General principles and different approaches to uncertainties in climate change adaptation

Dr Suraje Dessai

1 – School of Geography, University of Exeter, Exeter, UK

2 – Tyndall Centre for Climate Change Research, UK

s.dessai@exeter.ac.uk

Acknowledgements: Dr. Jeroen van der Sluijs, Copernicus Institute for Sustainable Development and Innovation
Utrecht University

Europe Adapts to Climate Change
Science-policy interactions in national adaptation policy
14-15 September 2009, Utrecht, the Netherlands

What is adaptation to climate change?

- An adjustment in ecological, social, or economic systems in response to observed or expected climatic stimuli and their effects or impacts (IPCC, 2001)
- Complex societal process of activities, actions, decisions and attitudes that reflect existing social norms and processes
- Adaptation to climate change does not happen in isolation – multiple actors and multiple stresses and stimuli
- What is successful adaptation?

Why does uncertainty come into play?

- Only partial knowledge of the future available
- Uncertain rate and magnitude of climate change
- Potential for non-linear changes (e.g., THC collapse)
- Long time horizons

Attitudes to risk and uncertainty

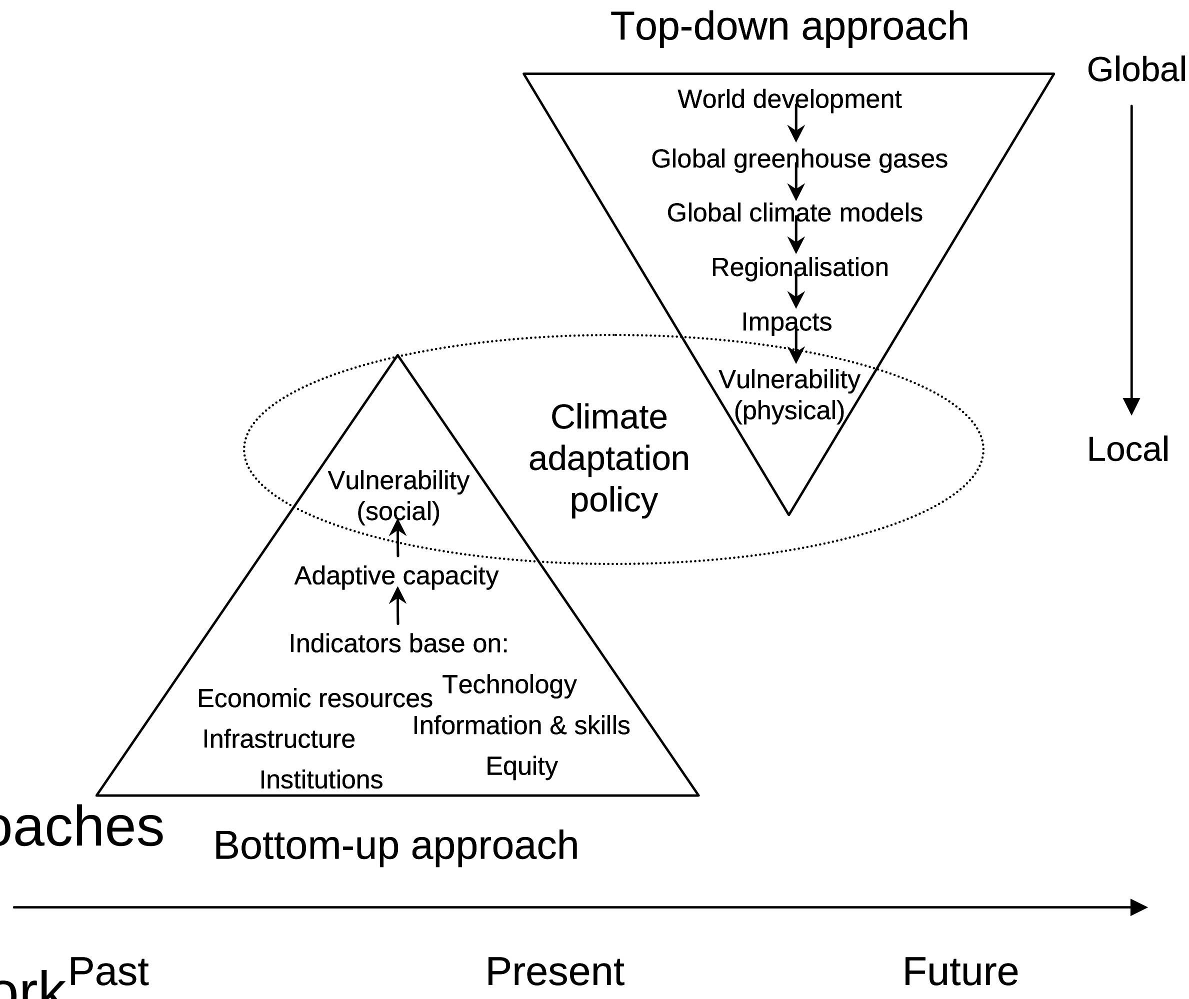
Risk = Probability x Consequence

Acceptability of risk is a function of many attributes. Risk is more than a number

- Severity and Nature of Consequences
- Cultural Orientations (there is no single ‘public’)
- Social Amplification Effects
- Trust in Risk Managers / Science

