Joint Defra/EA Flood and Coastal Erosion Risk
Management R&D Programme

Evaluating a multi-criteria analysis (MCA) methodology for application to flood management and coastal defence appraisals

Case studies report

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Statement of use
This report provides guidance on the use of MCA and ASTs to assist in the appraisal of flood and coastal erosion risk management projects, strategies and policies. It should be noted that it does not constitute official government policy or guidance, which is unlikely to be available until work to develop the methodology and identify appropriate sources of data has been undertaken through pilot studies.

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Contents

1. Introduction

1.1 Background

Multi-Criteria Analysis (MCA) covers a range of appraisal techniques that have the potential to capture a wide range of impacts that may not be readily valued in monetary terms, especially those relating to social issues. MCA aims to establish preferences between options by reference to an explicit set of specified objectives and associated criteria for assessing the extent to which these objectives have been achieved. Two of the key advantages of MCA are that it can allow greater stakeholder involvement and provide greater transparency to the decisions being made at all levels of appraisal.

As with all government-funded activities, spending on flood management and coastal defence is constrained and, hence, decisions have to be made to ensure that resources are used in an efficient manner. Cost-benefit analysis (CBA) for flood management and coastal defence is well established but there is growing concern that it fails to take full account of social and environmental factors. One method of including these impacts is by using a MCA approach. A scoping study was therefore undertaken in 2001/02 (FHRC/RPA, 2002) to look at the existing appraisal and decision framework and whether the use of a MCA approach would be appropriate and acceptable.

The conclusion from that study was that flood management and coastal defence appraisal needed the ‘best of both worlds’. Any method should retain the rigour of CBA, particularly in regard to demonstrating that the chosen option is a good use of resources, but should also provide a framework within which social and environmental issues can be more explicitly included in the decision-making process.

The study also identified the need for any new method to be able to be used at a number of decision levels:

- high-level (such as Shoreline Management Plans and Catchment Flood Management Plans);
- strategy-level (for defined lengths of river or coastline); and
- scheme-level (for individual defence projects on a river or coast).

In addition, the need for a method of prioritising funds on a national basis (which currently uses the priority scoring method) that is consistent with the appraisal methodology was identified. This nested approach is vital for consistency to ensure that policies identified at the high level can be implemented at the lower levels in the manner expected.

Following the scoping study, the Department for the Environment, Food and Rural Affairs (Defra) and the Environment Agency (the Agency) decided to further investigate developing a methodology through the R&D project: “Evaluating a MCA methodology for flood management and coastal defence appraisal”.

The aim of the methodology is to complement the current approach to economic appraisal, based on cost-benefit analysis, rather than substitute it. In this context, Risk and Policy Analysts (RPA) set out to develop a MCA-based component that could be added onto the current appraisal method.
The project commenced in January 2003 and has been approached in two Phases. The first phase included:

- scoping of impact categories;
- consultation to identify issues associated with the current approaches;
- methodological scoping; and
- a seminar on the proposed methodology.

The work carried out under the first three items was reported in the Issues Report (RPA, 2003a) and provided the background information for the MCA Seminar.

The aim of the second phase of the project was to undertake a range of case studies to develop the methodology for the MCA-based component in detail and produce guidelines for its application. This MCA-based methodology has to sit within the current economic appraisal approach set out in the FCDPAG series (MAFF, 1999-2001), but is to extend it to allow the inclusion of intangible benefits and costs in the flood and coastal defence appraisal and decision-making process. For simplicity this MCA-based component is referred to as the MCA-based approach and/or MCA-based methodology.

1.2 The present study

This case study report sets out the work undertaken to develop the MCA-based methodology, its application to two sets of case studies and the implications of the research findings for the production of guidelines for the application of the methodology.

The intention of the case studies was to test the methodology to answer two different questions:

- does the methodology provide information in a format that can be used to inform a range of different decisions? and
- does the methodology have added value over current approaches, i.e. would it help ensure that decisions are more robust and sustainable and/or can it help to take the views of all stakeholders into account such that conflicts that have arisen can be addressed specifically in the assessment?

This report constitutes one of the two milestones identified for the second phase of the MCA project. The second report 'guidelines for the implementation of the MCA-based methodology for flood defence and coastal management' runs in parallel and complements this case study report.

1.3 Organisation of the report

The aim of this report is two-fold. Firstly, it lays down the theoretical background for the MCA-based methodology, in particular in terms of the scoring and weighting methods. Secondly, it reports on the two sets of case studies, how their progress moulded the MCA-based approach to appraisal, how key issues raised in previous reports were dealt with and the key findings and their implication for the MCA-based methodology guidelines.

To provide the context for the study, this report starts with a section on the theoretical underpinnings for Multi-Criteria Analysis. Hence, Section 2 sets out the context and basis from which the MCA-based approach was developed, including the relationship between MCA and CBA.

The MCA-based methodology developed from the case studies is then described in Section 3. This is to introduce the reader to the overall process and each of its steps, so that readers are better able to understand the reasons why the methodology was developed as it was, the reasons behind the inclusion of each of the steps within it, and the advantages that it brings to the overall economic appraisal and decision-making processes.

Section 4 of the report details the criteria used in the selection of the case studies, while Sections 5 and 6 of the report give the results of the case studies. In Sections 5 and 6, the report guides the reader through the various stages of development of the MCA-based method, showing how each of the tools used in it were created, developed and refined. This is done through the presentation of each case study and the findings that led to the advancement of the various elements of the methodology.

How the MCA-based approach is to be applied to the three different levels of appraisal is discussed in Section 7. Attention is drawn to the differences between the three levels of the appraisal process, whilst maintaining consistency throughout the decision-making cycle. This section also summarises the key findings of the case study work.

Finally, Section 8 highlights how the MCA-based approach to appraisal improves the decision-making process for flood and coastal erosion risk management.

2. Theoretical context to the methodology

2.1 Introduction

For any flood defence project or policy there will be winners and losers. It is important, therefore, that some consideration is given to the full range of economic, environmental and social damages (reflecting the losers) and damages avoided (reflecting the winners).

A hierarchy of techniques can be applied to consider such costs and benefits, i.e. proformas, checklists, scoring and weighting, and, finally, CBA. All of these methods have their uses in highlighting the trade-offs between costs and benefits. They should not be seen as mutually exclusive, or indeed in conflict with one another, but all useful in support of the appraisal and decision-making process.

Within government, there is considerable emphasis on the use of financial and economic appraisal, with the latter particularly important for project appraisal. Economic appraisal, which is based on the principles of neoclassical welfare economics, goes wider than financial appraisal in that it considers the impact of a project in terms of its value to the nation as a whole.

The serious flooding over the past few years has focused the minds of both those involved in the flood and coastal defence industry and the public at large. A study for the Ministry for Agriculture, Fisheries and Food (MAFF) (MAFF, 2000) concluded that 10% of the population in England live within areas potentially at risk from flooding (with property worth over £200 billion) and current investment levels are not sufficient to maintain current defence standards.

Inevitably, these events have generated a series of reviews of the whole structure of flood and coastal defence management. The floods provided an opportunity both to re-assess the basis of flood management and the level of resources provided, questions that normally are very low on the national agenda. Simultaneously, the Water Framework Directive and the Aarhus Declaration require significant changes to be made; again, this provides an opportunity and one that is not likely to recur for twenty years or so. If there are improvements that can be made, now is the chance to make them.

