



Risk-based climate change adaptation decisions

Jim Hall

Newcastle University





Contents

1. The role of government in adapting to climate change
2. The Adaptation Sub-Committee
3. Climate change risks assessment
4. Risk-based water resources management planning

The Stern Review

“Adaptation will be crucial in reducing vulnerability to climate change and is the only way to cope with the impacts that are inevitable over the next few decades... It provides an impetus to adjust economic activity in vulnerable sectors and to support sustainable development...”

Stern, N. (2007). The Economics of Climate Change: The Stern Review. Cambridge, Cambridge University Press.

The Stern Review

“Without a proper understanding about the likely consequences of climate change, it is difficult for individuals or businesses to weigh up the costs and benefits of investing in adaptation.”

“Adaptive action is most likely to be taken where it is in people’s and businesses’ direct interest to do so... However, in some cases the benefits of adapting could extend beyond those who have paid for them, and provide benefits to the wider economy and society. In this case the private sector is unlikely to invest in the amount of adaptation society would desire, because they cannot capture the full benefits of the investment.”

HM Government



Adapting to climate change in England

A FRAMEWORK FOR ACTION



Phase 1 of the Adapting to Climate Change programme



Objectives

1. develop a more robust and comprehensive evidence base about the impacts and consequences of climate change on the UK;
2. raise awareness of the need to take action now and help others to take action;
3. measure success and take steps to ensure effective delivery; and
4. work across Government at the national, regional and local level to embed adaptation into Government policies, programme and systems.

Climate Change Act 2008



Mitigation

- Setting emissions targets & carbon budgets
- Annual Government reports on progress
- Trading schemes & policies to reduce emissions

Adaptation

- National climate change risk assessment
- National adaptation programme
- Reporting requirement for many critical services

Committee on Climate Change & Adaptation Sub-Committee to advise and report on progress

The role of the ASC



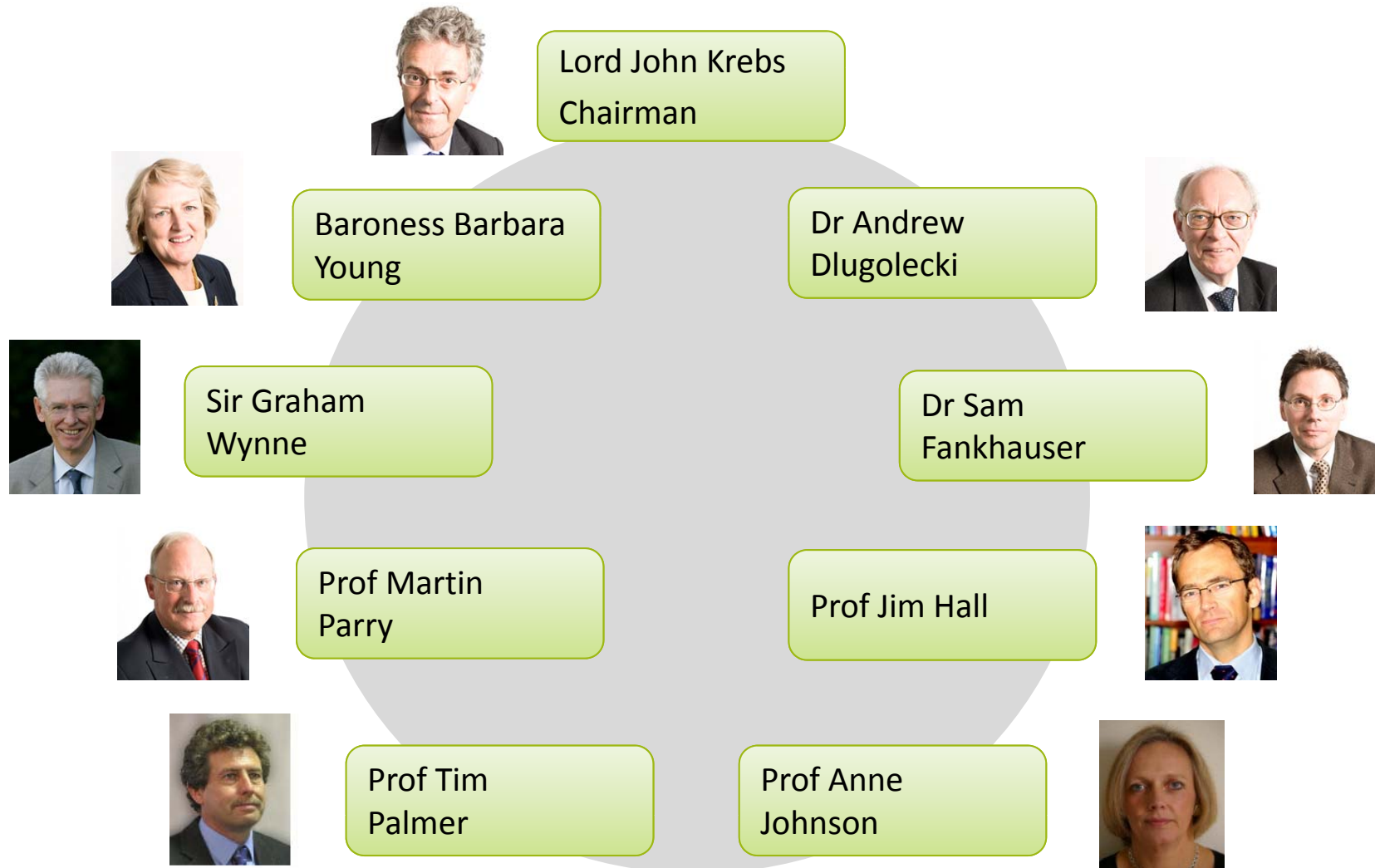
To provide independent advice to the UK Government on preparing for climate change, by:

→ **Scrutinising** the development of Government's Climate Change Risk Assessment

→ **Assessing** the preparedness of the UK to meet climate change risks and opportunities

→ **Promoting** effective adaptation actions by society as a whole

Adaptation Sub-Committee (ASC) members



Adaptation Sub-Committee (ASC) activity



- Scrutinising progress of the UK Climate Change Risk Assessment
- Reviewing the Departmental Adaptation Plans
- Advising Defra on guidance for risk assessment in the reporting requirements for critical sectors
- Report on UK preparedness to be released in September 2010

Climate Change Act 2008

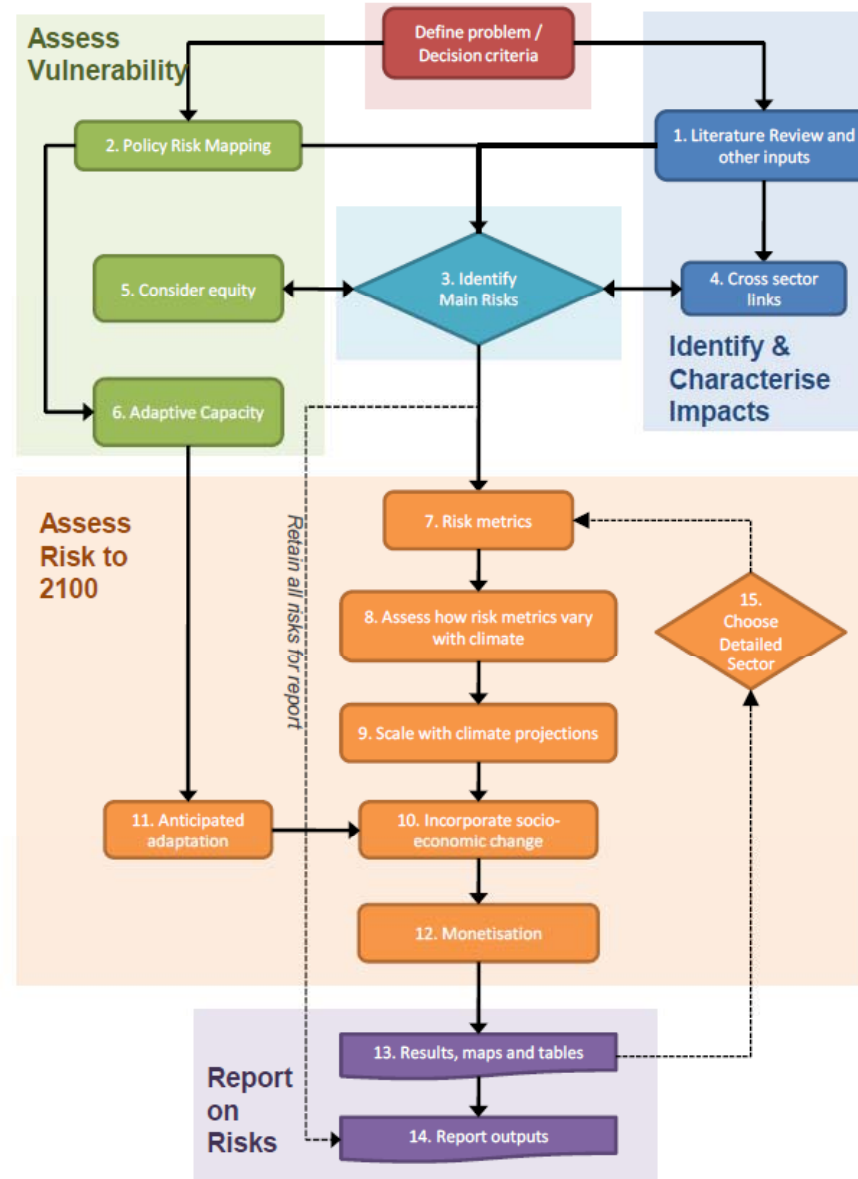
→ Adaptation Sub-Committee

→ Climate Change Risk Assessment

→ National adaptation programme

→ Ad hoc requests for advice

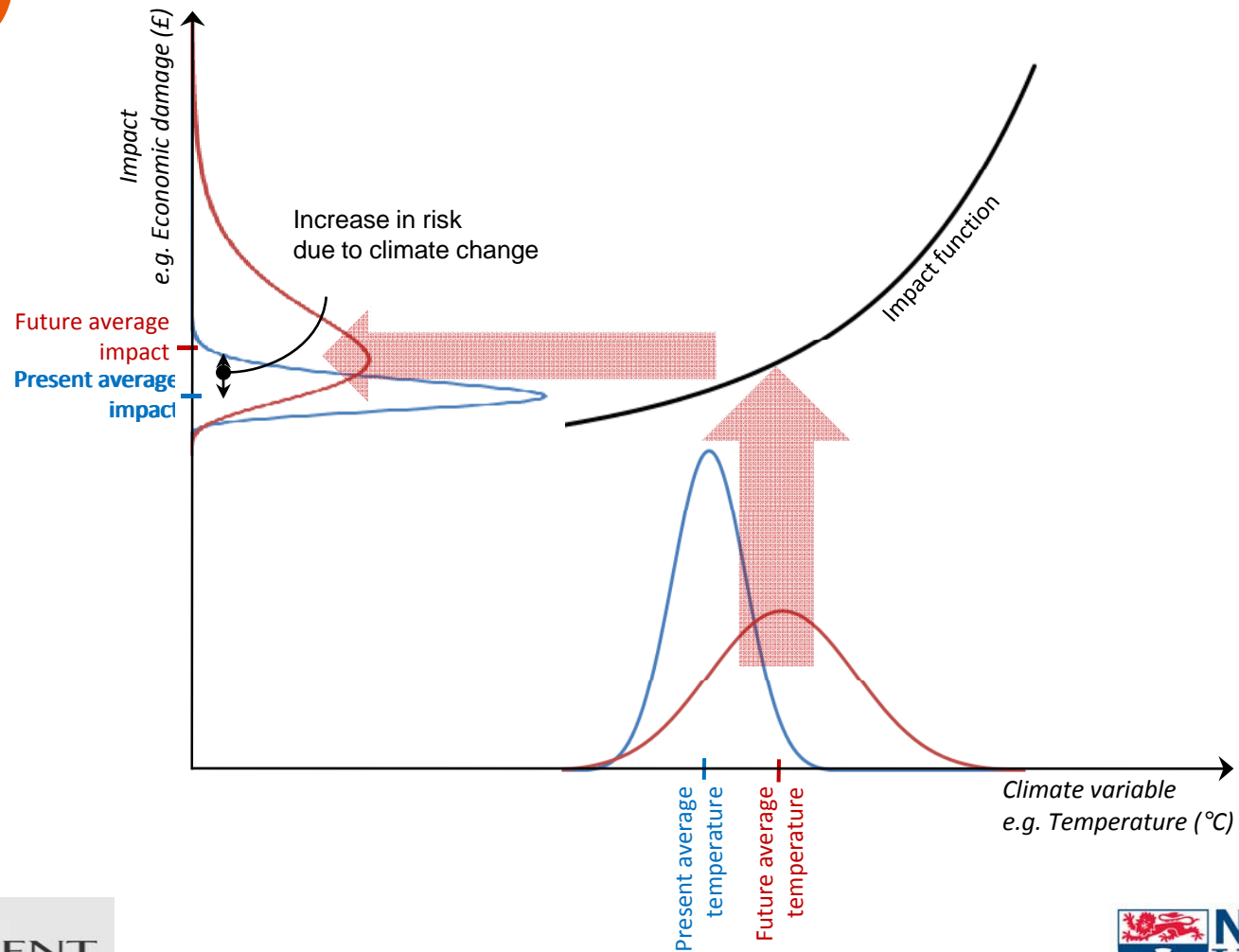
The UK Climate Change Risk Assessment



**UK
2012** | **Climate
Change
Risk
Assessment**



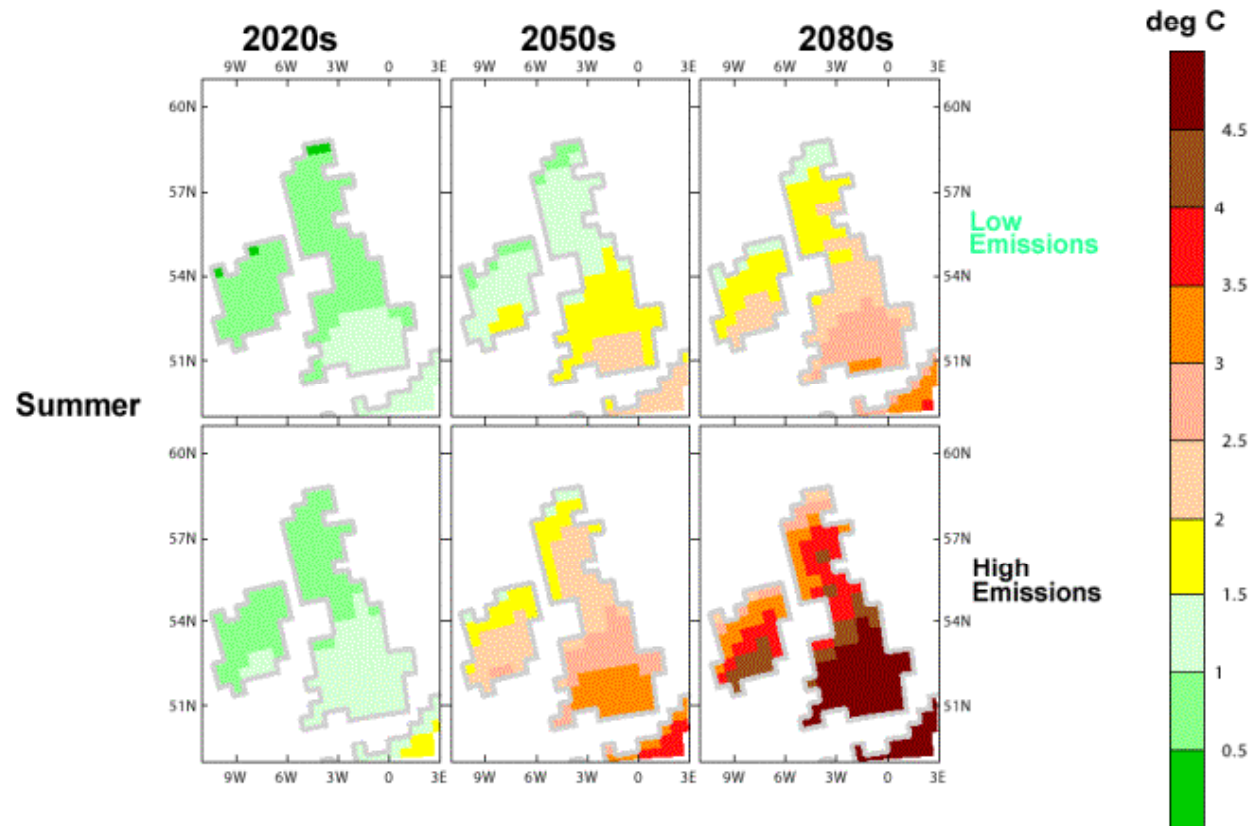
Climate Change Risk Assessment



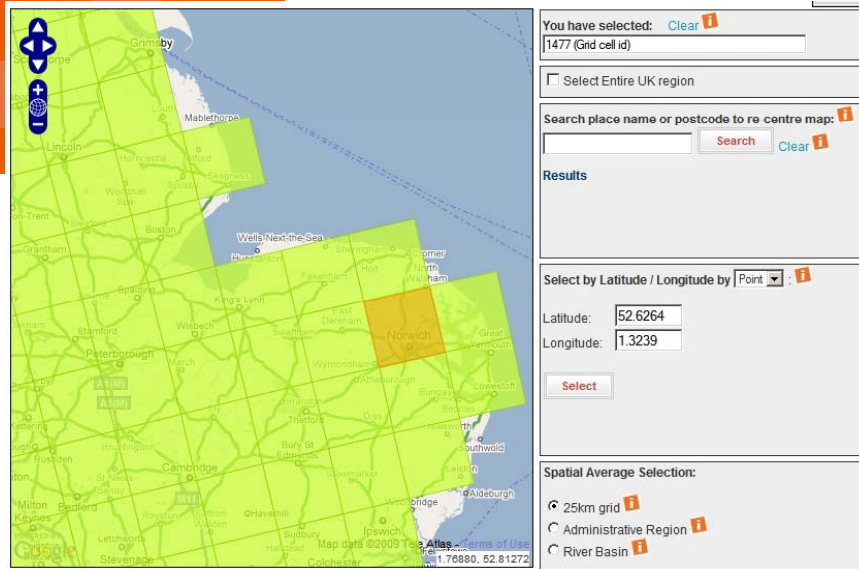
Assessing the risks: climate change scenarios