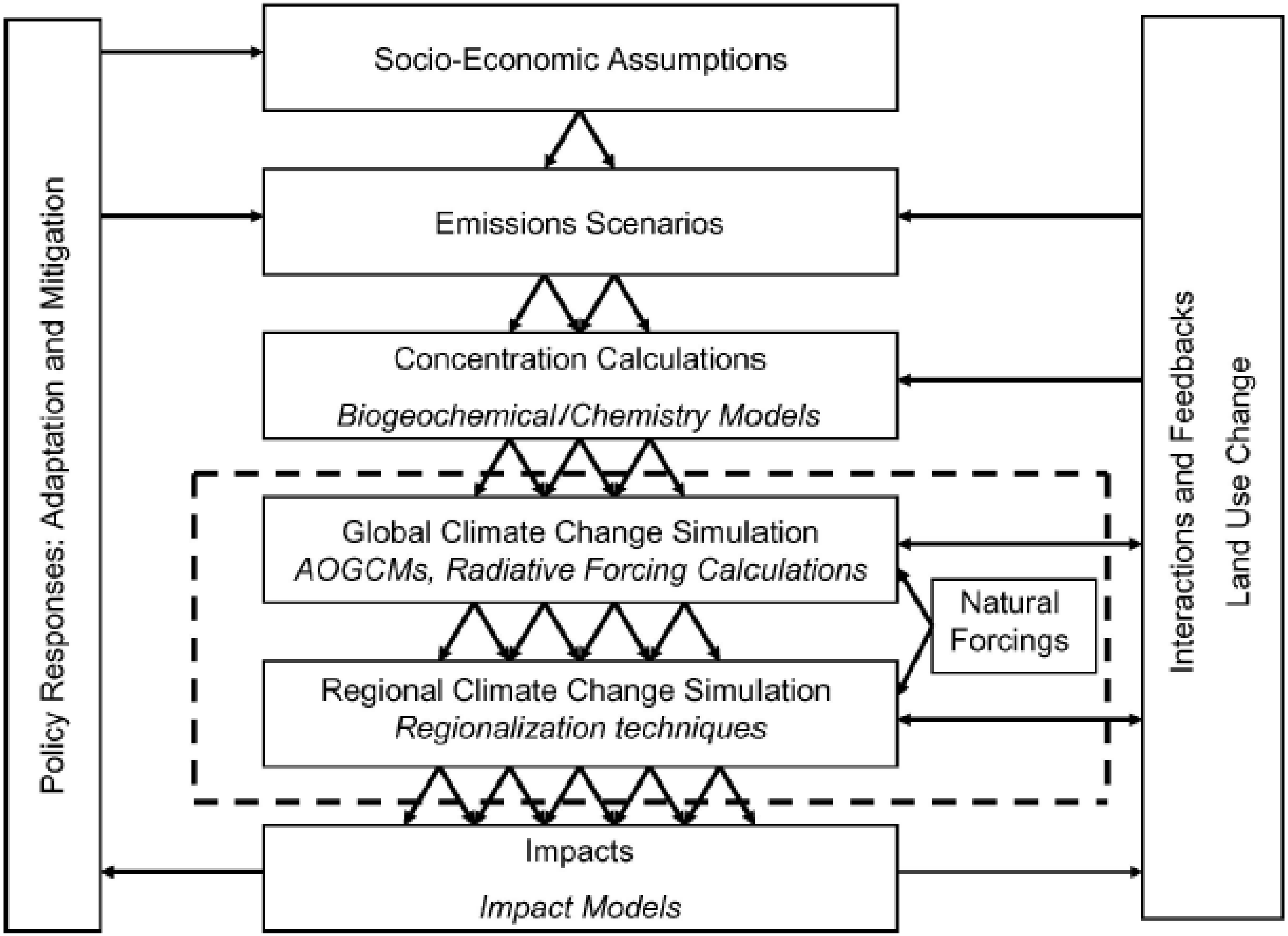
Decision-making frameworks

- Top down approaches
  - Prevention Principle
  - IPCC approach
  - Risk approaches
- Bottom up approaches
  - Precautionary Principle
  - Engineering safety margin
  - Anticipating design
  - Resilience
  - Adaptive management
  - Human development approaches
- Mixed approaches
  - Adaptation Policy Framework
  - Robust decision making



UNIVERSITY OF EXETER

Cascade of uncertainties in climate change prediction



(from Giorgi 2005)

Methods and tools of uncertainty management

- Scenario analysis ("surprise-free")
- Expert elicitation
- Sensitivity analysis
- Monte Carlo
- Probabilistic multi model ensemble
- Bayesian methods
- NUSAP / Pedigree analysis
- Fuzzy sets / imprecise probabilities
- Stakeholder involvement
- Quality Assurance / Quality Checklists
- Extended peer review (review by stakeholders)
- Wild cards / surprise scenarios