Two key questions that have been asked are: how should flood and coastal defence be funded and what is the appropriate level of funding? How should decisions be taken as to when to provide flood or coastal defence and to what standard? So, for example, the Agriculture Select Committee stated in 1998 that "*…as a matter of priority, MAFF [now Defra] must develop methodologies addressing social and environmental criteria…*".

As with all government-funded activities, spending on flood and coastal defence is constrained. Decisions, therefore, have to be made regarding where money is spent, for what reasons and how. Given the need to ensure that scarce budgetary resources are used in an efficient manner, expenditure on flood and coastal defence should be spent in such a way as to maximise the net benefits to society as a whole. This has led to the development of guidelines for use by flood and coastal defence planners in preparing formal economic benefit-cost analyses of proposed schemes. Although these guidelines cover most of the impacts likely to arise, it is increasingly argued that additional tools are needed to address social and environmental issues in a more consistent and comprehensive manner.

Within the Agency and Defra, multi-criteria analysis (MCA) has been discussed as a potential way forward in this regard. The development of a MCA approach for use in flood and coastal defence appraisal is also timely as it builds on the guidance given in Multi-Criteria Analysis Manual published by DETR (2000).

2.2 Cost-benefit analysis

2.2.1 Overview

CBA provides a systematic framework for assessing the advantages and disadvantages of alternative project options, as it aims to express all of the potential effects of an activity in a directly comparable unit of measurement, that of money. By so doing, environmental and other effects are given equal consideration to financial gains and losses. In economic terms, the most efficient option is that which provides the greatest level of wellbeing for society as a whole. Any option is considered to be economically worthwhile if the benefits of the action outweigh the costs.

CBA thus requires that all of the effects of a project are valued in economic opportunity cost terms (the costs of the resources used or the benefits foregone as a result of an action). The underlying assumption in determining opportunity costs is that the preferences of individuals should determine the trade-offs that society is willing to make in the allocation of resources amongst competing demands. CBA, therefore, provides direct determination of the resource implications of a development proposal and whether or not it is justified from a national resource perspective.

2.2.2 Total economic value

With regard to environmental costs and benefits, it is essential to consider the total economic value (TEV) of an environmental asset. This is the sum of what are referred to as use values and non-use values.

Use values are those associated with the benefits gained from actual use (or ‘consumption’) of the environment and may include private sector uses (industry, agriculture, pollution assimilation and dilution, etc.), recreation benefits, education and scientific benefits, and general amenity benefits. They relate to use today and securing the potential use of resources in the future (referred to as option values).

Non-use values (also known as passive use values) are generally considered to be of two different types: bequest values and existence values. Bequest values reflect an individual's willingness to pay to secure the future of a good so that future generations may have the option of using the asset. Existence values are defined as those values, which result from an individual's altruistic desire to preserve an environmental asset and ensure its continued existence into the future. These values are not associated with actual or future use, but solely with the knowledge that the asset is being conserved or preserved. The protection of SSSIs and other habitats and species as part of meeting conservation objectives are good examples of non-use value.

One of the key requirements of a fully quantified CBA is the valuation of environmental and other social costs (and benefits) to ensure that the total economic value of the action is taken into account. As many environmental and social costs (and benefits) frequently fall outside the marketplace and hence are not traded, the economic value of such impacts has to be imputed through some other means. As noted earlier, a range of economic valuation survey techniques has been developed to assist in this valuation process. These techniques attempt to derive an individual's willingness to pay for environmental benefits (or willingness to be compensated for an environmental loss) as revealed in the marketplace, through individual's actions, or as directly expressed in surveys.

Benefits transfer

To date, most CBAs undertaken for flood defence projects and policies have not attempted to place monetary values on environmental and social impacts. Increasingly though, specific valuation exercises are being undertaken to allow the preparation of more fully quantitative, monetary analyses; although the financial costs of undertaking such exercises, together with the length of time required to do so, are still significant constraints.

As a result, decision-makers are increasingly turning to the use of benefits transfer as an alternative to the commissioning of issue-specific valuation studies. There are a number of definitions as to what is meant by benefits transfer (see for example Bhattarai *et al*, 1997). For the purposes of this study, benefits transfer can be defined as the process of taking a value (or benefit estimate) developed for a previous project and transferring it to another. For example, if a previous study found that individuals were willing to pay £5 each per year to restore a river channel to a more natural state, then benefits transfer would assume that this value provided a good indication of the benefits arising from another scheme located elsewhere which would also create a more natural river channel. It is therefore assumed that the river, its current characteristics, post-restoration state, and value to the relevant community are similar in making this transfer.

Making this type of assumption is a key issue within benefits transfer, raising questions over the reliability (and validity) of the transfer process. It is an issue that affects benefits transfer in relation to certain types of impacts more than others. For example, benefits transfer is more accepted when it relates to the valuation of 'use' values, such as the valuation of a recreation day along a river. It is less accepted in relation to the valuation of non-use benefits. To a degree, this is due to the higher number of valuation studies that benefit transfer values can be drawn from in valuing recreation.

In the context of flood and coastal defence, there is a body of economic valuation literature that can be called upon to expand the use of benefits transfer. This includes current guidance such as the Multicoloured Manual (Penning-Rowsell *et al*, 2003), but also guidance developed for other water management related contexts. For example, the benefits assessment guidance developed for the Environment Agency (RPA, 2003b) for use in the 2003/04 periodic review of the privatised water companies expenditure plans also provides a series of relevant valuation studies. Furthermore, it sets outs methods for applying these valuations, including the calculation of the relevant populations for aggregation purposes and issues in applying individual values. However, in the discussion that followed application of the benefits assessment guidance, concerns were expressed regarding the adequacy of some values (although general agreement was shown as to the methods of aggregation).

2.3 Multi-Criteria Approaches

2.3.1 The different MCA techniques

MCA covers a range of techniques for assessing decision problems characterised by a large number of diverse attributes where these do not need to be expressed in money terms. At a simple level, there is a range of methods that have been designed to screen out 'worse' options and possibly to identify the 'best' option, without aggregating information across different attributes. In contrast, some of the more sophisticated techniques are aimed at providing a means for aggregating information into a single indicator of relative performance.

The MCA techniques differ as to the characteristics of the set of options and measurement scales that they can handle, the decision rule that they apply, and the way scores are standardised. It is impossible to review all of methods that make up the enormous array of those available. Extensive reviews are given in Nijkamp *et al* (1990, *in* FHRC/RPA, 2002), Janssen (1992, *in* FHRC/RPA, 2002) and Vincke (1992, *in* FHRC/RPA, 2002). DETR (2000) also provides a review of several of these methods.

In general, the various methods can be classified in terms of three main characteristics (FHRC/RPA, 2002):

- **the set of alternatives:** discrete versus continuous problems. All multi-criteria decision problems can be represented in multi-dimensional space. Discrete decision problems involve a finite set of options. The selection of a flood management option from several possible options (e.g. a storage reservoir, channel improvement, source control, flood embankment) is an example of a discrete choice problem. Continuous decision problems are characterised by an infinite number of possible alternatives: for example, the selection of the design standard of protection to be offered by a flood embankment;

- **the measurement scale:** quantitative versus qualitative attribute scales. Many problems include a mixture of qualitative and quantitative information. Qualitative and mixed multi-criteria methods such as the regime method, permutation method, evamix method and expected value method can process mixed information. Evaluation by graphics can be used in quantitative, qualitative and mixed decision problems; and
- **the valuation function:** quantitative scores can be measured in a variety of measurements units. To make these scores comparable, they must be transformed into a common dimension or into a common dimensionless unit. Scores can be transformed into standardised scores using a linear standardisation function, or by using value or utility functions. Value and utility functions transform information measured on a physical measurement scale to a value or utility index.

