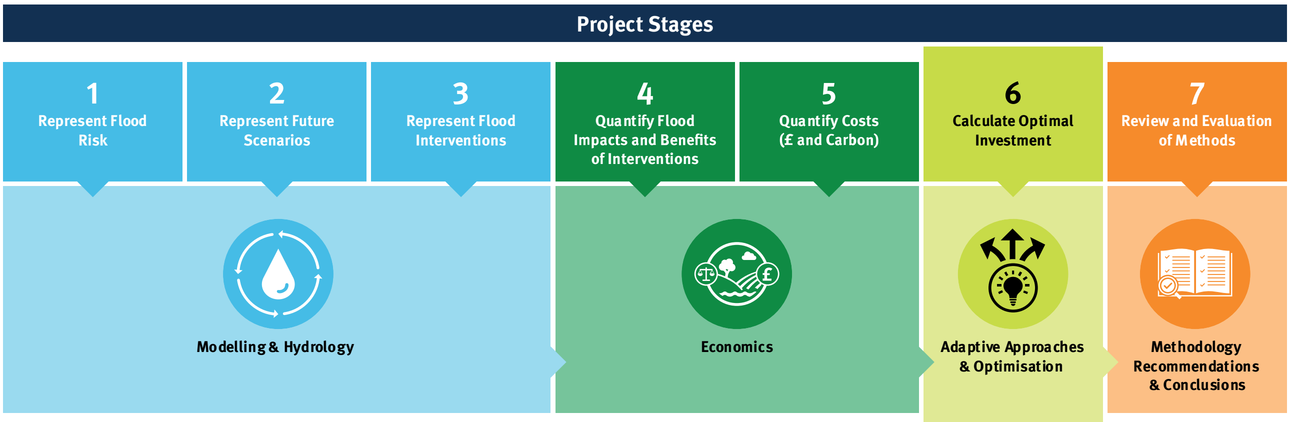
Flood Risk Investment Study

Adaptive Approaches & Optimisation Technical Report Summary



Overview

The Oxford-Cambridge (OxCam) Arc Flood Risk Investment Study (FRIS) aimed to identify the optimum level of investment in, and timing of, flood protection measures across the OxCam Arc to achieve the highest economic return. The OxCam Arc covers a large part, but not all of, three major UK river catchments. The Thames, the Great Ouse and the Nene. This study only considers the impacts within the OxCam Arc boundaries (Figure 1)

To achieve this, different combinations of flood risk protection investment options were analysed to identify the optimum/best economic return over the next 100 years. An adaptive approach works on the premise that because the future is uncertain, if you gamble on a singular future happening, you will be wrong. Instead, it encourages you to keep your options open so that you can allow for adjustment in the future depending on the future reality while still gaining the benefits of planning and investing ahead of time. By applying adaptive planning in this instance, it allows more robust decision making which considers a range of future risks and has helped highlight early flood risk investment opportunities where the evidence has identified no regrets options which will always be cost beneficial despite the uncertain future.

A summary of the adaptive approach optimisation methodology is set out in this summary note. More details can be found in the full Adaptive Approaches & Optimisation Technical Report. This summary note is part of a series of summary notes which also includes a modelling & hydrology summary, an economic modelling summary and an overarching project summary.

Figure 1: OxCam Arc River catchments

Decision points

There are an infinite number of 'decision points' throughout time at which investment in interventions to reduce flood risk could be made. To simplify this for modelling purposes a decision point every 10 years was allowed for, at which point the intervention was assumed to become immediately operational.

Investment/intervention options

At each decision point there were a range of flood intervention options available as shown for fluvial/tidal risk in Figure 2. Decisions on interventions to reduce surface water flood risk were considered in the same way, but separately to fluvial/tidal risk. There are fewer potential intervention combinations for surface water.

It has been assumed that investment in some types of interventions will preclude certain other interventions being chosen at future decision points. For example, linear defences can be raised in the future but never lowered or removed.