Scenario analysis

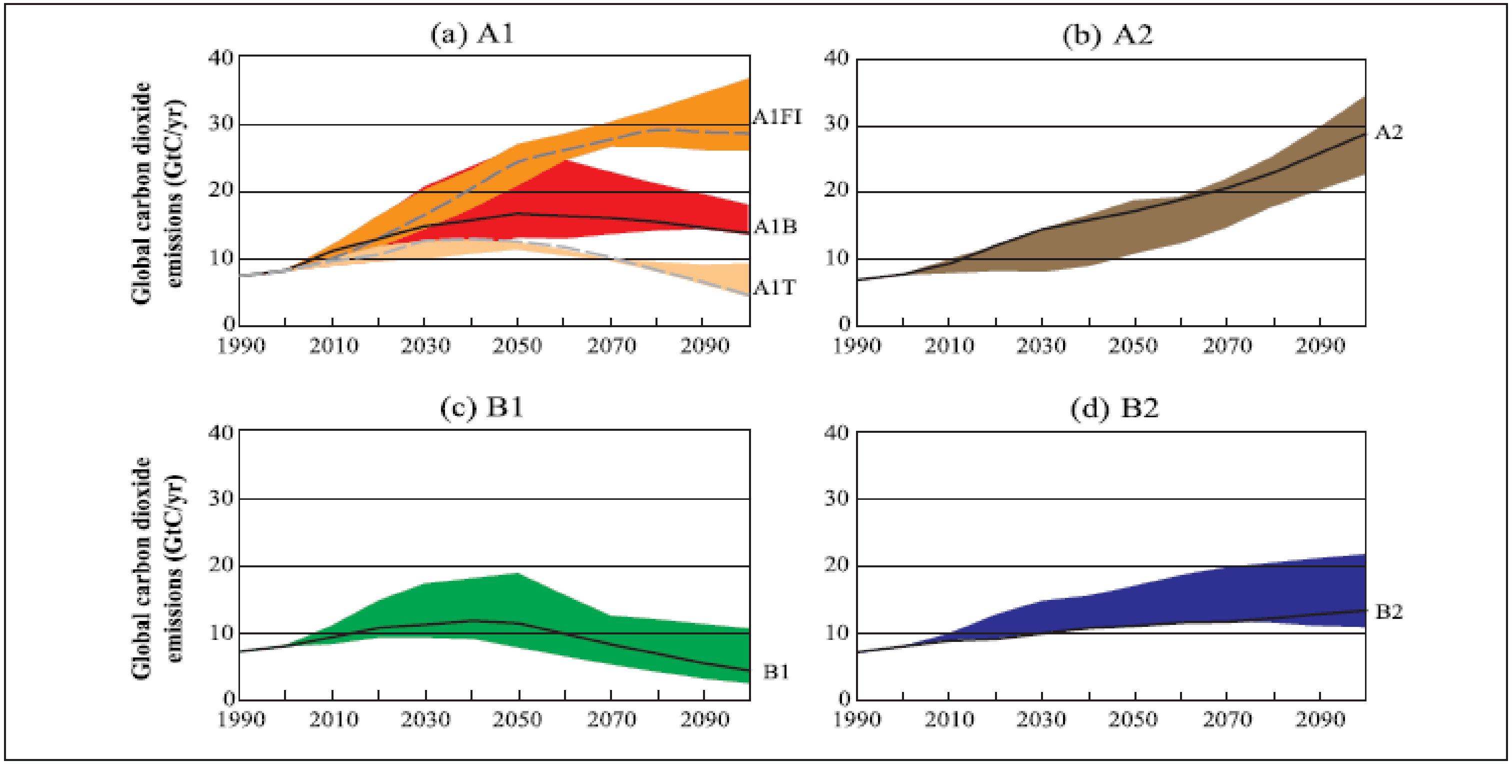


Figure 3: Total global annual CO_2 emissions from all sources (energy, industry, and land-use change) from 1990 to 2100 (in gigatonnes of carbon (GtC/yr)) for the families and six scenario groups. The 40 SRES scenarios are presented by the four families (A1, A2, B1, and B2) and six scenario groups: the fossil-intensive A1FI (comprising the high-coal and high-oil-and-gas scenarios), the predominantly non-fossil fuel A1T, the balanced A1B in Figure 3a; A2 in Figure 3b; B1 in Figure 3c, and B2 in Figure 3d. Each colored emission band shows the range of harmonized and non-harmonized scenarios within each group. For each of the six scenario groups an illustrative scenario is provided, including the four illustrative marker scenarios (A1, A2, B1, B2, solid lines) and two illustrative scenarios for A1FI and A1T (dashed lines).

UNIVERSITY OF EXETER

Nakicenovic et al. 2000. Emissions Scenarios. A Special Report of Working Group III of the Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge.