Following the above classification, four main categories of methods can be identified (FHRC/RPA, 2002):

- Simple methods, including pairwise comparison and ranking;
- Multi-attribute utility analysis (MAUA) including: weighted summation, ideal point method, and evaluation by graphics;
- Outranking methods; and
- Qualitative methods including the analytic hierarchy process (AHP), regime method, permutation method, the evamix method.

Table 2.1, presented at the end of this section summarises each of the four main categories of methods and the key issues arising from their application.

Table 2.2 further characterises the multi-criteria methods listed above according to the type of information required, the type of results produced, the transparency of the method, the computational effort required and finally, the costs of use of the method.

Table 2.2 Characteristics of different multi-criteria methods

Method	Information	Result	Transparency	Computation	Costs
Weighted Summation	Quantitative	Performance scores/ranking	High	Simple	Low
Ideal Point Method	Quantitative	Distance to target/ranking	Medium	Simple	Low
Evaluation by Graphics	Qualitative, Quantitative and Mixed	Visual presentation	High	Simple	Low
Outranking Methods	Quantitative	Ranking/ incomplete ranking	Low	Very complex	Medium
Analytical Hierarchy Process (AHP)	Qualitative	Performance scores/ranking	Low	Complex	Medium
Regime Method	Qualitative, Quantitative and Mixed	Ranking/ probability	Low	Very complex	Low
Permutation Method	Qualitative	Ranking	Low	Very complex	Medium
Evamix Method	Mixed	Ranking	Low	Simple	Low

Note: Adopted from FHRC/RPA (2002)

As can be seen from Table 2.2, the type of information available determines to a large extent the methods that can be used. Most quantitative methods produce performance scores as well as a ranking. In addition to a ranking, weighted performance scores provide information on the relative performance of the alternatives. Comprehensiveness is achieved if all the information is presented to decision-makers, while presenting a final ranking, or even only one best alternative, results in maximum simplicity and possibly an over-simplification. Graphic or other presentations of the information take an intermediate position. Although a complete ranking provides maximum simplicity, in aggregating all information into a final ranking, priorities need to be included and a decision rule needs to be selected (FHRC/RPA, 2002).

Transparency is low across a number of the methods, suggesting that such methods should not be used if many stakeholders are involved in or concerned with decision-making. Computation is complex in some of the methods. Since software is generally available to support the use of the methods, this is in itself not an important issue. The costs of adopting methods based on the use of value/utility functions are likely to be higher than those associated with the use of AHP and outranking methods. These additional costs result from the involvement of an expert in the assessment procedure (FHRC/RPA, 2002).

2.3.2 The advantages and disadvantages of MCA

The advantages of many of the approaches to MCA are that:

- it enables a number of different objectives to be considered (as does CBA);
- it is relatively transparent (it is easy to see what would be the consequences of giving a different order of importance to the different objectives or making different assessments of the performance of the available options against the different objectives);
- its relative simplicity makes it easier to adopt appraisal-led design, the appraisal being refined as the design process develops; and
- there is some evidence that it promotes the identification of an option about which a consensus develops that it is the best option.

However, it is necessary to remember the limitations of MCA (FHRC/RPA, 2002):

- the scores of the options against the objectives can generally be considered to achieve no more than an ordinal level of measurement;
- the assessment will be made by a limited number of judges and there is consequently an issue as to whether their views are representative of any wider constituency;
- the scores are themselves relatively subjective. This results in two problems; firstly, whilst issues of the distribution of consequences over time and over people are central problems in decisions, these issues are hidden in MCA. Although the issue of discounting is also necessarily embedded in MCA, as it is in CBA, there is no rigorous way of defining it in MCA;
- it is difficult to maintain consistency between decisions and groups of judges because keeping the scoring system simple means that it loses rigour;
- the strength of MCA lies in comparing options. Its weakness lies in determining whether any of those options are sufficiently worthwhile to justify transferring resources from other areas of expenditure, for example, whether any one of the available flood alleviation options is preferable to a new hospital; and
- work on MAUA has shown that the form of multi-attribute utility functions can be much more complex than simple additive utility functions. This is a further reason why weighting the criteria and multiplying the scores of each option on each criterion to get an overall score can be seriously misleading.

These limitations should determine both the form of MCA adopted and the way in which it is used.

Table 2.1 Brief summary of the four main categories of methods and the key issues arising from their application (adapted from FHRC/RPA, 2002)

Method	**Description**	**Key issues**
Simple methods		
Pairwise comparison	Involves listing the criteria and comparing options in pairs against each of these criteria, indicating a preference for one option over another. The results are recorded in a table. An overall preference is then identified, or the information is used to highlight the trade-offs involved in selecting one option over another. The decision-makers must make a judgement on the relative importance to be assigned to the different criteria and thus to determine the 'best' option.	No attempt is made to incorporate the relative importance of different magnitudes of impact or of the different criteria. Undertaking the comparisons and ensuring consistency becomes increasingly complex as the numbers of criteria and options increases. Applying pairwise comparison techniques in such cases can only effectively be achieved through the use of the more sophisticated mathematical approaches (such as the analytical hierarchy process) that have been developed for these purposes.
Ranking	Involves the ordering of options or impacts into ranks using verbal, alphabetical or numerical scales and provides an indication of relative performance. Value judgements (e.g. expert opinion or a decision maker's) are used to decide the order of preference for different options or impacts. These methods provide a simple means of evaluating the performance of different options over a range of different criteria.	When used on their own, they provide little information on the degree or magnitude of any differences in impact between options. They hide any uncertainty that may exist as to the extent of such differences. In addition, when there are several options under consideration, it may be difficult to select a preferred option. Also, there is a tendency to add ranks together, a mathematical operation which is invalid unless it is assumed that decision-makers place an equal value on impacts falling under the various criteria and that all trend scores or ranks reflect proportional changes in level of impact (i.e. +++ is three times better than +). Such methods must, therefore, be backed up by further descriptive information if decision-makers and others are to be provided with an accurate picture of the implications associated with alternative flood and coastal defence options.

