Methods for Decision Making Under Climate Change Uncertainty

HR Wallingford

Tom Roach, Zoran Kapelan, Michelle Woodward, Ben Gouldby

stream

Introduction

This EngD research project is being carried out in collaboration with HR Wallingford and as part of the STREAM IDC programme. It aims to identify the most suitable decision methods for handling uncertainties relating to climate change when developing water related climate change adaptation strategies, such as those within Integrated Water Resource Management (IWRM) and Flood Risk Management (FRM). Methods that are currently being promulgated for use in this area include; Info-gap decision theory, Minimax regret, Real Options analysis, Wald's Maximin theory, Robust Decision Methods, Laplace theory and Robust Optimisation techniques.

Research Challenge

Climate change adaptation is an increasingly important market sector for HR Wallingford. They have undertaken many consultancy studies relating to providing advice on climate change adaptation and recently have led the UK's first climate change risk assessment (CCRA). With experience gained on these projects it has become increasingly apparent that, there is currently no clear guidance on which decision making methods are most appropriate for these types of problems. This research will result in a new knowledge providing answers to the questions:

- Do all of the methods produce the same outcomes in terms of most appropriate adaptation strategies?
- How do the different likelihood assumptions influence the outcomes?
- Do some of the methods produce demonstrably superior results than the others?
- Are some methods more suited to handling climate change related uncertainties than others?
- How do these uncertainties interact with the epistemic uncertainties that influence the decision making process?

Methodology

The main project tasks are as follows:

1) Critical review of the range of potential methods available.
2) Development of generic software system to implement the range of decision methods.
3) Development of pilot site systems models. These will be based upon existing regional scale models where data is already held by HR Wallingford and Exeter University.
4) Application of different decision making methods to pilot water engineering problems/sites.
5) Compare the performance of the different approaches.
6) Development of recommendations for the selection of a suitable method for decision making under uncertainty given the climate change adaptation problem.

