within the planning horizon of the assessment, and adaptive capacity that is constrained by existing information, technology and resources of the system under consideration.*

Levine and Tirpak highlight that these lead to different interpretations, i.e. does adaptation lead to increased adaptive capacity? Or does increased adaptive capacity increase your ability to adapt? Or does adaptive capacity indicate the possible extent/limit of adaptation? They highlight that most authors and practitioners use the term 'adaptive capacity' as simply a characteristic of a system and its ability to adjust to climate change on its own.

### **Adaptation assessment**

The IPCC (WGII: glossary, 2007) defines adaptation assessment as:

*The practice of identifying options to adapt to climate change and evaluating them in terms of criteria such as availability, benefits, costs, effectiveness, efficiency and feasibility.*

### **Adaptation costs**

The IPCC (WGII: glossary, 2007) defines the costs of adaptation as:

*The costs of planning, preparing for, facilitating, and implementing adaptation measures, including transition costs.*

This is also used in the CCRA.

### **Adaptation benefits**

The IPCC (WGII: glossary, 2007) defines the benefits of adaptation as:

*The avoided damage costs or the accrued benefits following the adoption and implementation of adaptation measures.*

This is also used in the CCRA

### **Consequence**

The CCRA method statement defines consequence (using a minor derivation from the UKCIP definition) as:

*The end result or effect on society, the economy or environment caused by some event or action (e.g. economic losses, loss of life). Consequences may be beneficial or detrimental. This may be expressed descriptively and/or semi-quantitatively (high, medium, low) or quantitatively (monetary value, number of people affected etc).*

### **Likelihood**

The IPCC (WGII: glossary, 2007) defines likelihood as:

*The likelihood of an occurrence, an outcome or a result, where this can be estimated probabilistically, is expressed in this Report using a standard terminology, defined in the Introduction. See also uncertainty and confidence.*

The CCRA method statement defines it as:

*A general concept relating to the chance of an event occurring. Generally this is expressed as a probability or frequency.*

### **Impact**

The CCRA method statement defines impact as:

*An effect of climate change on the socio-bio-physical system (e.g. flooding, rails buckling etc).*

### **Risk**

The CCRA method statement defines risk as:

*Defined as the probability multiplied by consequence. Ideally the probability and consequence would be quantified but a similar qualitative matrix can be used.*

Risk is often used in the context of climate change, though Levina and Tirkpak (2006) identify that it has not yet been defined, either by the UNFCCC or by the IPCC and that definitions vary. A number of definitions in the context of CC:

Risk - Is the probability that a situation will produce harm under specified conditions. It is a combination of two factors: the probability that an adverse event will occur; and the consequences of the adverse event. Risk encompasses impacts on human and natural systems, and arises from exposure and hazard. Hazard is determined by whether a particular situation or event has the potential to cause harmful effects. (Australian Greenhouse Office. 2003)

Risk (climate-related) – Is the result of interaction of physically defined hazards with the properties of the exposed systems – i.e., their sensitivity or (social) vulnerability. Risk can also be considered as the combination of an event, its likelihood, and its consequences – i.e., risk equals the probability of climate hazard multiplied by a given system's vulnerability (UNDP, 2005)

AR4 Chapter 2 (Carter et al, 2007), reports in the text that: Risk is generally measured as a combination of the probability of an event and its consequences, with several ways of combining these two factors being possible. There may be more than one event, consequences can range from positive to negative, and risk can be measured qualitatively or quantitatively.

Risk is the likelihood, measured by its probability, that a particular event will occur (The UK Green Book, 2007, Appraisal and Evaluation in Central Government in central Government)

A similar definition is also adopted by the UK national risk register, e.g. setting out risks by their likelihood and their impact. This also uses a matrix of the relative impact and relative likelihood to consider risks (and prioritise them). The UKCIP Risk, uncertainty and decision-making framework also uses the same format.

Other more complex definitions do exist, e.g. the ASCCUE project (Adaptation Strategies for Climate Change in the Urban Environment) define

$\text{Risk} = f \{ \text{Hazard, Exposure, Vulnerability} \}$

Where hazard is the extent, severity and probability of a climate related hazard; exposure is the extent and value of elements that would be affected were the hazard to be realised; and vulnerability is the susceptibility of the elements to the hazard.

### **Sensitivity**

The CCRA method statement defines risk as:

*The degree to which a system is affected, either adversely or beneficially, by climate variability or change.*

### **Uncertainty**

The IPCC (WGII: glossary, 2007) defines uncertainty as:

*An expression of the degree to which a value (e.g., the future state of the climate system) is unknown. Uncertainty can result from lack of information or from disagreement about what is known or even knowable. It may have many types of sources, from quantifiable errors in the data to ambiguously defined concepts or terminology, or*

uncertain projections of human behaviour. Uncertainty can therefore be represented by quantitative measures (e.g., a range of values calculated by various models) or by qualitative statements (e.g., reflecting the judgement of a team of experts). See also confidence and likelihood.