Table 2.1 Brief summary of the four main categories of methods and the key issues arising from their application (adapted from FHRC/RPA, 2002)

Method	Description	Key issues
More complex methods		
Multi-attribute utility analysis ***Weighted summation***	All methods evaluate the attractiveness of alternative options in terms of three discrete elements: • the consequences of the options in terms of the decision criteria; • the relative preference or priority assigned to the decision criteria are denoted in terms of weights; and • if the effects scores are measured on different scales, they must be standardised to a common dimensionless number. The methods vary with respect to their treatment of scores and weights. In common the methods require the use of quantitative scoring systems as well as quantitative weights. Weighted summation is the simplest form of multi-attribute utility analysis that applies a linear relationship. It involves standardising the scores across all criteria, assigning preference weights, multiplying the weights by the scores, adding up the resulting scores to obtain total weighted scores for each option, and determining the ranking of the total weighted scores. An appraisal score is calculated for each alternative by first multiplying each value by its appropriate weight and then summing the weighted scores for all criteria. Although the method requires quantitative information on scores and priorities, only the relative values are used in the assessment. The method does, however, provide a complete ranking of options and information on the relative differences between options.	The computational requirements of the methods are fairly simple. The difficulty with weighted summation lies in choosing a good standardisation method and attribution of the weights. In general, linear standardisation can be seen as an approximation of more complex non-linear value functions. If the range of scores is not too large for all criteria, linear standardisation will in many cases be sufficiently accurate. If the range of scores is large or if the scores are in a range where the value of a score is very sensitive to changes in the range, expert judgement should be used to determine the shape of the value function. However, this is a relatively time consuming activity. One of the key disadvantages of the method is that it is less suitable for processing qualitative information. In practice, this disadvantage is not very significant as in many cases qualitative scores, for example plusses and minuses, represent underlying classes of quantitative data. With a well-chosen method of standardisation, this underlying quantitative scale can be used in the weighted summation of these scores. The results of weighted summation can easily be presented in bar graphs. A stacked bar can be used to present the relative contribution of all criteria or objectives to the overall score. In addition, Monte Carlo analysis can be used to generate probabilistic rankings of the alternatives. These rankings can be used to analyse the sensitivities of ranking of alternatives to overall uncertainty in both effects and priorities. Line graphs can easily be generated to show the effect of changes in weights or scores to the total scores and ranking of the alternatives.

Table 2.1 Brief summary of the four main categories of methods and the key issues arising from their application (adapted from FHRC/RPA, 2002)

Method	Description	Key issues
Ideal point method	Based on the concept of value or utility maximisation, the Ideal Point Method ranks the options in terms of the degree to which they achieve a pre-specified target or ideal situation (i.e. their distance from the target outcome). It is assumed that there is an ideal level of impact for the criteria of concern and that the decision-makers utilities decrease as one moves away in either direction from this level. Options that are closer to the ideal are preferred to those that are further away. By using a scaling coefficient it allows for the inclusion of the relationship between relative size of effect and weight into the decision rule. In a linear relationship (such as CBA) the scaling coefficient is 1. The Iideal point method provides a complete ranking of options and information on the relative distance of each from the ideal solution.	
Evaluation by graphics	Computerised models often provide a graphical interface to facilitate the development and analysis of a decision problem using multi-criteria analysis. One of the key benefits of using a graphical output is that it enables the analyst or decision maker to see easily the relative performance of options under different weighting systems. With the rapid development of GIS software tools, it is possible to use graphics-based methods to assess the geographical variation of the impacts of risk management options.	

Table 2.1 Brief summary of the four main categories of methods and the key issues arising from their application (adapted from FHRC/RPA, 2002)

Method	Description	Key issues
Outranking methods	The various Electre methods (also referred to as concordance analysis) are the most important representatives of the class of outranking methods. These methods are widely used. They first translate criterion scores to an outranking relationship and then analyse this relationship. The variant described here is known as Electre II. It is based on a pairwise comparison of the alternative options, using only the interval character of the scores in the evaluation of the effects table. The basic idea is to measure the degree to which scores and their associated weights confirm or contradict the dominant pairwise relationships among alternatives. Within this method, a dominance relationship for each pair of alternatives is derived using two indices, one index indicating *concordance* and the second index indicating *discordance*. The concordance index represents the degree to which alternative *i* is better than alternative *i'*. This index, $c_{ii'}$, is simply the sum of all the weights for those criteria where alternative *i* scores at least as highly as option *i'*. The set of such criteria (i.e. those for which alternative *i* is at least equally attractive as alternative *i'*) is referred to as the concordance set $C_{ii'}$. The discordance set $D_{ii'}$ is defined as the set of evaluation criteria for which alternative *i* is worse than alternative *i'*. It reflects the idea that, beyond a certain level, bad performance on one criterion cannot be compensated for by good performance on the other criterion. Thresholds supplied by the decision maker, in combination with the concordance and discordance tables, are used to establish a weak and a strong outranking relationship between each pair of alternatives. A procedure of step-by-step elimination is used to transform the weak and the strong graph representing these outranking relationships into an overall ranking of the alternatives.	The analysts using these methods need to be trained well in their use since interaction with the decision-makers is a complicated task. The results are very sensitive to the level of the thresholds used to define the concordance and discordance relationships. Setting these levels requires complex interactions between the analyst and decision maker, which are not always transparent. In particular, there may be difficulties for others in trying to understand the role that the various thresholds have played in determining the end ranking of options and in interpreting the weights assigned to the different criteria. In addition, the procedure used to generate the final ranking does not always result in a complete ranking of alternative options. In some cases one or more options cannot be ranked or two partial rankings are produced. As a result, it is likely that the complexity of the method makes it less transparent and therefore less suitable for the purposes of flood defence appraisal than the techniques described above.

Table 2.1 Brief summary of the four main categories of methods and the key issues arising from their application (adapted from FHRC/RPA, 2002)

Method	Description	Key issues
Qualitative methods		
Analytical hierarchy process (AHP)	Pairwise comparisons provide the basis for the AHP. AHP structures the decision problem into levels that correspond to a decision maker's understanding of the situation: goals, criteria, sub-criteria, and options, so that the decision maker can focus on smaller sets of decisions. The aim of this method is to derive quantitative scores and weights from qualitative statements on the relative performance of alternatives and the relative importance of criteria obtained from comparison of all pairs of alternatives and criteria. If the judgements supplied by the decision maker are completely consistent, one row of the comparison matrix A would be enough to produce all relative weights. Complete consistency implies that (triangular) relationships of the type $a_{13} = a_{12}a_{23}$ hold for all sets of three criteria. This is almost never the case. An approximation of the weights, therefore, needs to be generated that makes the optimal use of the (inconsistent) information available in the comparison matrix. It should be noted, that the AHP method can be used not only to assess relative criteria weights but also to assess the performance of options through pairwise comparisons. The resulting tables of pairwise comparisons are translated to weights and scores using the Eigenvalues of these tables.	The Analytical Hierarchy Process (AHP) is widely used all over the world. Many applications can be found in the literature and lively discussions on its theoretical validity can also be found. Although some controversy surrounds the theoretical basis of the method, it is easy to use and produces results that match the intuitive expectations of the users. Despite its ease of use, the procedure for processing information obtained from the decision maker is far from transparent. This makes the method less suitable for situations with many stakeholders. A special group decision version of the method is popular, however, for situations where stakeholders are brought together to negotiate their positions. In addition, for AHP, the number of pairwise comparisons to be made increases rapidly with the number of criteria. Therefore the use of a hierarchical structure of goals, sub-goals and criteria, may be a better option Decision situations where only strictly ordinal information is available are rare. In these rare cases the Regime method and Permutation method can be used to process this information. Both methods process the ordinal information in a theoretically sound way. Both methods are, however, very complicated and far from transparent. This prevents their use in most practical applications. The Evamix method is relatively simple and was specially designed to deal with mixed information. Although the procedure is relatively transparent, interpretation of the results is ambiguous.

