View metadata, citation and similar papers at core.ac.uk

brought to you by CORE

provided by Open Research Exeter

The use of Real Options and Multi-Objective Optimisation in Flood Risk Management

Submitted by

Michelle Woodward

to the University of Exeter as a Thesis for the degree of

Doctor of Philosophy in Engineering

April 2012

This thesis is available for Library use on the understanding that it is copyright material and that no quotation from the thesis may be published without proper acknowledgement.

I certify that all material in this thesis which is not my own work has been identified and that no material has previously been submitted and approved for the award of a degree by this or any other university.

…….

Abstract

The development of suitable long term flood risk intervention strategies is a challenge. Climate change alone is a significant complication but in addition complexities exist trying to identify the most appropriate set of interventions, the area with the highest economical benefit and the most opportune time for implementation. All of these elements pose difficulties to decision makers. Recently, there has been a shift in the current practice for appraising potential strategies and consideration is now being given to ensure flexible, adaptive strategies to account for the uncertain climatic conditions. Real Options in particular is becoming an acknowledged approach to account for the future uncertainties inherent in a flood risk investment decision.

Real Options facilitates adaptive strategies as it enables the value of flexibility to be explicitly included within the decision making process. Opportunities are provided for the decision maker to modify and update investments when knowledge of the future state comes to light. In this thesis the use of Real Options in flood risk management is investigated as a method to account for the uncertainties of climate change.

In addition to Real Options, this thesis also explores the use of optimisation techniques to aid the decision making process when identifying the most appropriate long term intervention strategies. Methods are required which can search for the most optimal solutions whilst accounting for a range of performance metrics. Single and multi-objective genetic algorithms are therefore investigated in this thesis.

The Real Options concepts are combined with a multi-objective optimisation algorithm to create a decision support methodology which is capable of searching for the most appropriate long term economical yet robust intervention strategies which are flexible to future change. A state of the art flood risk analysis model is employed to evaluate the risk associated to each strategy.

The methodology is applied to a section of the Thames Estuary as a case study to demonstrate the techniques above. The results show the inclusion of flexibility is advantageous while the outputs provide decision makers with supplementary knowledge which previously has not been considered.

Acknowledgements

I would first like to thank my academic supervisor Zoran Kapelan and my industrial supervisor Ben Gouldby for their help and guidance throughout my PhD. I am very grateful for their commitment, continuous support and encouragement.

I would also like to acknowledge colleagues at HR Wallingford for their technical assistance and support. I would like to thank in particular the members of the floods group who have welcomed me into their team and provided help and advice on many occasions.

In addition, I am grateful to members of staff at the University of Exeter, in particular the Research and Knowledge Transfer team and the Centre for Water Systems.

I express my gratitude to the Knowledge Transfer Partnership (KTP) scheme that made this PhD possible. I also acknowledge the Flood Risk Management Research Consortium (FRMRC) for their financial assistance to undertake this research

Finally, I would like to thank Ralph. His love, support and encouragement as well as the occasional technical assistance he has given me has been invaluable.

Table of Contents