Expert elicitation

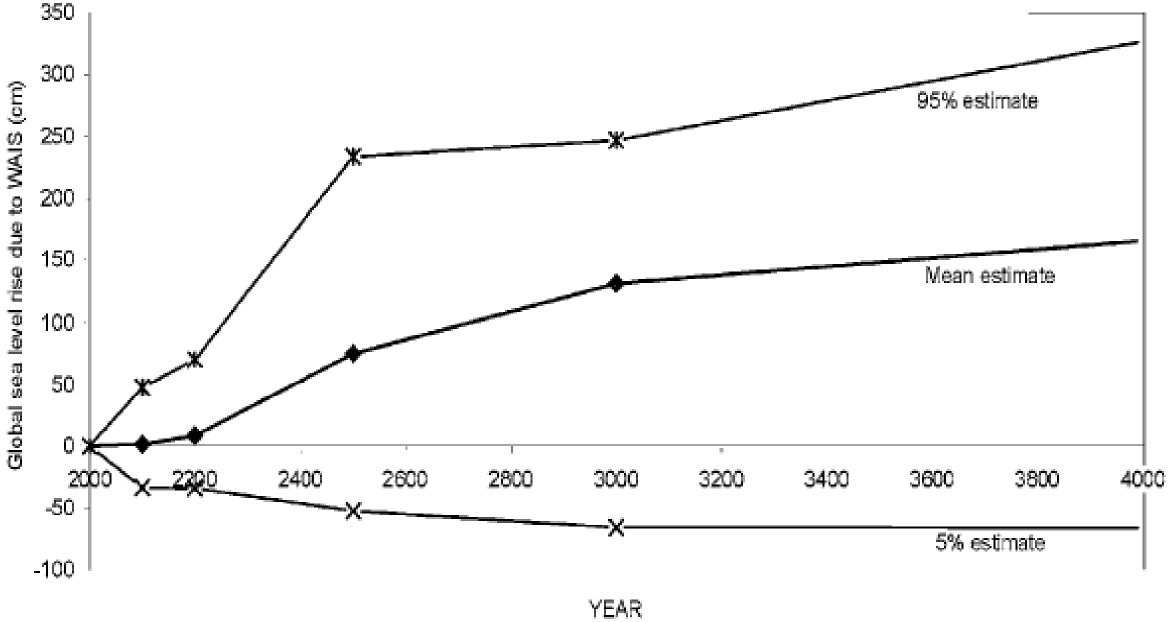


Figure 7. The combined predictions of the likely contribution to sea level rise from the WAIS. The upper and lower bounds bracket the 90% confidence estimate.

quantified estimate is shown and the spread indicates the level of agreement across the panel.

Vaughan, D. G., and J. R. Spouge. 2002. Risk estimation of collapse of the West Antarctic Ice Sheet. Climatic Change 52:65-91.

Sensitivity analysis

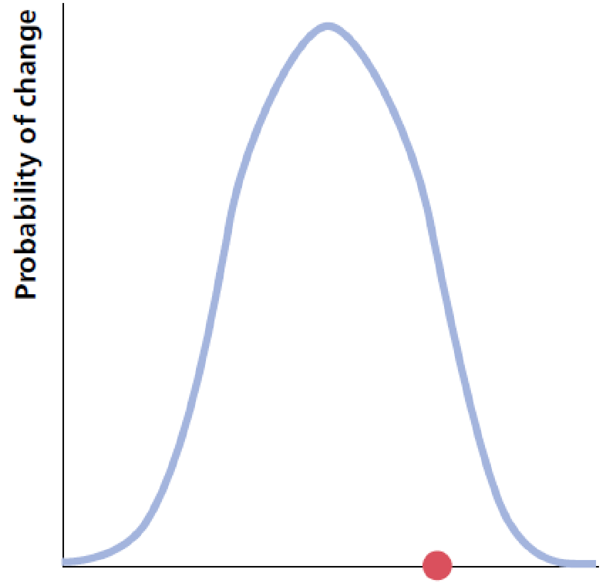
Parameter	East Suffolk & Essex WRZ	
	Uncertainty range (Ml/d)	**AWS shortfall (Ml/d)**
GHG emissions scenario	5.55	7.35
Climate sensitivity	8.27	9.39
Aerosol forcing	7.53	5.63
Ocean diffusivity	2.69	3.74
Carbon cycle	2.91	4.01
Regional climate response GCMs (RCMs)	22.66 (14.88)	7.28 (9.10)
Climate impacts	8.28	6.06

UNIVERSITY OF EXETER

Dessai, S. and M. Hulme (2007) Assessing the robustness of adaptation decisions to climate change uncertainties: A case study on water resources management in the East of England. *Global Environmental Change*, **17**, 59-72.