Table 2.1 Brief summary of the four main categories of methods and the key issues arising from their application (adapted from FHRC/RPA, 2002)

Method	Description	Key issues
Regime method	The Regime method is also based on pairwise comparisons of alternatives. For each criterion all pairs of alternatives are compared. The best alternative receives +1, the worst –1 and both alternatives receive 0 if they are the same. These scores are then combined with quantitative information on weights attached to the criteria to determine which of the two alternatives is preferred if all criteria are taken into account simultaneously. This is straightforward if quantitative weights are available. If only qualitative weights are available, they are interpreted as unknown quantitative weights. A set *S* is defined containing all sets of quantitative weights that conform to the qualitative priority information. In some cases, for parts of the set *S*, one alternative is preferred while for other parts the other alternative is preferred. The distribution of the weights within *S* is assumed to be uniform and, therefore, the relative sizes of the subsets of *S* can be interpreted as probabilities, which can be aggregated to produce an overall ranking of the alternatives.	
Permutation method	The Permutation method addresses the following question: which, of all possible rank orders of alternatives, is most in harmony with the ordinal information contained in an effects table? In the case of *I* alternatives, the total number of possible permutations is equal to *I!*[1]. Each permutation can be numbered as *p* (*p=1,,I!*). Each rank order from the permutations is then confronted with the ordinal information contained in each of the rows of the effects table. Rank correlation coefficients[2] are then used to compute the statistical correlation between the *I!* rank orders and the *j* columns of the effects table. This results in a large number of rank correlation coefficients. The weighted sums of the rank correlation coefficients are used to determine the most attractive of the *I!* permutations.	

[1] Where *i!* means the factorial of *i*.

[2] Kendall's rank correlation coefficient is used for these purposes.

Table 2.1 Brief summary of the four main categories of methods and the key issues arising from their application (adapted from FHRC/RPA, 2002)

Method	Description	Key issues
The Evamix method	The Evamix method is designed to deal with an effects table containing both qualitative and quantitative criteria. The set of criteria in the effects table is divided into a set of ordinal criteria *O* and as set of quantitative criteria *Q*. For both sets, dominance criteria are calculated: The method requires quantitative weights but can be used in combination with any of the methods dealing with ordinal priority information. A total dominance score is found by combining the indices α_{ij} and β_{ij} calculated separately for the qualitative and quantitative scores. To be able to combine α_{ii}' and β_{ii}' both indices need to be standardised. The most straightforward standardisation divides qualitative indices by the absolute value of their sum and does the same with quantitative indices. The total dominance score is calculated as the weighted sum of the qualitative and quantitative dominance scores.	

2.3.3 Choosing between the MCA approaches

Taking into consideration both the advantages and the drawbacks of the various MCA techniques, the selected method to be combined with CBA for application in flood and coastal erosion risk management has to be simple to apply, have a low cost and respect transparency in the appraisal process. It also has to be able to deal with both qualitative and quantitative data or a mixed type of information.

From Table 2.2, it can be concluded that:

- in order to deal with quantitative information, the weighted summation methodology seems to be the most appropriate; it retains a high level of transparency, it is simple to apply and has a low cost; and
- in order to deal with qualitative information, all methods seem to provide only a low level of transparency. The AHP method seems to be the most appropriate since it is the only one that, using qualitative information, provides both performance scores and ranking. However, it is considered to be more complex in application, reducing its usefulness in a flood and coastal defence context.

Furthermore, as the initial selection of the preferred option in flood and coastal defence appraisals is based on benefit-cost ratios and incremental benefit-cost assessments between options, the decision context is of a comparative nature. Use of comparative scoring methods ensures simplicity and ease of application, and in this sense may be preferred. At the same time, though, funding decisions are based on the relative performance of options on the basis of benefits and costs. This requires that some account is taken of how to convert the scored (intangible) costs/benefits of one scheme relative to another when the nature of these intangible benefits varies in geographic scale, type and severity.

In addition, when considering alternative ways of eliciting weights, whether the weights should be elicited from individuals or groups of individuals (such as in focus groups) should also be considered.

Eliciting weights through focus groups provides agreed sets of weights (for example, swing weights). Such focus groups may often be made up of individuals representing the same type of interest (e.g. conservation), or are sometimes mixed to represent a diverse range of interests. Issues with such approaches include the fact that they can be very time-consuming and the group is often forced to reach a group consensus on the importance of different impacts. The results can be significantly affected by the make up of the group and the dominance of individuals or groups of individuals.

Eliciting weights from individuals does not require a group consensus that may, in extreme circumstances, reflect the priorities of no one. Analysis of weights from individuals can then be used to identify whether there is any consensus on the relative importance of one impact versus another and, if so, the level of this consensus. Even where there is no identifiable consensus in the magnitude of the weights, for each individual it is simple to calculate what the outcome of the analysis would be using each and every set of weights. Such analysis can reveal a consensus on outcomes in an appraisal even where there is little or no consensus on relative importance of impact categories.

3. The MCA-based methodology

3.1 Introduction

As stated in the introductory section, flood and coastal erosion risk management appraisal needs an approach that retains the rigour of CBA, particularly in regard to demonstrating an economic justification, whilst providing a framework within which social and environmental issues can be more explicitly included in the decision-making process. MCA can provide this complementary framework.

The MCA-based methodology developed for this study sits within the current economic appraisal approach set out in the FCDPAG series (MAFF, 1999-2001) and extends it to allow the inclusion of intangible costs and benefits. Starting with the process presented in the FCDPAG 3 (MAFF, 1999), the MCA-based methodology adds new steps and enhances some of the existing steps of the procedure.

This section gives an overview of the proposed MCA-based methodology in its final format with the aim of showing the reader the end product of the case study work. The following sections then run through each set of case studies and show how each step of the process was developed to reach the final form.

3.2 The MCA-based methodology

As identified in the FCDPAG 3, the project appraisal process involves four discrete stages – Define, Develop, Compare and Select – within which are included various procedural steps. The current approach to appraisal including the MCA-based methodology comprises the following steps:

Step 1: definition of problem, the objectives and identification of all options;
Step 2: elimination of unreasonable options;
Step 3: structuring the problem, i.e. screening using the Appraisal Summary Table for High Level Screening (S-AST);
Step 4: qualitative assessment of impacts, using the Appraisal Summary Table for Main Assessment (MA-AST);
Step 5: quantitative assessment of impacts, using the MA-AST;
Step 6a: determination of the tangible benefits and costs of options;
Step 6b: scoring impacts;
Step 7: weight elicitation, as appropriate (with the use of a weight generation analysis as optional to determine the necessity for weight elicitation);
Step 8: comparison of options using expanded decision rules;
Step 9: testing the robustness of the choice; and
Step 10: selecting the preferred option.

Figure 3.1 illustrates these steps. Those steps highlighted in grey are new to the approach and represent a MCA-based component.

