UKCIP Adaptation Wizard

Extract from Climate adaptation: Risk, uncertainty & decision-making

Stage 3 – Tier 1: Preliminary climate change risk assessment

Key issues

A preliminary climate change risk assessment can be helpful in ensuring that all potentially significant climate-related hazards that may affect or impact a decision are identified at an early stage. This provides better understanding, when identifying options (see Stage 4), of the factors that may affect their consequences.

Completing a preliminary climate change risk assessment may usually benefit from some degree of information gathering. However, the intention should be to limit the time and effort spent on data collection at this time. The intention is to provide an indication (not involving quantification) of the areas where climate change risk could significantly influence the final decision.

Completing a checklist will help identify whether or not climate change related impacts may be important to the selection of options (at Stage 5) – a task which will be facilitated by consideration of the questions in the box below.

Willows, R.I. and Connell, R.K. (eds). 2003. Climate adaptation: Risk, uncertainty and decision-making. UKCIP Technical report, UKCIP, Oxford

www.ukcip.org.uk/wordpress/wp-content/PDFs/Risk.pdf

Questions

Key questions for Stage 3, Tier 1

1. What is the lifetime of your decision? Over what period are the benefits of the decision expected to be realised?
    - » This will inform the choice of climate scenarios to be used in future analysis, and how they are interpreted.
2. Which climate variables are likely to be significant in relation to meeting your decision criteria?
    - » Does information on past variability in climate or past extremes of weather indicate potential vulnerability to climate change?
    - » Vulnerability to changes in mean climate may be less obvious, and therefore more difficult to foresee than vulnerability to changes in climate extremes.
3. How might future changes in these climate variables affect your decision and ability to meet your decision criteria?
    - » Are certain climate variables likely to be of greater significance than others?
    - » Judgements should be based on information contained within the latest UKCIP climate change scenarios. Climate analogues may also be helpful.
    - » Changes in the frequency and magnitude of extreme values of climate variables are more difficult to predict, and more uncertain, than changes in mean values.
4. If an initial portfolio of options exists, is it possible at this stage to judge the potential significance of the impacts of climate change to the options?
    - » Is the risk posed to certain receptors likely to be of key importance to the choice of option?
5. Is there uncertainty regarding forecasts of particular climatic hazards, or their associated impacts?
    - » Can the level of confidence associated with particular hazards and their impacts be determined?
6. Can any climatic variables, or impacts be screened out at this stage?
    - » For example, because they are not likely to affect the choice of option or would apply equally to all possible options.
7. What other (non-climate) factors could also be relevant in relation to meeting your criteria?

Tools and techniques

Table 7 opposite provides an example of a **checklist** that can be used in preliminary climate change risk assessments. The rows and columns of the table together provide an overall checklist of climate variables and their associated characteristics, which can be used to help describe potential climate pressures or hazards. (Further information about the variables in Table 7 is provided is Part 2, Table 3.1 and explanations for the other column headings are provided in Table 3.2).

Using this checklist should make possible a comprehensive identification and screening of potential future climate hazards on receptors, and facilitate the definition of climate variables for consideration in more formal Tier 2 and 3 risk assessments (including the development of impact assessment models). The outcome of applying the checklist in Table 7 should be a well-reasoned description of those climate variables to which different receptors may be sensitive.

Table 8 provides an example of an application of a risk assessment checklist, for a National Park Management Strategy. The overall objective for the strategy was provided in Table 2. Table 8 outlines specific objectives aimed at achieving this overall objective, and describes some of the climate and non-climate factors that could affect them.

Climate scenarios can also be used at this stage to provide the basis of a list of potentially significant climate variables, together with a range of anticipated future values. While future climate scenarios include an increasing number of potentially important climate variables, they may not be presented in a form, or at a level of detail, most relevant to certain problems. It is important not to constrain the preliminary climate change risk assessment because a potentially relevant variable is not included in a particular **scenario** or report. Hence it is recommended that **checklists** should either precede or accompany consideration of the climate variables and changes described in climate scenarios.

Often **brainstorming** can give a good initial overview of impacts. A key technique that can also assist at this stage is the use of **process influence diagrams**, which help identify the causal pathways that link the impacts of both climatic and non-climatic factors to the receptors that form the important components of the decision. Further tools that may help are shown in Table 9.