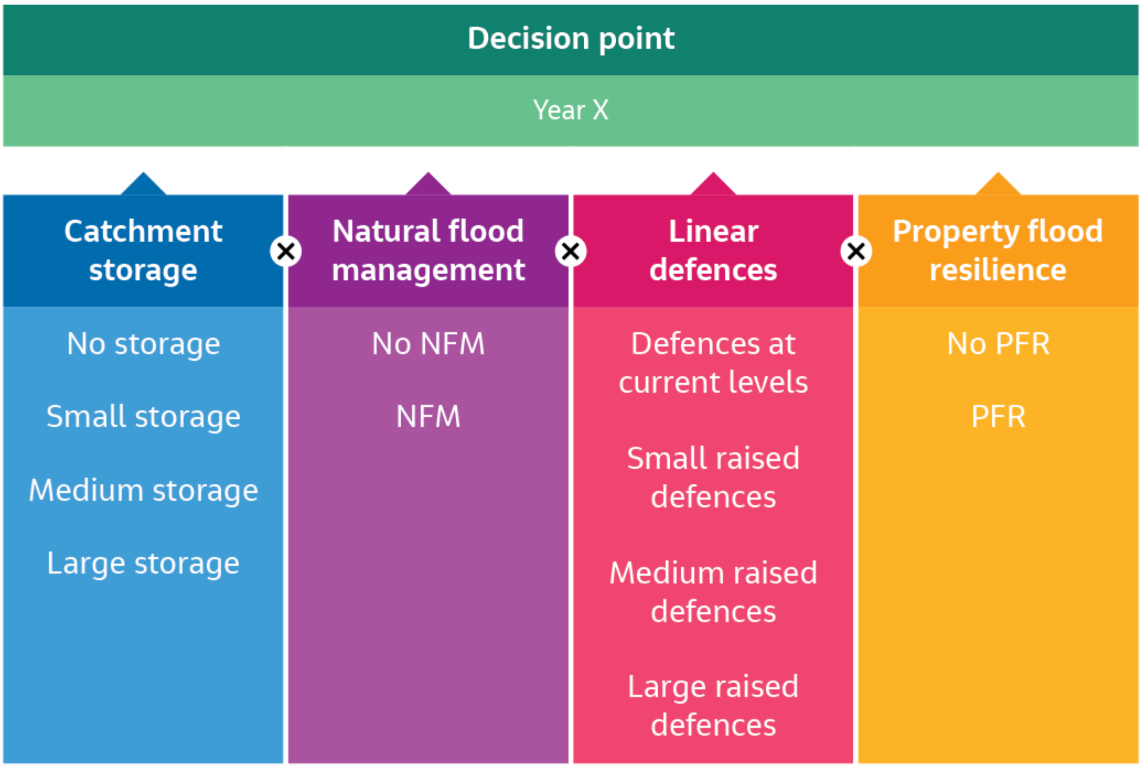


Figure 2: Flood intervention options available at each decision point for fluvial/tidal risk. – sourced from *OxCam FRIS Adaptive approaches and optimisation technical report 2022*

Identifying optimum investment for individual future scenarios

This initial step does not apply 'adaptive' thinking, but instead it was done to set baseline investment pathways for each of 27 potential future scenarios that we looked at. These single future scenarios are 'simple' net present value (Costs Vs Benefits) calculations and show the optimum investment pathway for each future, assuming no diversion from this scenario. The study was then to considering optimisation across an 'all futures' scenarios which brings in 'adaptive' thinking.

The benefit of undertaking these preliminary calculations is that they gave a benchmark against which to compare how 'robust' the proposed investment under the 'all futures' scenario was. It also provided a baseline showing the potential 'cost' of remaining flexible.

While one set of interventions might be optimal under a given future scenario, a different set of interventions might provide better value under a different future scenario. Our interest is not just in a single optimum, but also how that optimum varies under different futures.

What is a real options analysis?

In this project, consideration beyond the suite of individual optimums is made via a 'real options analysis', which is defined in the Green Book (HM Treasury, 2022[1]), this is the method for assessing against all futures.