The UKCIP02 climate scenarios

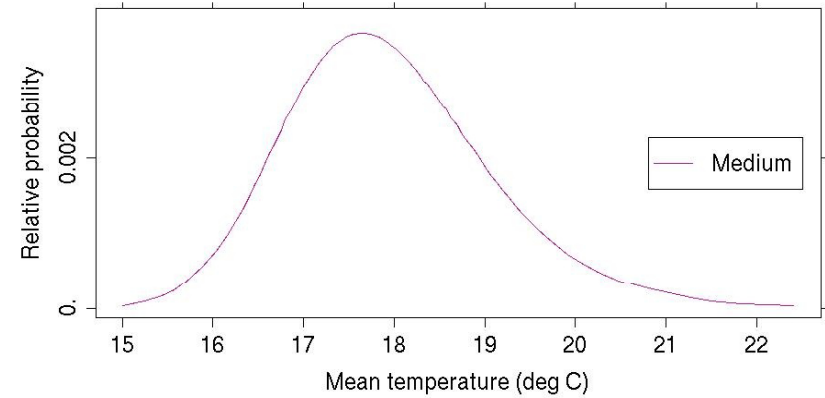
Mean temperature change



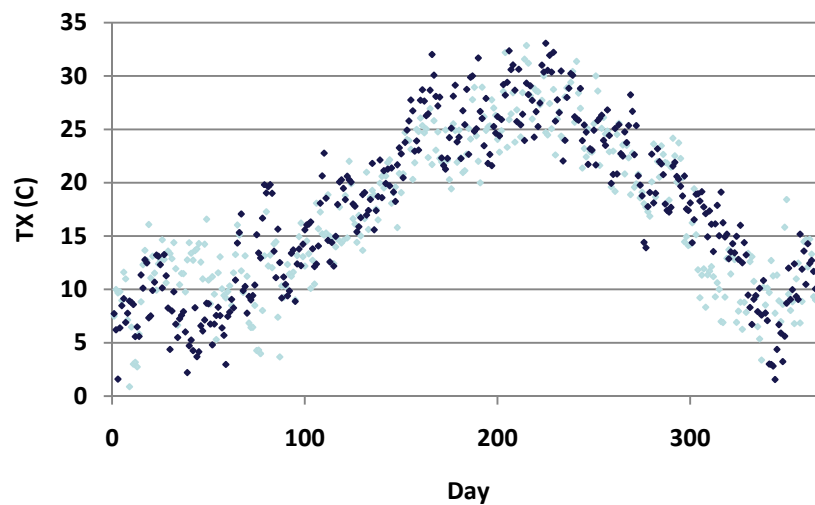
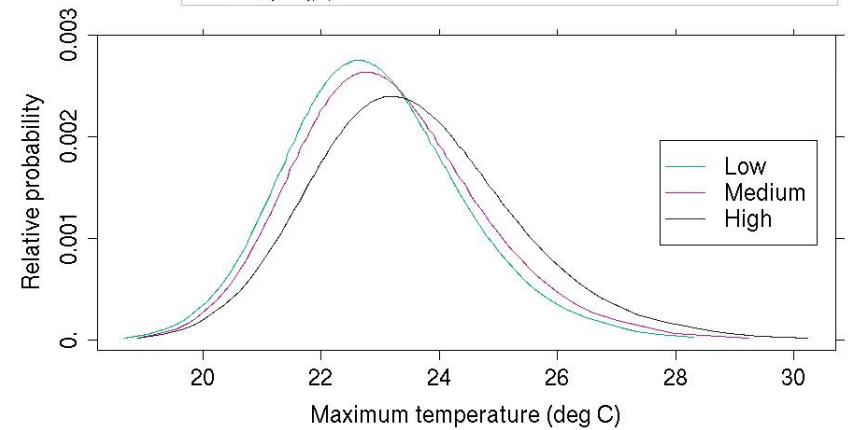
UKCP09 – Probabilistic projections



Plot Details:	
Time Period: 2040-2069	Data Source: Probabilistic Land
Emissions Scenario: Medium	Location: Grid Box No. 1477
Spatial Average: Grid Box 25km	Temporal Average: JJA
Variables: temp_dmean_tmean_abs	Future Absolute Climate: True
Probability Data Type: pdf	

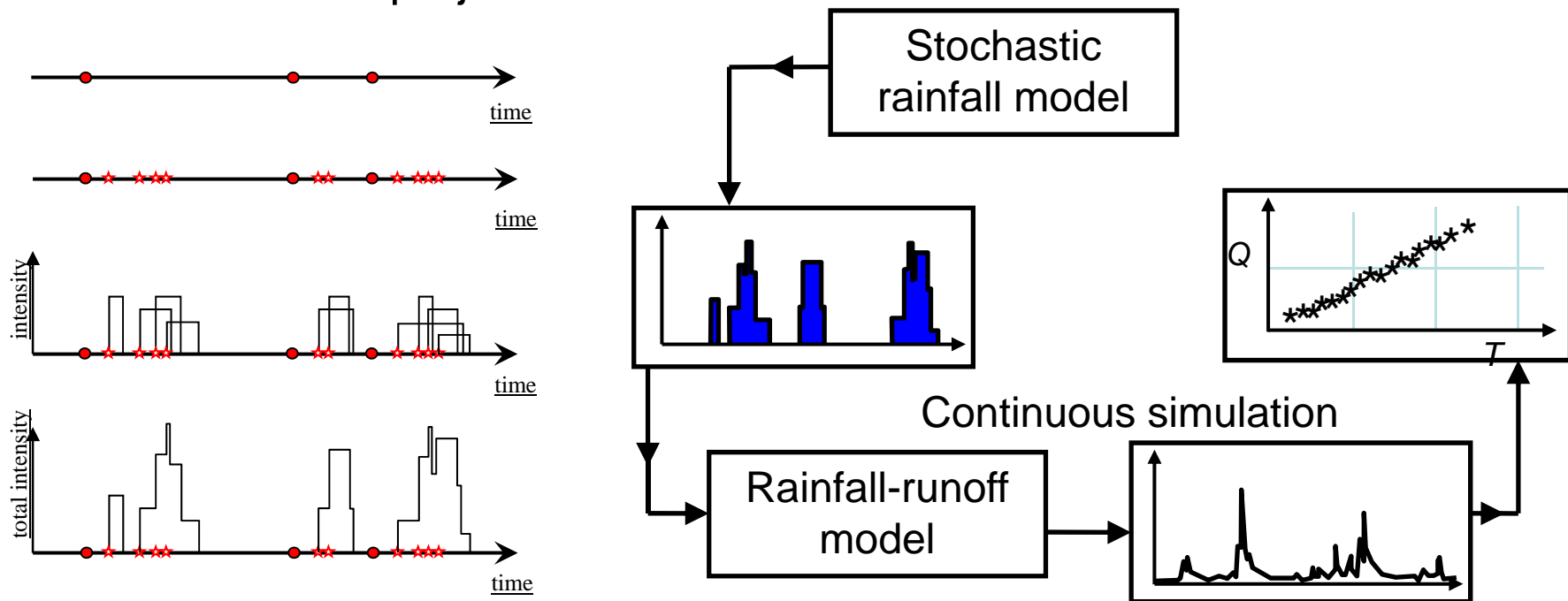


Plot Details:	
Time Period: 2040-2069	Data Source: Probabilistic Land
Emissions Scenario: Low, Medium, High	Location: Grid Box No. 1477
Spatial Average: Grid Box 25km	Temporal Average: JJA
Variables: temp_dmax_tmean_abs	Future Absolute Climate: True
Probability Data Type: pdf	



Using UKCP09: Weather Generator

- A tool to provide time series of weather variables for baseline and projected climate at daily time-scales that is consistent with the UKCP09 probabilistic climate projections.