The decision-maker may have greater or lesser confidence in his knowledge of how each climate variable affects his decision criteria. It is important that a systematic approach is adopted to describing the knowledge on which the assessment is based. Table 10 provides some qualitative terms, which can be used within Stage 3 risk assessments and Stage 5 options appraisal to describe different types of knowledge and the associated probability, uncertainty and confidence of that knowledge.

Table 7: Summary matrix of climate variables and characteristics for use in preliminary climate change risk assessments (PCCRA).

Variable	Characteristics of variable				Sensitivity of decision to criteria / system to changes in variable	Confidence in assessment of link between variable and decision criteria / system
	Magnitude (M) and Direction (D)	Statistical basis of change	Averaging or sampling period	Joint prob-ability events and variables		
	No Change Change (M&D) Decrease (M only) Increase (M only) Rate of change	Average value Cumulative value Variability in values Frequency of values (inc. percentiles, extreme values, maxima & minima)	Instantaneous Hourly or sub-hourly 'Day' or 'Night' Daily Monthly Seasonal Annual Decadal or longer	Not consecutive Consecutive occurrence Coincident or joint occurrence	Not sensitive Low sensitivity Medium sensitivity High sensitivity	Known, established Reliable Extremely doubtful (see Table 10)
PRIMARY						
Carbon dioxide						
Sea level						
Temperature						
Precipitation						
Wind						
Cloud cover						
SYNOPTIC						
Weather types						
Pressure						
Pressure gradient						
Storm tracks						
Ocean climatology						
Lightning						
COMPOUND						
Humidity						
Evapo-transpiration						
Mist, fog						
sea level						
Growing season						
PROXY						
Soil moisture						
Water run-off						
Wave climate						

Table 8: Example checklist for a preliminary climate change risk assessment of a National Park Management Strategy			
Objective	**Criteria**	**Examples of potential climate change impacts on the criteria**	**Examples of potential non-climate impacts on the criteria**
To increase the number of visitors to the park all year round	Increase number of summer visitors by 20% by 2015 (compared to 2000). Increase number of winter visitors by 30% by 2015 (compared to 2000).	Higher average summer temperatures and reduced summer rainfall could lead to increased visitor numbers in summer. Visitor numbers are sensitive to frequency and duration of higher summer temperatures and reduced rainfall. Reduced average summer and autumn rainfall will reduce the available water resources, and may constrain the park's ability to increase visitor numbers. Warmer winters and less snowfall could encourage more visitors in winter, but increased average winter rainfall, and more rainy days, may put them off. More frequent and intense winter rainfall events may lead to localised flooding on routes in to the park, affecting visitor numbers.	A new wildlife centre is opening in 2005, close to the park. Potential day visitors to the park may choose to go there instead.
To promote sustainable tourism: encouraging visitors but not cars, and promoting use of public transport	50% of visitors to travel to the park by public transport by 2015. Four new Park and Ride schemes to be introduced by 2010.	Increased average and extreme winter rainfall is likely to discourage visitors from using public transport. Reduced summer rainfall (average and frequency distribution) may mean that more summer visitors use public transport.	Any new Park and Ride schemes are likely to be opposed by local businesses, who say that they reduce trade.
To conserve landscapes and biodiversity: reversing the 75% decline in flower-rich meadows which occurred between 1990 and 2000	By 2010, increase the area of flower-rich meadows by 50% (compared to 2000).	Climate changes – e.g. higher average carbon dioxide concentrations, higher seasonal average temperatures, higher average winter rainfall, reduced average summer rainfall, more growing degree days, less snow – could affect the distributions of some of the plant species occurring in the flower-rich meadows. Some species are likely to benefit, while others may suffer. Increased frequency of above average, intense periods of winter rainfall may increase soil erosion on steep slopes in some meadows. Pests and diseases which are killed off when temperature falls below freezing may increase in numbers, as the annual number of cold/frost days falls, causing knock-on effects on some plant species.	The amount of flower-rich meadowland will depend on the types of agricultural activities undertaken. Moves to more intensive agriculture were the main cause of the decline in the meadows between 1990 and 2000. The economic viability of traditional farming, which allows the meadows to flourish, is uncertain.