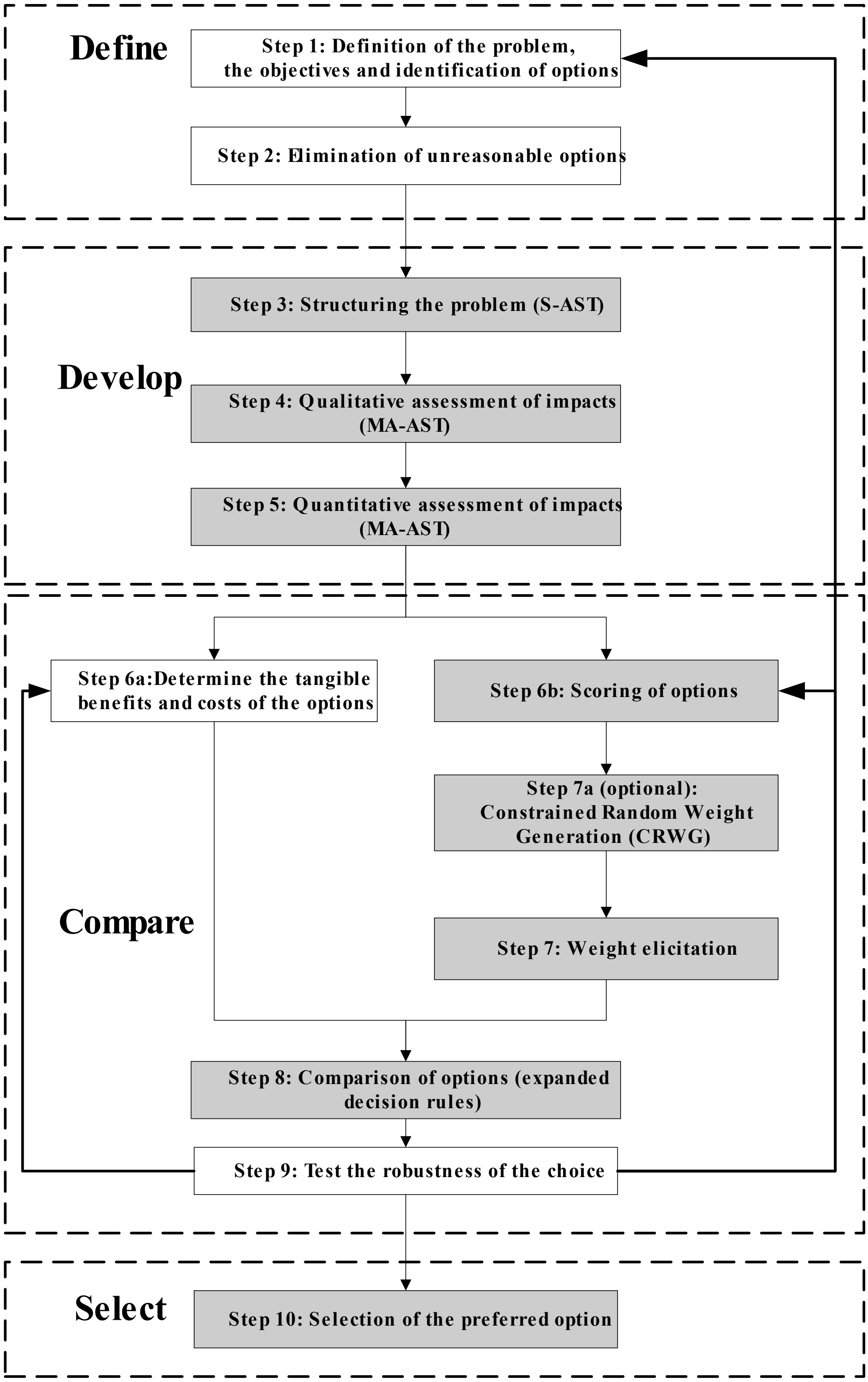

Figure 3.1 New methodological approach to economic appraisal including the MCA-based component

As can be seen by comparing this stepped approach to the process set out in FCDPAG 3, the MCA component of the approach is introduced in Step 3 – structuring the problem. The Develop stage of the approach is not changed from the original one but further structured and enhanced by the use of appraisal summary tables (ASTs). Steps 6 and 7, in the Compare stage, are new to the appraisal and they enable a more thorough consideration of the intangible impacts in the overall process. Steps 8, 9 and 10 have been slightly modified to include the new MCA-based component of the process. A description of how each of these new or transformed steps is carried out is given in the following sub-sections. It was not thought necessary to describe those steps that are currently included in the CBA approach to economic appraisal as they are current practice. It is nonetheless important to reiterate that FCDPAG 3 guidance should be followed.

3.3 Definition of the problem, the objectives and identification of options, and elimination of unreasonable options (Step 1 and 2)

The aim of step 1 is to identify and define the flood and coastal defence problem (without presupposing any particular outcome or solution), to make the objectives of the project explicit, be it a plan, a strategy or a scheme, and all reasonable and significant options to address the problem. This stage should include an introduction to the project, a description of the flood and coastal defence problem being assessed, its policy context, and a list of stakeholders and interested parties.

The aim of step 2 is to screen out unreasonable options, with reference to the objectives identified for the project.

Following the presentation of the background, the objectives and chosen management options, the high level screening of impact categories can be carried out.

3.4 Structuring the problem (Step 3)

Step 3 is a high level screening exercise to identify the relevant criteria or impact categories that will be used to inform the decision. This should not be confused with the options screening exercise that is undertaken in Step 2.

This high level screening is carried out using the appraisal summary table for high level screening (S-AST) illustrated in Table 3.1, overleaf.

The MCA-based methodology is structured around the use of two appraisal summary tables (ASTs), the S-AST referred above and the AST for the main assessment (MA-AST) detailed in Sub-section 3.5, below.

ASTs are tabular summaries of the main economic, environmental and social impacts of a proposed option, whether relating to a policy/programme, strategy or scheme. The impact categories included in it are further explained in Section 3.5. The S-AST fulfils two main functions:

- firstly, it serves as a screening checklist to identify the range of potential impacts under each option, with the aim of ensuring that all impacts of the project are consistently considered; and
- secondly, it serves to indicate whether the appraisal of individual impacts would be best undertaken using a quantitative or qualitative assessment (MCA-based component) or through monetary valuation (CBA) techniques by means of ticks.

Table 3.1 Appraisal summary table for high level screening (S-AST)

Project name	Project name (high, strategy or scheme level)			
Description of option	Description of option being assessed (do-nothing, maintained, improve, etc.)			
Description of area affected by option	Brief description of area affected			
Impact category	**Impact likely? (Y/N)**	**Impact details**	**Qualitative or quantitative assessment**	**Monetary valuation**
Economic impacts				
Assets				
Land use				
Transport				
Business development				
Environmental impacts				
Physical habitats				
Water quality				
Water quantity				
Natural processes				
Historical environment				
Landscape and visual amenity				
Social impacts				
Recreation				
Health and safety				
Availability and accessibility of services				
Equity				
Sense of community				

The purpose of this high level screening table/checklist is to ensure consistency and transparency across appraisals. If all projects and management options are appraised using the same checklist of impacts, the likelihood of omission of impacts is greatly reduced.

The S-AST sets out qualitatively, simply and concisely the key consequences for the 'do-nothing' option[3]. The 'do-nothing' option is used here for two main reasons:

- it provides a good basis for the assessment of most alternative options; and
- it will be used in the later stages of the appraisal so it ensures that time and resources are used efficiently.

However, the S-AST only provides qualitative information for the do-nothing option and, therefore, cannot be used as an overall assessment tool.

3.5 Qualitative and quantitative assessment of impacts (Step 4 and 5)

The qualitative and quantitative assessment of impacts for all of the options (Steps 4 and 5) is carried out using the AST for the Main Assessment (MA-AST) illustrated in Table 3.2.