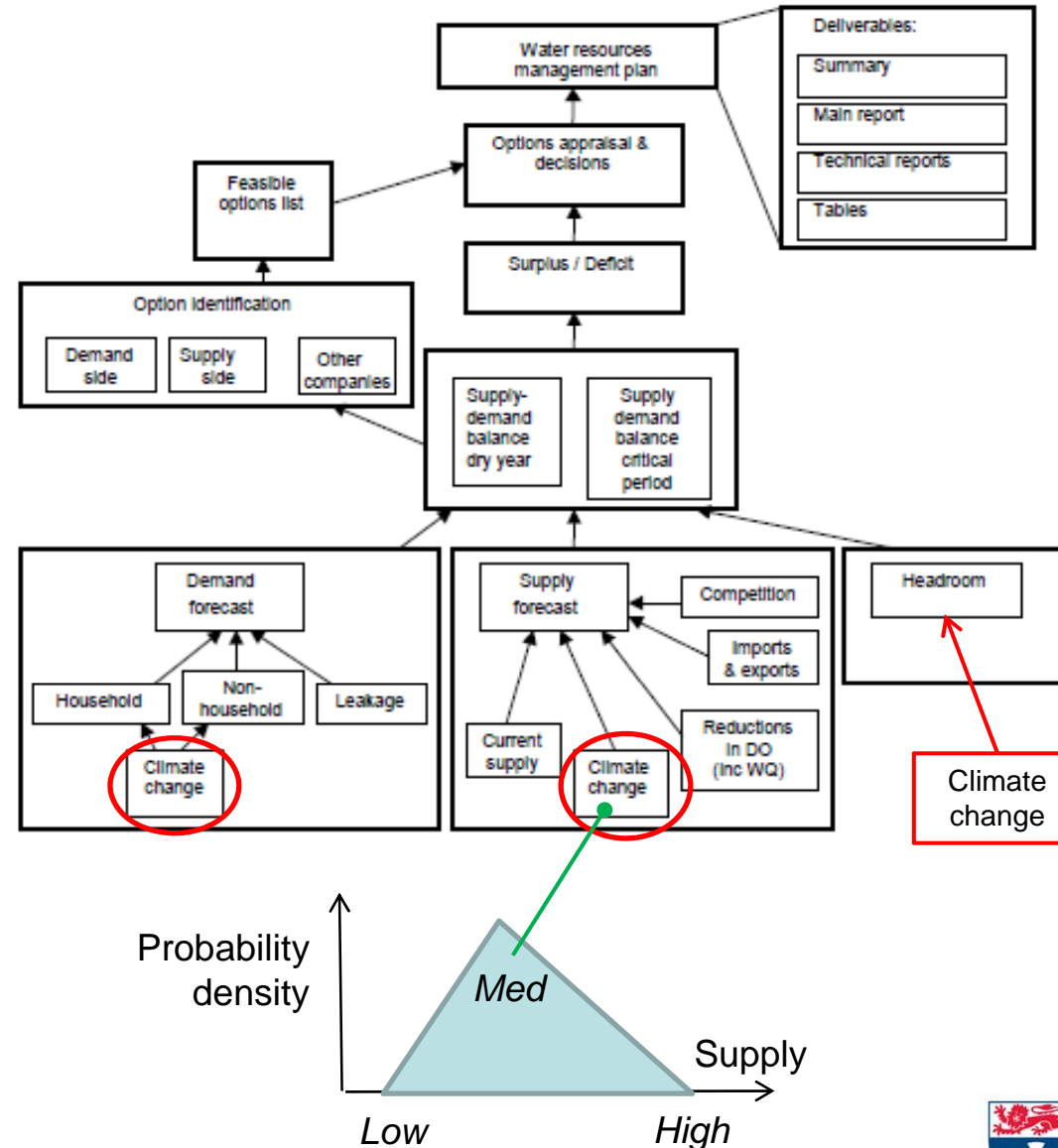




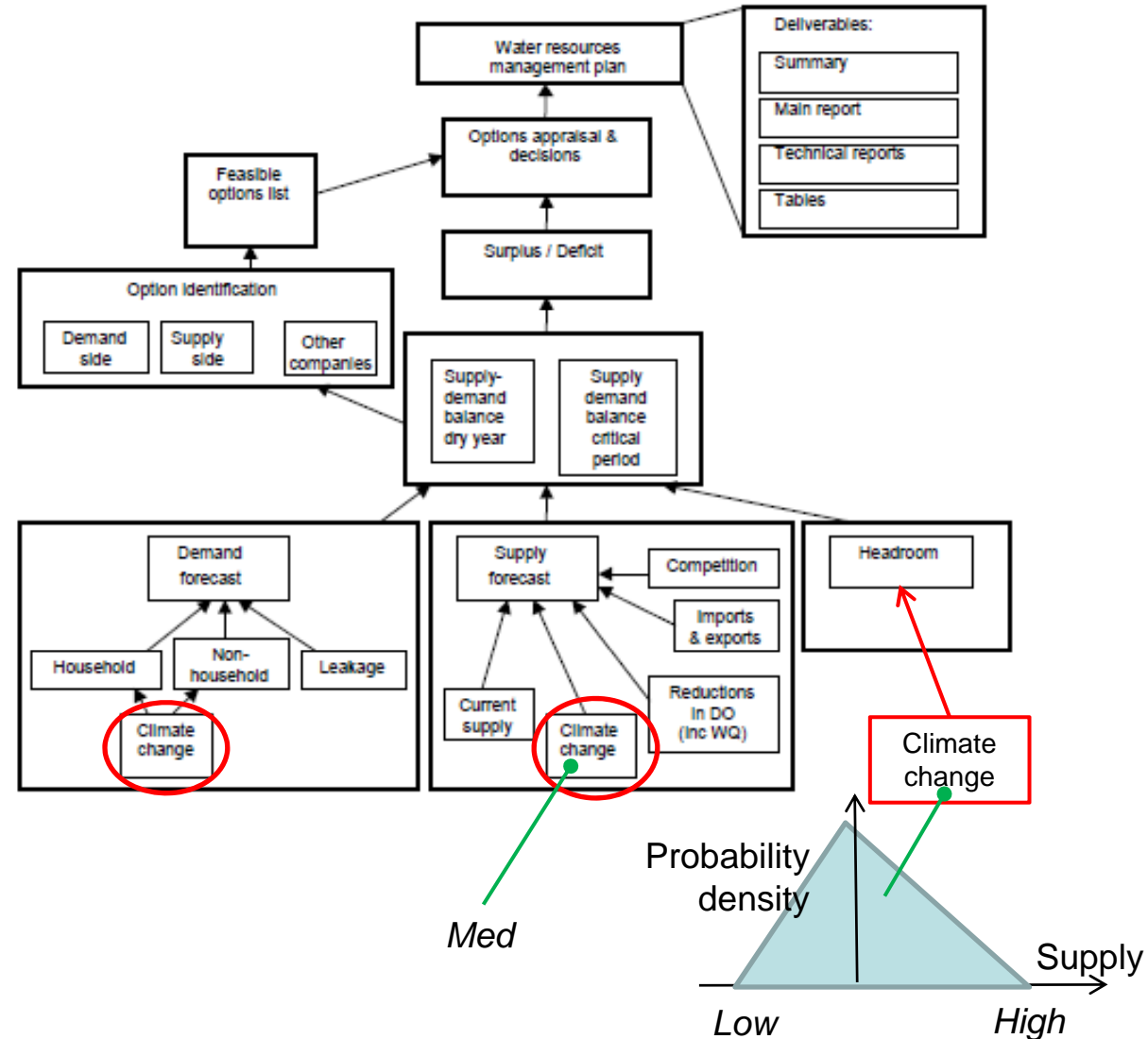
Using UKCP09: Water Resources Management Planning (WRMP)

- UKCP09 is a stimulus introduce better probabilistic treatment of uncertainties in WRMP
- The existing probabilistic headroom framework can be adapted to accommodate UKCP09 derived estimates of water supply and associated uncertainties
- There are significant deficiencies with this approach which should be dealt with before PR14