Table 9: Tools and techniques for Stage 3, Tier 1				
Tool/technique	Qualitative and/ or quantitative	Complexity	Data requirements	Comment
Checklists	qualitative	easy to use	minimal	Table 7 is a checklist
Brainstorming	usually qualitative	may require specialists	minimal	
Problem Mapping Tools	usually qualitative	may require specialists	minimal	
Process Influence Diagrams	qualitative	easy to use may require specialists with expertise	minimal	
Consultation Exercises	either	may require inputs from experts	low	
Fault/Event Trees	either	requires specialists	potentially high	Data requirements high to inform precise estimates of probabilities
Expert Judgement and Elicitation	either	requires inputs from experts	low	Various methodological approaches, including: Structured questionnaires and encoding methods Facilitated workshops Delphi technique
Scenario Analysis	either	easy to use with guidance	medium	See Part 2, Sections 3.6 and 3.7
Climate Change Scenarios	either	easy to complex	medium to high	See Part 2, Section 3.6
Cross-Impact Analysis	either	easy to use with guidance	medium for simpler versions	Both formal and modified/ versions in use
Deliberate Imprecision	qualitative	easy to use with guidance	minimal	
Pedigree Analysis	qualitative	easy to complex	low	Supports interpretation of expert judgement

Table 10: Qualitative classified descriptions of probability, risk, confidence, uncertainty, pedigree of knowledge and information, and acceptability, together with indicative quantitative probabilities. Classifications should be agreed in the context of a particular study and applied consistently. Based partly on IPCC (2001a), Moss & Schneider (2000) and others. Pedigree scores can be used within a decision analysis framework to assist the decision-maker in accounting for different qualities and certainties associated with different types of knowledge.

Quantitative descriptor	Subjective descriptor			Pedigree and acceptability				
Probability of event or outcome, Confidence or Relative frequency	Probability of event or outcome	Risk[5] (including hazard con-sequence, sensitivity)	Confidence or Uncertainty	Theoretical basis or model	Information or data	Acceptance by peers	Acceptance by colleagues	Acceptance by stakeholders
Greater than 99%	Virtually certain to certain	Extremely high	Extremely confident Virtually certain Known, established	Established Validated model Proven	Experimental	Absolute, universal	All but cranks	Universal support Almost total support
90–99% chance	Highly probable Very likely	Very high	Very confident Highly certain Very reliable					
66–90% chance	Likely Probable	High	Confident Quite certain Reliable	Process-based model, underpinned by some theory	Historical experience or Observational data	High	All but rebels	Widely supported Largely supported
33–66% chance	Possible	Moderately high	Plausible Debatable Medium confidence Unreliable	Black box and Simulation models	Calculated	Medium	Different schools	Majority (>55%) to minority (<45%) support
10–33% chance	Unlikely	Moderate	Low confidence Uncertain Not reliable	Statistical models Fuzzy models	Educated or expert guess	Low	New field	Little support or local support
1–10% chance	Very unlikely Improbable	Low / small	Very uncertain Very unreliable Doubtful Very low confidence	Concepts and definitions unproven	Uneducated or non-expert guess	Very low to none	No opinion	Widely unsupported or rejected to absolute rejection
Less than 1%	Virtually impossible to impossible	Very small to negligible	No confidence Extremely doubtful					

5 The tolerable level risk will normally be set towards the bottom of the scale.

Stage 3 – Tier 2 and Tier 3: Qualitative and quantitative climate change risk assessment

Key issues

As outlined in Table 6, a Tier 2 or 3 assessment can be undertaken by:

- a decision-maker addressing a climate adaptation decision problem; and
- a decision-maker who has already identified a range of options, and is interested to know how climate change might influence the choice between them, whether the options need to be amended, or new options considered.

Quantitative climate change risk/impact assessments (Tier 3) enable the decision-maker to evaluate risk quantitatively, including sources of uncertainty, and the influence of factors on the probability and magnitude of the risk. This tier of analysis also allows a more detailed, quantitative assessment of the prospective performance of a particular well-defined portfolio of options under the range of uncertainty concerning future climate, as well as non-climate factors.

As with other steps in the decision-making process, the outputs of risk assessment may require other stages to be revisited. Similarly, risk assessments may need to be reviewed in the light of outputs from options appraisal.

Questions

The selection of the appropriate risk assessment tool for a particular circumstance is not always straightforward but consideration of the questions in the box below should provide some assistance.