Probabilistic multi model ensemble & Bayesian methods

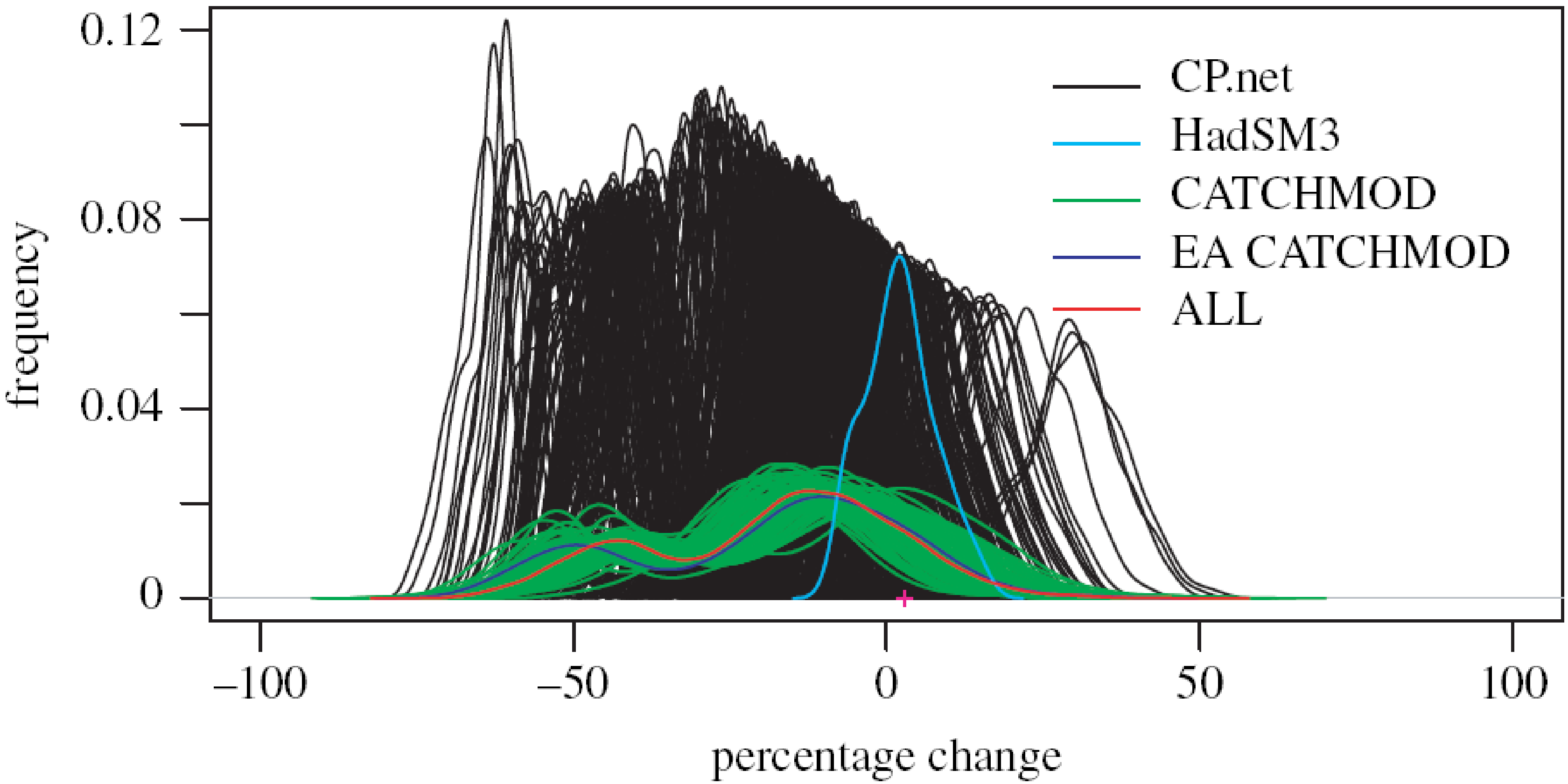
Figure 5: A schematic diagram showing the progression from UKCIP02 to UKCP09, using temperature as an example. The single estimate of change in temperature from UKCIP02 (left, for a given emissions scenario, location, time period, etc.) gives no information about uncertainty. A range of changes in temperature from different climate models (centre) gives no information about which model to use, and only partly reflects uncertainties. The PDF given in UKCP09 (right) shows the probability of different outcomes, that is, different amounts of change in temperature.



Change in temperature	Change in temperature	Change in temperature
UKCIP02 gave a single estimate of change in temperature	Using many models would give a range of different changes in temperature, but no information on which to use	UKCP09 gives the probability of different amounts of change in temperature