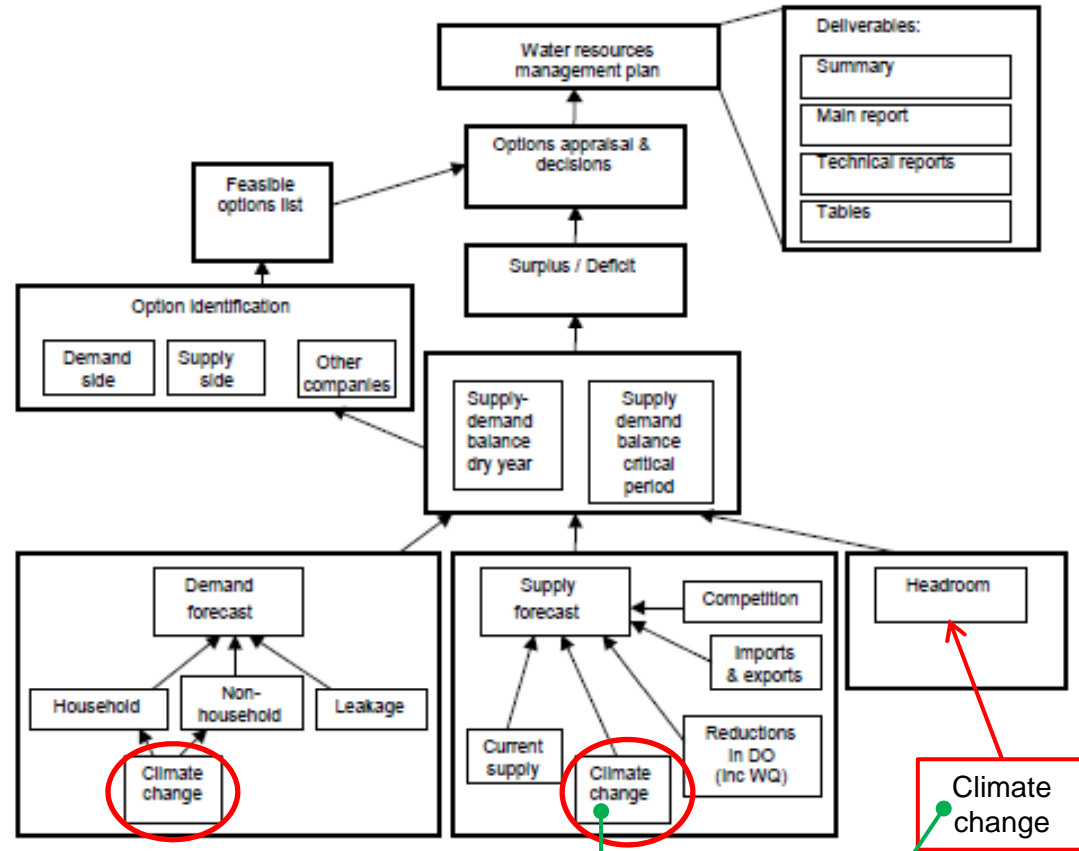
Using UKCP09 in WRMP – a quick fix



Using UKCP09 in WRMP – a quick fix



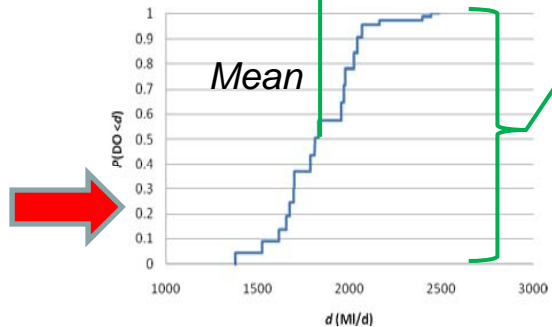
Using UKCP09 in WRMP – a quick fix



Simulated flow series from UKCP09 precip and PE



Water resource management system simulation





Limitations of the current headroom approach

- Uncertainty is separated from mean values
- Does not permit analysis of sequences of events and adaptive management
- The meaning of 'Level of Risk' is opaque

Towards a more coherent risk-based approach

1. Define physical metrics of the WRM system that trigger various actions that are of relevance to customers (e.g. hosepipe bans). We denote the events in which physical indicators are passed and the action is invoked as being L_i ; $i = 1, \dots, 4$ (corresponding to four target Levels of Service).
2. A set of sources of uncertainty are identified and quantified as probability distributions e.g. from UKCP09.
3. Appraisal of climate change should extend to 2050 and beyond, which the Environment Agency believes is necessary in order to consider the implications of climate change fully. Denote each year in this simulation period as t . $t = 2010, \dots, 2050$.

Towards a more coherent risk-based approach

4. Simulation of multiple transient (i.e. changing) futures is the most coherent approach to dealing with uncertainty. There are two sources of uncertainty that need to be sampled:

Natural variability, which is sampled by simulating multiple realisations of the same scenario, each one of which will yield a different sequence of events. Suppose there are m such simulations $j: j = 1, \dots, m$, of years $t = 2010, \dots, 2050$.

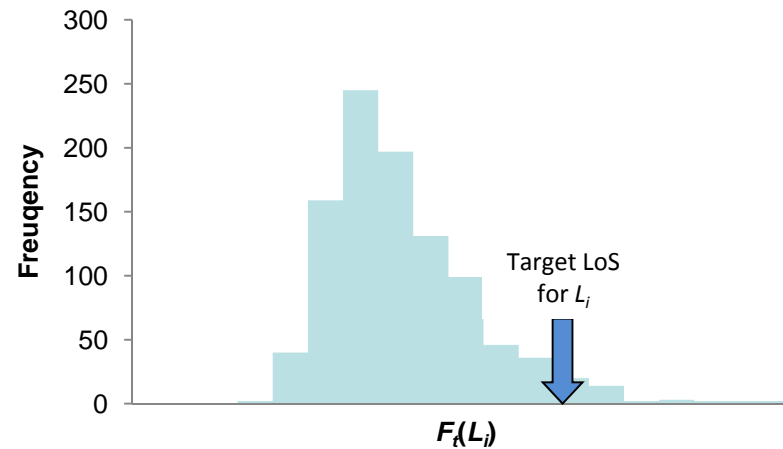
Epistemic uncertainty, which is dealt with by repeating the simulations in (i) for different samples of uncertain quantities (e.g. demand assumptions or climate change factors). These quantities are simulated from their full distributions i.e. mean values are not separated from uncertainties. Suppose there are n such simulations $k: k = 1, \dots, n$:

For any given k , it is possible to estimate the actual LoS in year t as follows:

$$F_{k,t}(L_t) \approx \frac{\text{\# simulations in which } L_t \text{ is activated in year } t}{m}$$

Towards a more coherent risk-based approach

Each k will yield a different value of this quantity, so it is then possible to construct a histogram of $F_{t,k}(L_i)$



The probability of not achieving a given LoS in year t is approximated as:

$$P_t(L_i) \approx \frac{\# \text{ simulations in which } F_{t,k}(L_i) \text{ is greater than the Target LoS}}{n}$$

$P_t(L_i)$ is a meaningful measure of risk as it relates to a quantity of direct relevance to customers.

Investment by the water utility is justified on the basis of reducing the probability of not meeting a LoS.



The Science Challenges

- Inter-annual variability and drought persistence
- Spatial correlation
- Uncertainties in demand
- Integrating objectives and assessment frameworks (e.g. WFD and WRMP) under long term uncertainties
- Tolerable probability of violating a given LoS; how much it is justifiable to spend on reducing this probability?



Review

1. The role of government in adapting to climate change
2. The Adaptation Sub-Committee
3. Climate change risks assessment
4. Risk-based water resources management planning