Table 3.2 Appraisal summary table for main assessment (MA – AST)

Project name	Project name (high, strategy or scheme level)		
Description of option	Description of option being assessed (do-nothing, maintained, improve, etc.)		
Description of area affected by option	Brief description of area affected		
Impact category	**Impact likely? (Y/N)**	**Qualitative description of impacts**	**Quantitative assessment of impacts (no. units/monetary)**
Economic impacts			
Assets			
Land use			
Transport			
Business development			
Environmental impacts			
Physical habitats			
Water quality			
Water quantity			
Historical environment			
Landscape and visual amenity			
Social impacts			
Recreation			
Health and safety			
Availability and accessibility of services			
Equity			
Sense of community			

[3] The 'do-nothing' option is defined as the option to walk away and abandon all maintenance and repair of existing structures, allowing nature to take its course. It serves as the common baseline against which alternative options can be assessed.

As can be seen from Table 3.2, the MA-AST includes cells for recording the following types of information:

- the project name with an indication of the level of decision being taken;
- a description of the option being assessed and the defence standard being provided;
- a brief description of the area being affected by the project;
- qualitative descriptions of the effects of the option for each of the impact categories, including any assumptions specific to the impact assessments or comments on their robustness and validity; and
- quantitative descriptions in physical or natural units of measure and/or monetary units of the effects of the option under each impact category, including any assumptions specific to the impact assessments or comments on their robustness and validity.

The impact types and categories that form the backbone of the ASTs, both the High Level Screening and Main Assessment, are defined in Table 3.3.

Table 3.3 Revised types and categories of impacts included in the MA-AST

Types	Categories	Category description
Economic Reflect impacts that affect goods and services that can be readily valued or that affect the local, regional and national economy.	Assets	Includes flood damages and/or losses relating to (permanent and temporary) private and public property such as residential, industrial and/or commercial property, caravan parks, public buildings (for example, schools, hospitals) sewage and water supply networks, pipelines, etc.
	Land use	Includes flood damages to land used for agricultural, industrial, urban, forestry and commercial fisheries purposes.
	Transport	Includes impacts to roads, bridges, railways and navigation.
	Business development	Includes regeneration/development and competitiveness. Regeneration includes impacts on the creation of sustainable communities, i.e. economic development and development or maintenance of social cohesion. Important indicators include: • creation (or not) of jobs; • enhancement of local environment; and • enhancement of social and leisure opportunities. Competitiveness includes impacts to businesses (their costs, investment, market structure, etc.).
Environmental Reflect impacts that affect the natural and built environment.	Physical habitats	Includes impacts to terrestrial (including coastal), aquatic and marine habitats and biodiversity, its conservation designations, and its flora and fauna.
	Water quality	Includes impacts on biological and chemical quality of surface and groundwater water. Important indicators to consider include: • chemical and biological GQA grades; • river quality objectives; • consented and un-consented discharges; and • designated bathing waters.
	Water quantity	Includes impacts on the water levels and water supplies (such as drainage and run-off).

Table 3.3 Revised types and categories of impacts included in the MA-AST

Types	Categories	Category description
	Historic environment	Includes impacts on heritage, archaeological and geological features.
	Landscape and visual amenity	Includes impacts on the appearance of the land (its shape, colour, and particular features), its landscape designations as well as its agreeable nature.
	Natural processes	Includes impacts on flow dynamics, sediment transport, geomorphology, etc.
Social Reflect impacts that affect the general public and their way of life.	Recreation	Includes impacts on the processes or means of entertainment. It includes angling, informal recreation (walking, sunbathing, picnicking, sitting, swimming, etc.) and formal recreation (sports and other activities that require specific equipment).
	Health and safety	Includes impacts such as risk to life or serious injury, stress and anxiety (mental health and livelihood) and other health effects, such as those created during the construction phase of the project (noise and air pollution, for example).
	Availability and accessibility of services	Includes impacts on availability and accessibility to public services such as education, housing, emergency and cleaning services, health, cultural facilities and other.
	Equity	Includes distribution impacts (consideration of interests of all groups of stakeholders), impacts on vulnerable groups (such as the elderly, children, etc.) and social tensions (rise of serious divisions and conflicts within the community).
	Sense of community	Includes impacts on local community, level of satisfaction with neighbourhood, social networks and community expectations.

Carrying on from the screening exercise, the assessment of impacts is carried out following a stepped approach moving from a qualitative to a quantitative assessment of all relevant impacts categories.

This stepped approach to the assessment of impacts – qualitative assessment followed by quantitative assessment – is important and should be respected as it functions as an awareness and progressive learning tool. By understanding both the qualitative and quantitative features of the impact, the practitioner has a better insight into the gaps in information that surround it and the way in which it relates to other impacts. In this way, the practitioner is in a better position to avoid double counting and reduce the uncertainty of the assessment.

It is important to note that the qualitative and quantitative assessment using the MA-AST is highly unlikely to be more time and resource consuming than the current impact assessment practice. In fact, because it structures and organises the analysis it should save time in the long run, as information will be presented in the same location in the report and it will be much easier to find.

It is also important to note that the ASTs presented here are not intended to constitute an inflexible framework, but a general framework for the assessment. The impact categories are not fixed and can be further subdivided into sub-categories as required for the area being assessed. This is particularly important in cases where the impact category includes different aspects of the same issue and positive impacts coexist with negative ones. For example, in relation to the physical habitat impact category, it may be the case that a specific habitat is lost but another (different) one is gained as a consequence of a certain option. Both of these sub-impacts should be accounted for. Hence, the impact category should be divided into sub-categories referring to distinct habitat types for the assessment.

3.6 Determination of tangible benefits and costs (Step 6a)

Following the qualitative and quantitative assessment (and depending on the impact category) the appraisal can follow one of two routes:

- monetary valuation (Step 6a); or
- scoring of impacts (Step 6b – Section 3.7).

The monetary valuation follows the traditional CBA-based approach set out in FDCPAG 3 (MAFF, 1999). Besides the straightforward valuation using methods related directly to market prices, FCDPAG 3 also identifies benefits transfer (BT) as a viable method[4] for valuation of impacts during the appraisal process. In addition, the Green Book has acknowledged the increasing scope for using BT methods as databases expand (HM Treasury, 2003). For this reason, benefits transfer (BT) is included within this expanded assessment methodology for certain categories of environmental impact, where this is considered robust.

The use of BT has been steadily increasing in recent years, the underlying assumption being that existing valuation studies can provide a reasonable indicator of the value of an environmental change for another site and decision context.

Outside of the field of flood and coastal defence, guidance on the use of benefits transfer has been developed for application to scheme, strategy and policy level appraisals, with the most relevant including:

- guidance on the assessment of recreation benefits developed for the Environment Agency (Eftec, 2003)
- guidance developed for the Environment Agency for assessing River Basin Management Plans and designation of heavily modified water bodies (HMWBs: CEH 2003)
- guidance used in AMP4 on assessing the costs and benefits of non-statutory water quality and water resource schemes and water company resource development plans. This guidance covers impacts relevant to both freshwaters and coastal/estuarine waters.

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[4] FCDPAG 3 identifies benefits transfer as a viable option at the pre-feasibility stage of the appraisal of options. The purpose of the pre-feasibility study is to determine whether a scheme is likely to be justified, and whether it is worth investing in more detailed studies (MAFF, 1999).

In this context, the application of a benefits transfer approach structure should be based on the following steps:

Step 1: identification of the impact category of concern (from S-AST);
Step 2: description of the nature of any impact in terms of the physical changes that will take place under a given option (from MA-AST);
Step 3: selection of a relevant BT estimate by examining the set of available values for the type of change under consideration; this should take into account the applicability of the original study and, hence, value to the option being assessed;
Step 4: adjustment of the benefit estimate(s) as appropriate to suit the decision context;
Step 5: quantification of the affected population (user and/or non-user);
Step 6: calculation of the benefits by multiplying the transfer value by the affected population and aggregating; and
Step 7: undertaking of a sensitivity analysis.