Tools and techniques

Some of the relevant tools and techniques and their characteristics are listed in Table 11.

Statistical models may be of considerable value within risk assessments, but results need to be interpreted with care. Potential applications include: models based on empirical relationships between past variations in climate and impacts on the exposure unit; relationships between **forecast** and observed climate variables at different spatial scales (e.g. statistical downscaling methods); and forecasting the historical or prospective return periods of low probability events, such as intense rainfall events or extreme river levels, using generalised extreme value distributions (e.g. Coles, 2001).

There are often a further three considerations to take into account when selecting a tool for risk assessment:

- Regret, or the consequences and costs of being wrong (see Stage 1 on decision errors). The more that is at stake, the more important it is to reach a decision which is robust, and thus greater care should be taken in selecting the best tool or, possibly, combination of tools.

- The complexity of the problem. The ability of mathematical risk models to handle a large number of complex interrelated issues is well tested. However, problems may be so large and complex that they cannot be resolved through the use of sophisticated models, although such models can still be of help in understanding the problem. In principle simple models may provide a better basis for forecasting and assessing the level of confidence associated with the forecast.

- The adequacy of the data. The output from any assessment tool will always be constrained by the quality of the available data. Where it is possible to estimate the uncertainty in the input data, this can be propagated through an assessment model and the consequences for the assessment examined.

Key questions for Stage 3, Tiers 2 and 3 (in addition to those key questions in Stage 3, Tier 1)

1. Given the various options identified previously, what are the risks of failing to meet your criteria:

    a) posed by climate change?
    b) posed by non-climate factors?

    » Forecasts of both future climate, and non-climate futures, will be required. In most cases these forecasts will be scenario-based in order to account for sources of uncertainty.
    » Criteria will be represented by a number of defined receptors and assessment endpoints (refer to Stage 2).

2. What are the most important consequences? Which are the key hazard factors? How are the consequences dependent upon the hazards?

    » Risk assessments, including estimates of probability, will be contingent on the particular scenario or scenarios upon which they are based.

3. Are some of the options more vulnerable to these factors others?

4. What tools should be used to analyse risks? Do these reflect the scale of the problem, its complexity and data availability?

5. Could other tools be adopted which would allow more explicit consideration of climate change risk, including estimates of probability, analyses of uncertainties and the significance of key assumptions?

    » In-depth detailed quantitative studies (Tier 3) will usually be dependent on further data collection and the development of risk assessment models.
    » What would be the advantages or disadvantages of adopting alternative risk assessment tools?

Table 11: Tools and techniques for Stage 3, Tiers 2 and 3			
Tool/technique	**Complexity**	**Data requirements**	**Comment**
Uncertainty Radial Charts	easy to use	low	
Fault/Event Trees	may require specialists	high	Also suitable for Stage 3, Tier 1
Decision and Probability Trees	may require specialists	high	
Expert Judgement and Elicitation	requires inputs from experts	low	Various methodological approaches, including: Structured questionnaires and encoding methods Facilitated workshops Delphi technique
Scenario Analysis	easy to use if appropriate scenarios are available	medium	Also suitable for Stage 3, Tier 1 See Part 2, Sections 3.6 and 3.7
Climate Change Scenarios	easy to complex	medium to high	See Part 2, Section 3.6
Cross-Impact Analysis	easy to use with guidance	medium for simpler version	Also suitable for Stage 3, Tier 1 Both formal and modified/simpler versions in use
Monte Carlo Techniques	easy to use with guidance	high	
Modelling Tools: Process Response Models Statistical Models	requires specialists	low, medium or high	Deterministic or stochastic models may be used, but methods for sensitivity and uncertainty analysis will be needed to provide estimates of risk
Development and use of Specific Sophisticated Modelling Tools	requires specialists	high	
Climate Typing	requires specialists	high	
Downscaling	requires specialists	high	Precise methods depend on available environmental or climate data, and temporal and spatial scale of the exposure unit and receptors. See Part 2, Section 3.6.7
Bayesian Methods	requires specialists	high	Can be used to determine the value of additional data or alternative models, and for reviewing risk assessments
Markov Chain Modelling	requires specialists	medium to high	Can be applied to event and fault trees and similar models to examine propagation of uncertainty
Interval Analysis	requires specialists	low, medium or high	