UNIVERSITY OF EXETER

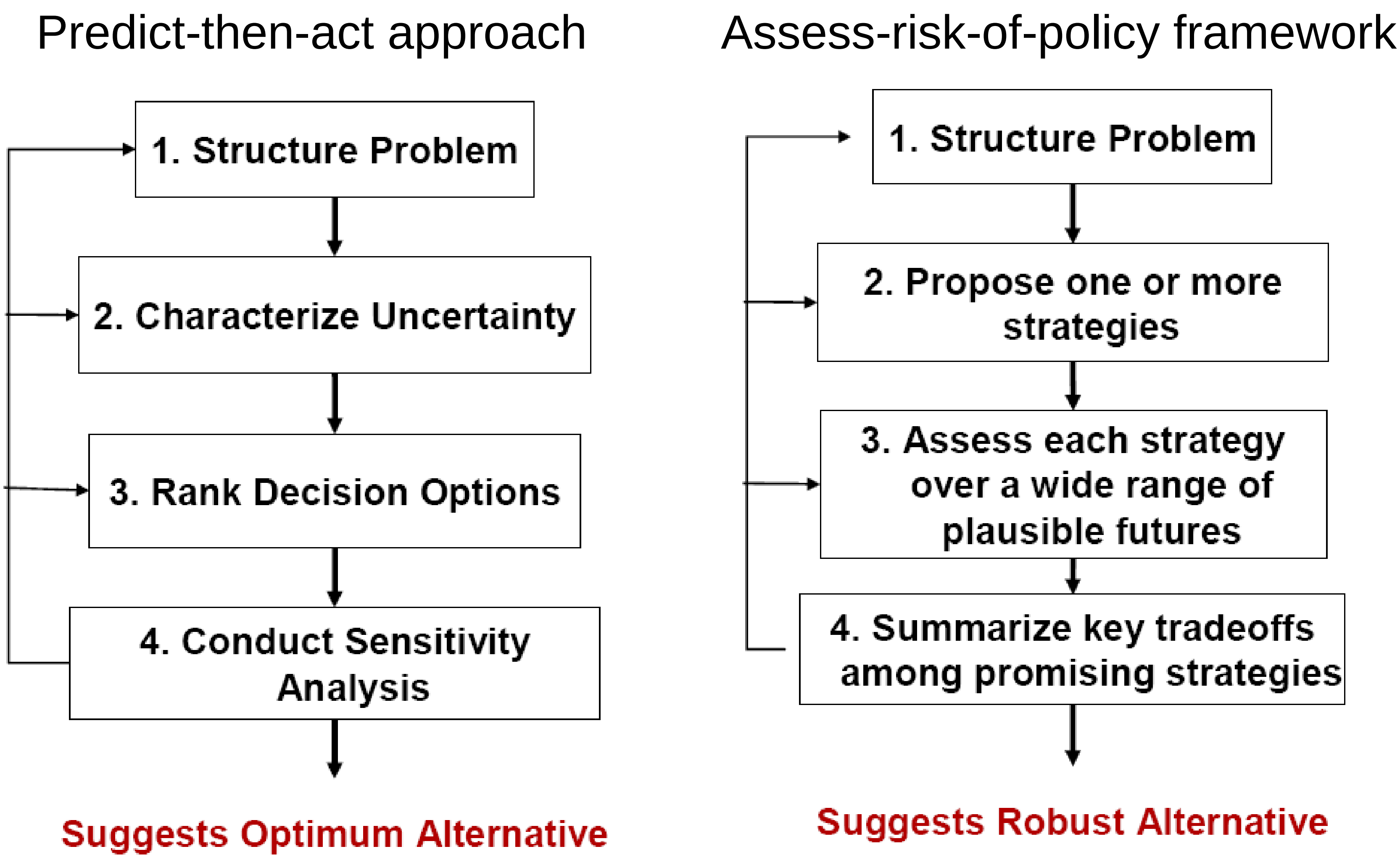
Probabilistic climate change impact assessment



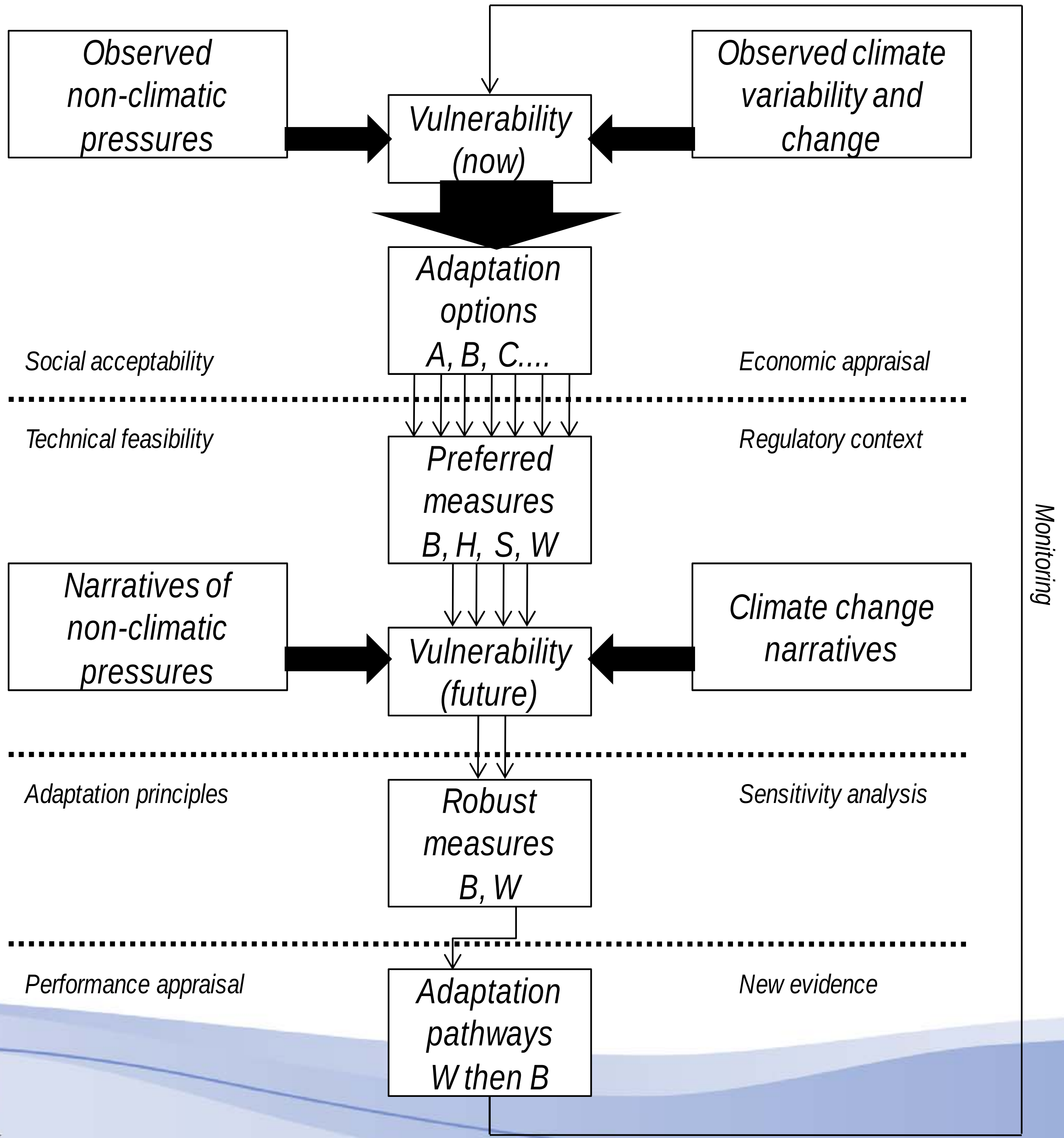
Changes in CATCHMOD simulated Q50 when uncertainties in CATCHMOD parameters are combined with the climateprediction.net ensemble