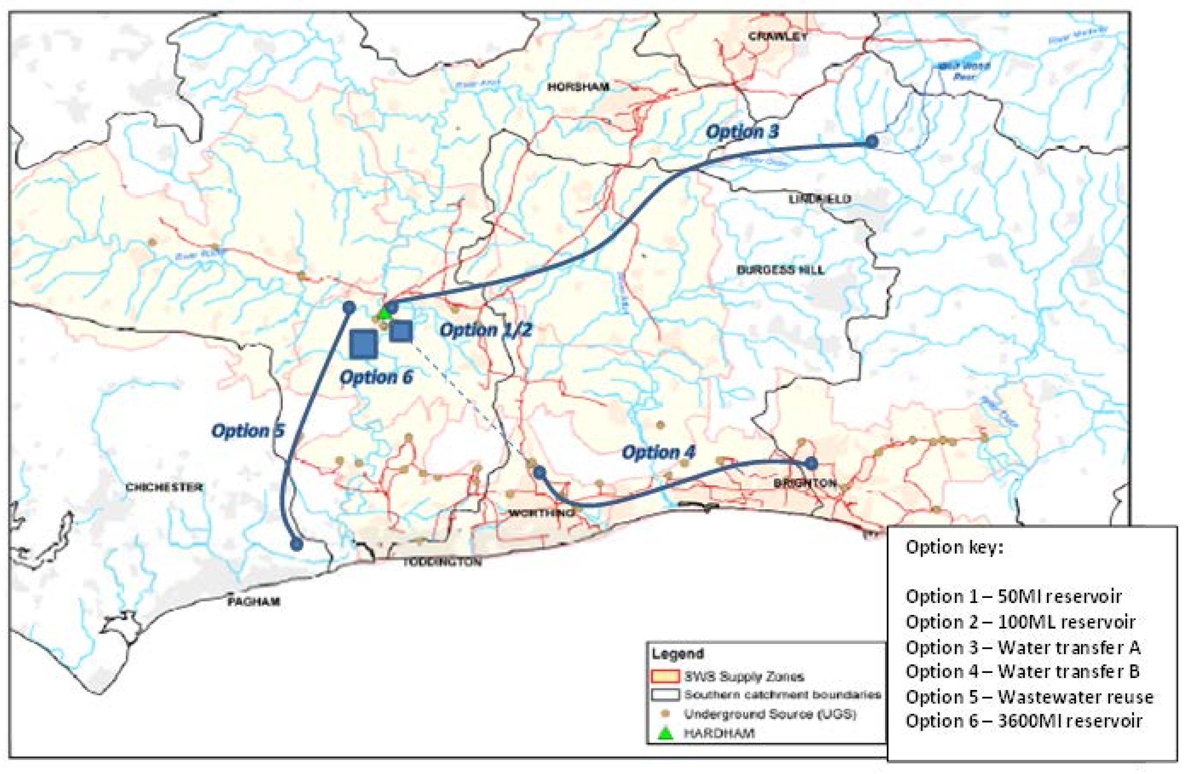

Figure 1. Case study option map for Sussex North water resource zone

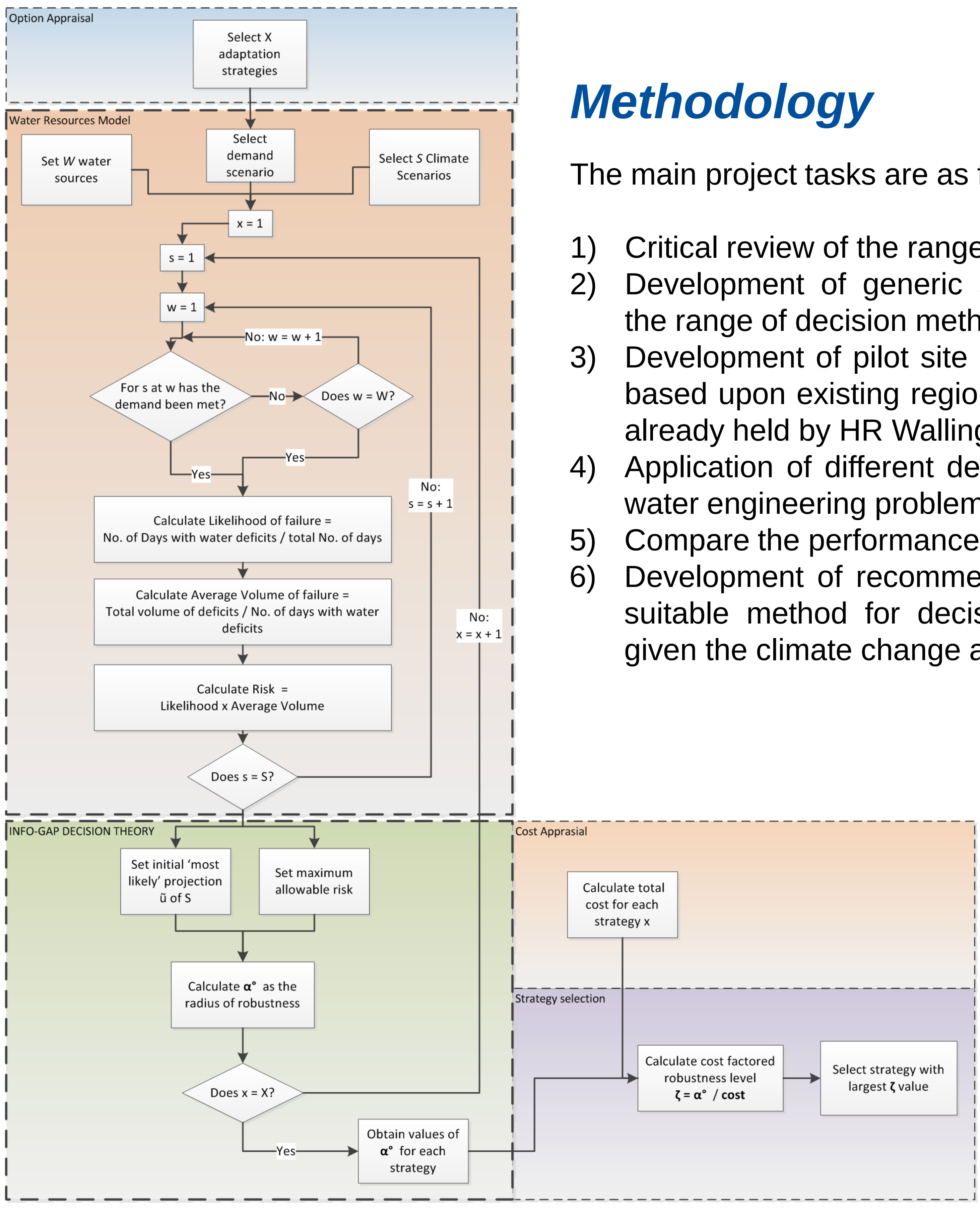

Figure 2. Flow chart of water resource case study model with Info-gap decision theory operation

Initial Work

<u>The Case Study</u> – A case study has been selected for initial trialling of the decision methods. The problem /site chosen is a follows:

- Southern Water is theoretically optioneering for new water resource assets to build in the Sussex North region to secure water supplies for an uncertain future climate.
- Several water resource options have been identified for construction in the region (figure 1), combinations of which form adaptation strategies.
- Numerous climate scenarios are simulated in the region.
- Decision methods will then assess and select the optimal strategy.