This real options analysis implicitly accounts for the flexibility, robustness, and lost opportunity of interventions, through the effect they have on the weighted net present value under all futures. For example, the net present value of a near-term intervention which only provides good value in half of the futures will be 'dragged down' by a negative net present value in the futures in which it does not provide good value.

A key challenge in implementing a real options analysis is estimating the likelihood of each future. Within the core of this study, all futures were given equal likelihood, however weighting the likelihood of scenarios was explored in the sensitivity testing. This interestingly concluded weighting the likelihood of each scenario did not change the results significantly compared to each scenario having an equal likelihood.

[1] The Green Book (2022) - GOV.UK (www.gov.uk)

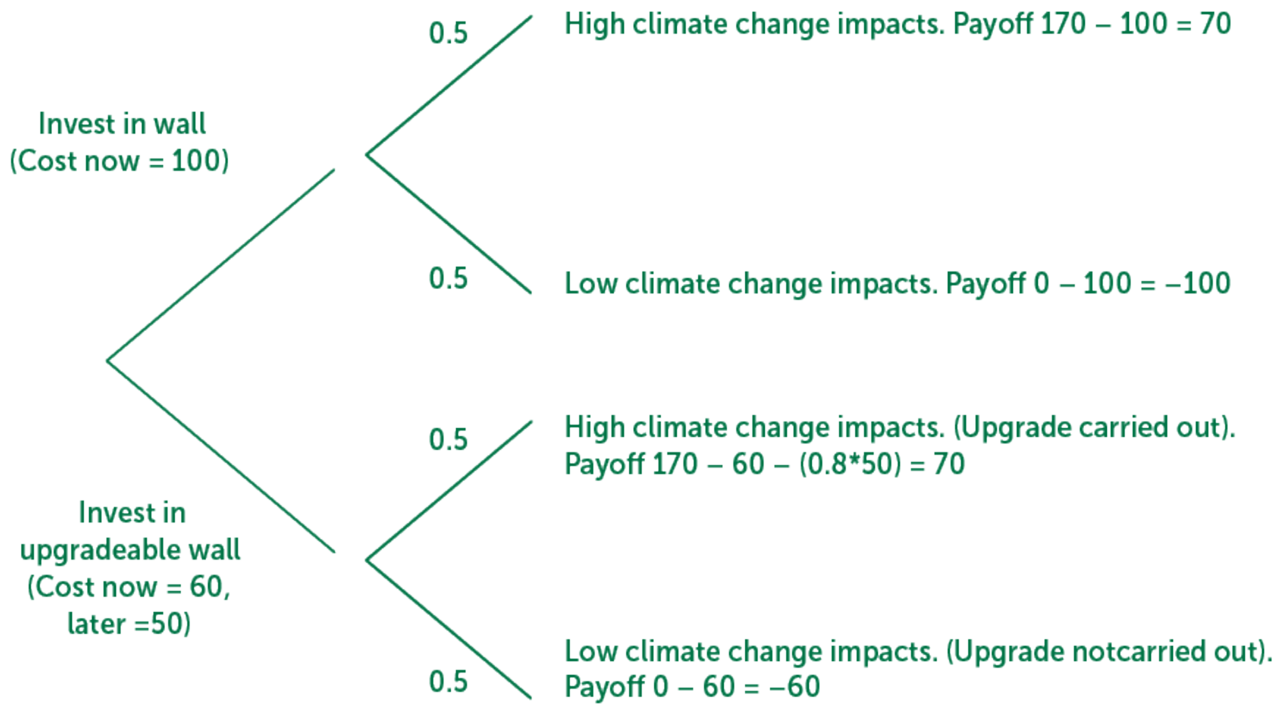


Figure 3: Example of a real options analysis, from *HM Treasury Green Book*

A real options analysis approach was taken for two scenarios. The scenario titled 'all futures' is the dataset used to present the main results:

All futures:

> Every combination of development rate (23k and 30k homes per year), development shape (new settlements, expansion of existing settlements, and hybrid) and climate change (central, upper central and high++) are considered.