New, M. et al. (2007) Challenges in using probabilistic climate change information for impact assessments: an example from the water sector. *Philosophical Transactions of the Royal Society A*, **365**, 2117-2131

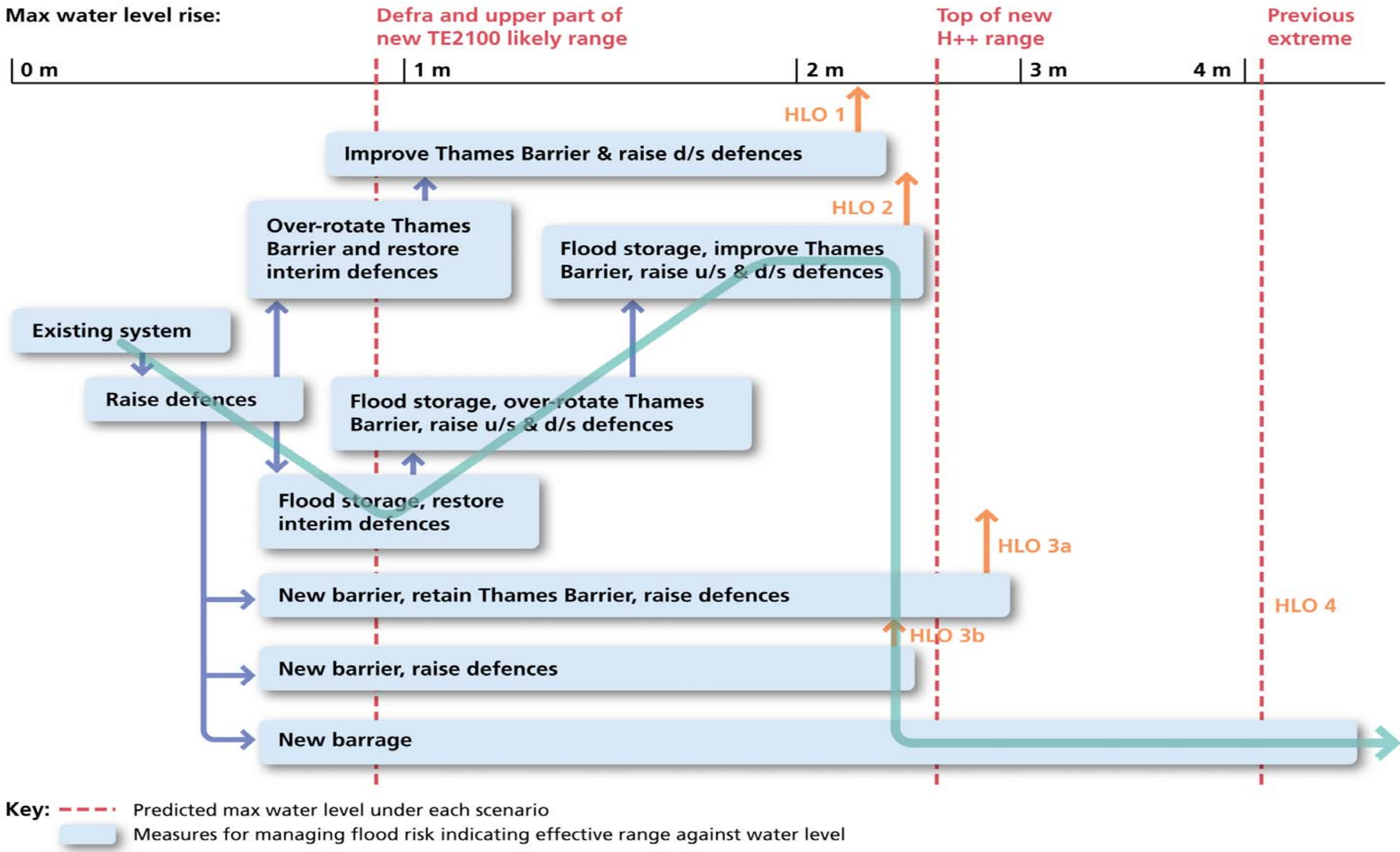
Robust decision-making



UNIVERSITY OF EXETER



From Wilby and Dessai (submitted)