<u>Info-Gap</u> – Infogap theory is the first method selected for assessment. Figure 2, displays a flow chart of the water resource system model created and the operation of the Info-gap decision theory.

Info-gap operates by calculating a 'stability radius' out from an initial 'best estimate' of the parameter under uncertainty (figure 3). In the case of this study; climate change scenarios form the field of uncertainty and a 'best estimate' climate scenario is initially selected. The Info-gap model then assess the failure or stability of the water system for each adaptation strategy under this selected scenario and then over staged scenario increases away from this initial point. The strategy with the largest stable system radius is described by info-gap as being the most robust to uncertainty.

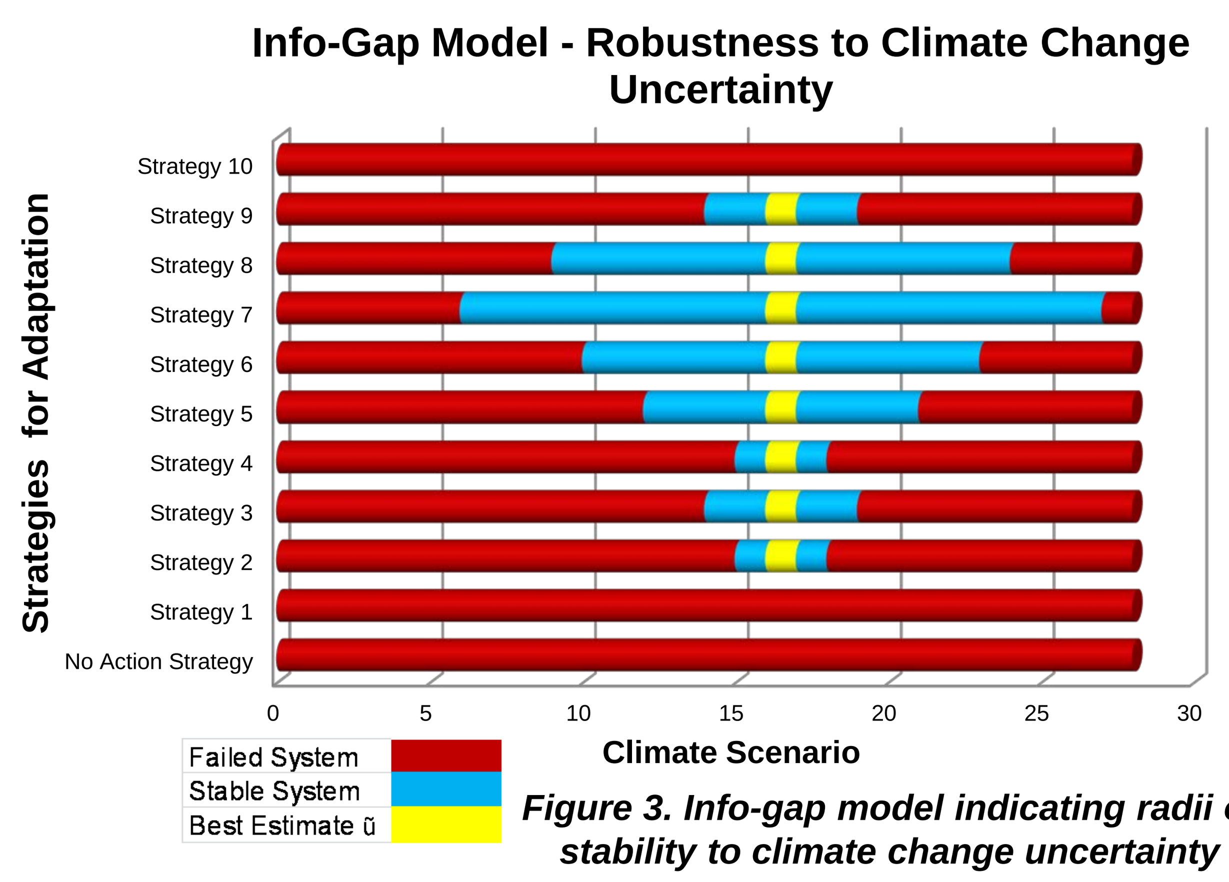

Figure 3. Info-gap model indicating radii of stability to climate change uncertainty

<u>Minimax Regret</u> – Regret methodologies are also being trialled on the case study in order to make a comparison of the methods under review.