The CCRA method statement defines it as:

*A characteristic of a system or decision where the probabilities that certain states or outcomes have occurred or may occur is not precisely known.*

### **Vulnerability**

The IPCC (WGII: glossary, 2007) defines vulnerability as:

*Vulnerability is the degree to which a system is susceptible to, and unable to cope with, adverse effects of climate change, including climate variability and extremes. Vulnerability is a function of the character, magnitude, and rate of climate change and variation to which a system is exposed, its sensitivity, and its adaptive capacity.*

This is also reported in the Defra glossary.

The CCRA method statement defines it as:

*Climate vulnerability defines the extent to which a system is susceptible to, or unable to cope with, adverse effects of climate change including climate variability and extremes. It depends not only on a system's sensitivity but also on its adaptive capacity.*

Levina and Tirpak found very different interpretations for vulnerability, for example.

*Vulnerability refers to the magnitude of harm that would result from a particular hazardous event. The concept recognises, for example, that different sub-types of a receptor may differ in their sensitivity to a particular level of hazard. Therefore climate vulnerability defines the extent to which a system is susceptible to, or unable to cope with, adverse effects of climate change, including climate variability and extremes. It depends not only on a system's sensitivity but also on its adaptive capacity. Hence arctic alpine flora or the elderly may be more vulnerable to climate change than other components of our flora or population.*  
(UKCIP, 2003)

*Vulnerability assessment identifies who and what is exposed and sensitive to change. A vulnerability assessment starts by considering the factors that make people or the environment susceptible to harm, i.e. access to natural and financial resources; ability to self-protect; support networks and so on.*  
(Tompkins, E. et al., 2005)

*Socio-economic vulnerability – Is an aggregate measure of human welfare that integrates environmental, social, economic and political exposure to a range of harmful perturbations.*

*Vulnerability – is the degree to which the exposure unit is susceptible to harm due to exposure to a perturbation or stress, and the ability (or lack thereof) of the exposure unit to cope, recover, or fundamentally adapt (become a new system or become extinct) (Kasperson et al., 2000) It can also be considered as the underlying exposure to damaging shocks, perturbation or stress, rather than the probability or projected incidence of those shocks themselves.*  
(UNDP, 2005)

They highlight that one interpretation views vulnerability as a residual of climate change impacts minus adaptation, whilst another views vulnerability as a general characteristic or state generated by multiple factors and processes, but exacerbated by climate change.

### **Adaptation Deficit**

Formal definitions do not exist, but Tirpak and Levine report the definition offered by Ian Burton at the In-session workshop on adaptation (May 21, 2005, Bonn), as

*Failure to adapt adequately to existing climate risks largely accounts for the adaptation deficit.*

This term has been the subject of considerable discussion in recent years, though this reveals a number of interpretations and different categories of an adaptation deficit. There has also been a discussion of the level of adaptation deficit that is acceptable or economically efficient, given it is not possible (or necessarily desirable) to completely climate proof all areas.

### **Mal-adaptation**

Formal definitions do not exist, but the TAR (IPCC, 2001) describes maladaptation as *any changes in natural or human systems that inadvertently increase vulnerability to climatic stimuli; an adaptation that does not succeed in reducing vulnerability but increases it instead.*

The Defra Adapting to Climate Change glossary defines it as:

*Action or investment that enhances vulnerability to climate change impacts rather than reducing them.*

An informal but widespread interpretation is that maladaptation involves conflict with mitigation, i.e. where an adaptation response increases greenhouse gas emissions.

However, a wider definition is emerging concept is that there are many forms of mal-adaptation, which might involve the following kinds of action (Downing et al, 2005):

- Inefficient use of resources compared to other options (e.g. the principle that all actions should be climate-proof through adaptation would be extremely expensive (and there will be many cases where benefits will certainly exceed costs, and would not provide good value for society as a whole),
- Ineffective, e.g. relying on scenarios of future climatic risks that are not subsequently realised and actions that have no other benefits,
- Displacing vulnerability (from one actor to another) and/or
- Reducing the possibility for future adaptations.

In economic terms, it has been defined that if net of adaptation costs, the negative consequences induced by the climatic stimulus are reduced, or its positive consequences are enhanced, there are benefits from adaptation, otherwise there is the potential for maladaptation. It is important to stress that adaptation which can be successful at a specific temporal or spatial scale can become maladaptation at a different spatial and temporal scope.