Max water level rise:
Defra and upper part of new TE2100 likely range
Top of new H++ range
Previous extreme
0 m
1 m
2 m
3 m
4 m
HLO 1
Improve Thames Barrier & raise d/s defences
HLO 2
Over-rotate Thames Barrier and restore interim defences
Flood storage, improve Thames Barrier, raise u/s & d/s defences
Existing system
Raise defences
Flood storage, over-rotate Thames Barrier, raise u/s & d/s defences
Flood storage, restore interim defences
HLO 3a
New barrier, retain Thames Barrier, raise defences
HLO 4
HLO 3b
New barrier, raise defences
New barrage
Key:
Predicted max water level under each scenario
Measures for managing flood risk indicating effective range against water level

Synthesis

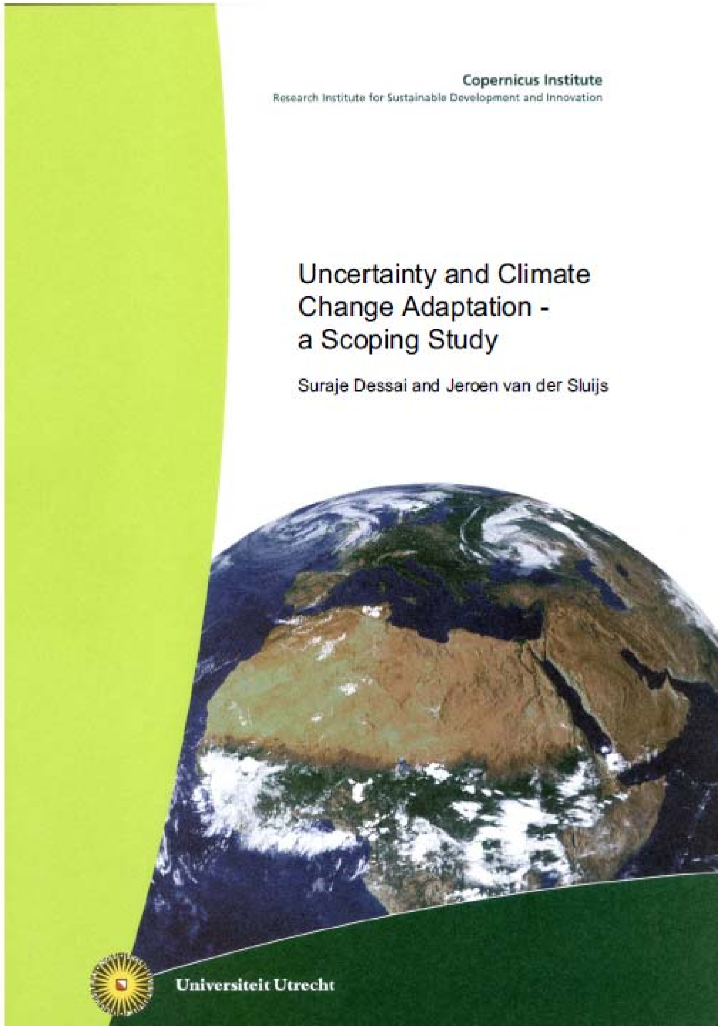
Uncertainty assessment methods / Frameworks for decision making under uncertainty	Scenario analysis ("surprise-free")	Expert elicitation	Sensitivity analysis	Monte Carlo	Probabilistic multi model ensemble	Bayesian methods	NUSAP / Pedigree analysis	Fuzzy sets / imprecise	Stakeholder involvement	Quality Assurance / Quality Checklists	Extended peer review (review by	Wild cards / surprise scenarios
IPCC approach	key	c	c	c	c	c	c	c	c	c	c	mm
Risk approaches	key	c	c	key	key	key	c	c	c	c	c	mm
Engineering safety margin	c	key	c	c	c	c	c	c	c	c	c	mm
Anticipating design	c	key	c	c	c	c	c	c	c	c	c	key
Resilience	key	c	key	c	c	c	c	c	key	c	c	key
Adaptive management	c	c	c	c	c	c	c	c	key	c	c	mm
Prevention Principle	c	c	c	key	key	c	c	c	c	c	c	mm
Precautionary Principle	c	c	c	c	c	mm	key		key	key	key	key
Human development approaches	c	c	c	c	c	c	c	c	key	c	c	c
Adaptation Policy Framework	key	c	c	c	c	c	c	c	key	c	c	key
Robust decision making	key	c	key	c	c	c	c	c	c	c	c	c

Concluding remarks

- No ‘silver bullet’ to the problem of uncertainty and adaptation to climate change
- Adaptation is very context dependent
- Need more case studies to test different approaches and see what works
- Statistical uncertainties – top-down/prediction
- Ignorance – bottom-up/resilience/robustness
- The synthesis matrix provides some preliminary guidance for analysts

UNIVERSITY OF EXETER

S. Dessai and J.P. van der Sluijs, 2007, Uncertainty and Climate Change Adaptation - a Scoping Study, report NWS-E-2007-198, Department of Science Technology and Society, Copernicus Institute, Utrecht University. 95 pp



s.dessai@exeter.ac.uk

http://www.nusap.net/download.php?op=getit&lid=45