Figure 4, illustrates two cost regret graphs for theoretical adaptation strategies X and Y. Cost regrets are formed over the radials of all projected climate scenarios under the regret calculations that a) money has been spent on an adaption strategy that was not required or b) money should have been spent to avoid a failed system. As a line gets closer to the centre point it indicates an increasing cost regret in relation to alternative strategies available. This allows comparison of worse-case cost regrets (Minimax regret) or valuation of the pathway of a strategy over the full field of uncertainty (Laplace regret).

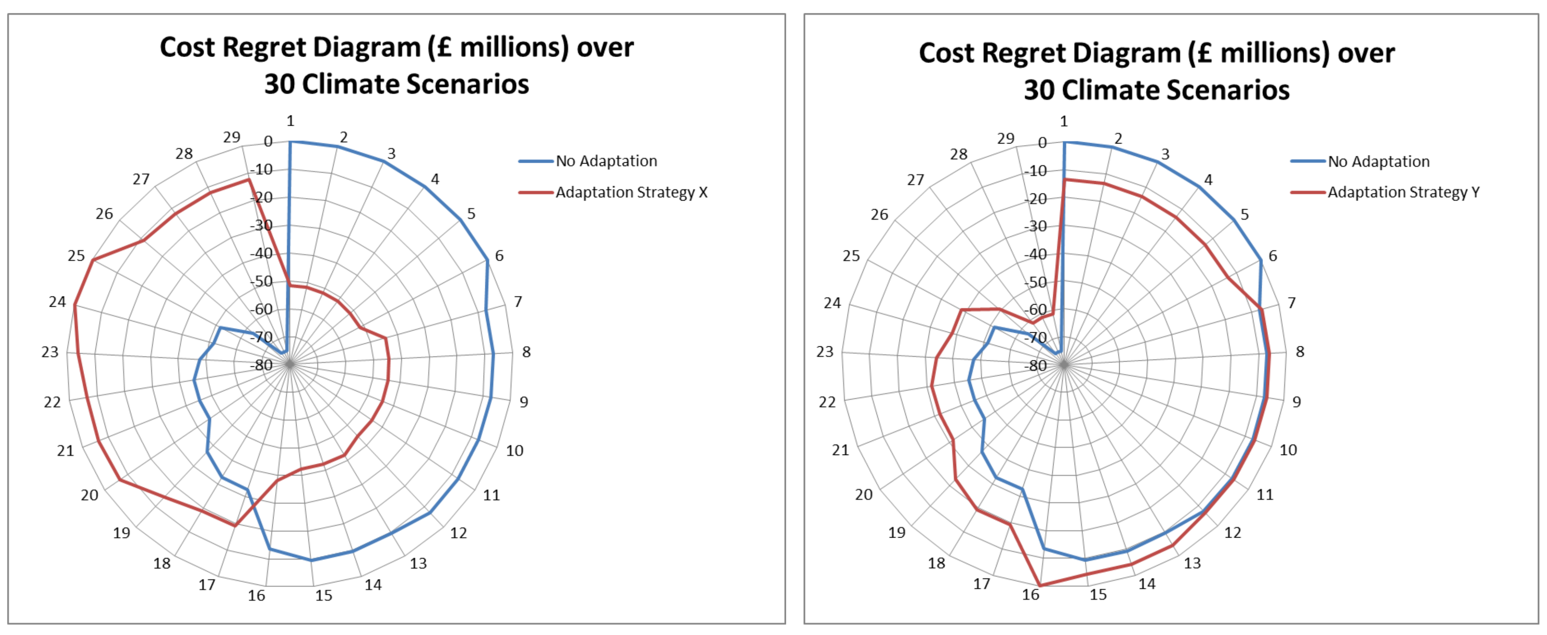

Figure 4. Cost regret diagrams indicating regret pathways within the field of uncertainty

<u>Results</u>

In early comparison work we find that a Minimax regret approach leads to a more stringent and robust adaptation solution as it seeks to minimise the worst-case scenarios of climate change. The Info-gap and Laplace regret method instead isolate cost effective robustness over a greater range of uncertainty as the ideal decision solution. They do not isolate the worse case scenarios but identify the best options to cover the greatest percentage of probable scenarios.

As 'severe' uncertainty can often seem boundless it may be logical to cultivate a robustness that covers a greater range of more extreme climate projections then one that merely meets the need of a most severe worse case situation that may be overly pessimistic.

For further info please contact Prof: Zoran Kapelan (z.kapelan@exeter.ac.uk or 01392 724054)

UNIVERSITY OF EXETER

College of Engineering, Mathematics and Physical Sciences