No development:

> Each climate change future (central, upper central and high++) is considered, but with no new development (existing properties only), with the three climatic future scenarios assumed to have an equal probability of occurring.

How a real options analysis was applied: An iterative optimisation approach

Throughout the study a number of different optimisation approaches were explored as candidates for determining the level and timing of investment in the OxCam Arc including: 'guided' brute force decision tree exploration; dynamic programming; routing algorithm; and genetic algorithm. Ultimately, a bespoke optimisation routine was adopted that took elements of some of each of the above approaches.

The diagram below (Figure 4) describes the process the computer models went through in order to identify the optimum investment pathway.

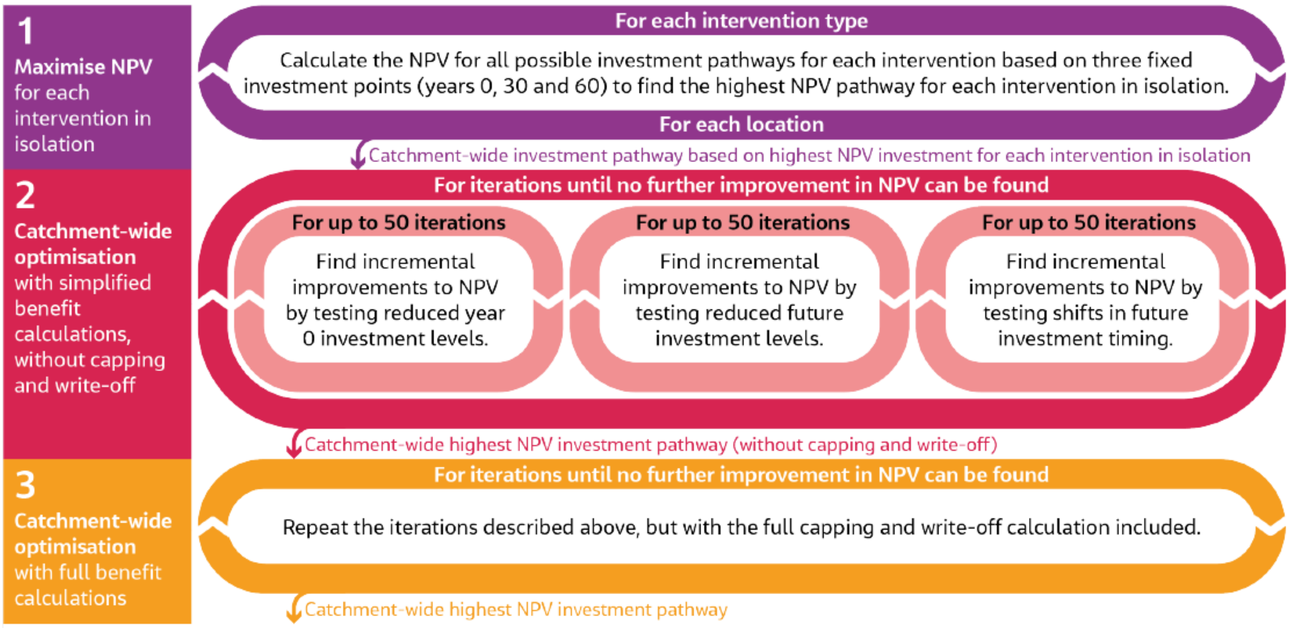


Figure 4: Summary of the iterative optimisation approach – sourced from *Oxford to Cambridge Arc flood risk investment study - summary report*

Document Hierarchy

Project Overview

Results

- Projects Outcome Report

Methodology

Summary Notes

- Modelling & Hydrology Technical Report Summary
- Economics Technical Report summary
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Technical Reports

- Modelling & Hydrology Technical Report
- Economics Technical Report
- Adaptive Approaches & Optimisation Technical Report
- Sensitivity Testing Analysis

Methodology recommendations and conclusions