More detailed guidance on how to apply the benefit transfer method in flood and coastal erosion risk management was developed as part of this study. This is presented in Annex A to this Report, for brevity.

3.7 Scoring of impacts (Step 6b)

For those impacts that cannot be valued in monetary terms, scoring (Step 6b) can provide a way of allowing the impacts to be quantified, compared and aggregated. The approach to scoring has to provide a way for those impacts that cannot be monetised to be captured and presented in numeric terms, as well as to reflect the proportionality of the differences in impact across options.

Hence, the scoring system has two main aims:

- to allow all of the impacts caused by options to be reflected in the appraisal. Scoring aims to minimise the number of impacts and impact categories that, because they cannot be valued in monetary terms, are not explicitly considered in decision-making. It does this by assigning a number value to the impacts based on information specific to a particular impact category. This means that all of the impacts are then presented in the same units and can be combined (through weighting - Step 7) to give an indication of the overall intangible impacts of each option; and
- to reflect the proportional differences in impacts between options. For scoring to be robust, the data upon which the scores are based must be able to identify the impacts of each option and the differences between them.

In mathematical terms, a range of different approaches can be used in the scoring of impacts. Numerical ranges can be developed based on standard measurement units for different impacts and scores assigned against these. Alternatively, qualitative descriptors and associated scores can be used in cases where there are no natural units of measure. Owing to the flexibility of MCA systems, quantitative and qualitative descriptors can be used alongside one another.

In general, a balance must be struck between level of detail and the need for simplicity. This means that the measure upon which scoring is based should be sufficiently detailed to enable a robust appraisal but simple enough to allow easy application. In addition, the complexity of the scoring system should be in line with the level of accuracy surrounding the data that will be used as the basis for assigning the scores (RPA, 2000).

In the context of this study, and taking into consideration the level of appraisal being undertaken, the most appropriate scoring systems are:

- qualitative scoring, for high level (policy) appraisal;
- scores ranging from zero or 1 to 100, for strategy level appraisals; and
- scores assigned are relative to 100, for scheme level appraisals.

In the first case, scores are assigned using a series of qualitative descriptors, similar to those recommended by DETR (2000), but modified for their use in scoring. The advantage of this approach is that it avoids the need to find a numeric basis for the scores, when most of the information provided is qualitative. However, it has the disadvantage of not being able to reflect the proportionality of impacts across the options, being more difficult to ensure that the descriptors are always applied in the same way and not being as transparent as other methods.

In the second case, a score of 100 is used to reflect the best that can be achieved and is assigned to the ‘best’ performing option (i.e. that with the greatest level of benefits or the lowest level of dis-benefits). Similarly, a score of zero or one is the worst that can be achieved and would be assigned to the ‘worst’ option. All other options are then scored relative to the best and worst options as this sets the range into which the other options must fit. This approach has the advantage of reducing the number of options for which scores have to be derived, making the scoring exercise simpler. It also links the scores to a numeric basis (even one which is uncertain) and ensures transparency is maintained. However, when a small number of options are being appraised the scores tend to be polarised which may not always reflect the real situation in terms of differences between impacts. Also, when impact can only be described in qualitative terms, it is difficult to find a basis for the scoring.

The alternative approach is to assign the ‘best’ option a score of 100 and then score all other options relative to 100. In this case, the spread of scores is determined by the differences between the options. This approach may require more data and it can be difficult to assign the scores without a good understanding of the implications of the differences between the options. Besides linking the scores to a numeric basis and ensuring transparency, it also allows for better reflection of the proportionality between all options. However, like the previous approach, when an impact can only be described in qualitative terms, it is difficult to find a basis for the scoring.

It is also considered that the process of scoring on a quantitative basis, even when it is difficult and uncertain, helps the practitioner to better understand the uncertainty that surrounds the scoring, the magnitude of the impact, and, most importantly, the proportionality between impacts and options. Without this knowledge, uncertainty can be greatly augmented and information on the relative importance of impacts can be lost.

3.8 Weight elicitation and constrained random weight generator (Step 7 and 7a)

3.8.1 Weight elicitation

Once the scoring has been undertaken, the next step within the process is to apply the weighting factors across the different impact types and categories. The purpose of weighting is to identify the relative importance of the different impact categories and thereby, assign weight to the individual scores within each category.

Weighting allows scores to be aggregated in such a way that they reflect people's preferences for one category of impacts over another. It allows these preferences to be identified and taken into account, and enables the relative importance of changes in one impact category to be compared to changes in another category.

It is important to note that, should no explicit weights be assigned to attributes, this would imply that each is weighted equally and, thus, 1 point on a 0-100 score for one category (for example, 'environmental impact') would have the same value as 1 point on the 0-100 score for another (for example, 'economic impact'). Clearly, this is unlikely to hold across all impacts, and so weights must be introduced to express the relative value of scores across impact types and categories.

The process of gathering weights for input to MCA is arguably the most time consuming and controversial part of the MCA-based process. The fundamental problems affecting the process are in determining whose weights are to be used and ensuring that the weights are credible and justifiable.

A variety of approaches exist to elicit relative impact weights, ranging from ranking methods, swing weights procedures, trade-off assessment and development of utility functions and the analytical hierarchy process (AHP).

In the context of the MCA-based methodology developed here, three different approaches are suggested:

- use of stakeholder responses to formal consultation to develop weights that reflect the relative (and proportional) differences in importance. This is an indirect method, which may be useful for preliminary or high level assessments. It has, however, several disadvantages such as the fact that stakeholder responses do not always provide enough information and can be difficult to interpret. Use in practice would also require a more structured and sophisticated approach to stakeholder consultation;
- the use of rankings of impact categories. This is a direct method, can be undertaken in groups or individually, and can be carried out at the type, category or objective levels. This method has the advantage of making clear the trade-offs involved in the appraisal and allowing for potential resolution of conflicts; and
- the use of swing weighting procedures through either focus groups or computer-based methods. This is a direct method, can be undertaken in groups or individually and follows from the ranking exercise. The category ranked as most important is assigned a weight of 100. The second most important category is then weighted in relation to this and so on; stakeholders are asked how important the second ranking category is compared to the first ranked category. For example, if it is considered half as important, it would be assigned a weight of 50. This method has the advantage of making clear the trade-offs involved, and if carried out in a group allows for potential resolution of conflicts.

3.8.2 Constrained random weight generator (CRWG) analysis

Active weight elicitation can be a time and resource consuming exercise besides being a controversial stage of the approach. It introduces subjectivity into the appraisal and it is always difficult to define whose weights should be used in the appraisal.

Given this, an additional method was developed to focus the weight gathering on the issues that actually influence the outcome of the analysis. This new method was based on the idea that, depending on the scores, there are occasions where one option will always be preferred over another regardless of the relative weights placed upon the different categories. In such cases, the gathering of weights is an unnecessary ‘formality’. This suggests that rather than ask the question ‘what are the relative weights for these criteria?’ at the outset, useful information may first be gained from considering ‘what would the weights have to be for the option to be the preferred option?’ This method is called the Constrained Random Weight Generator (CRWG) Analysis.

The way the CRWG works is simply to randomly generate sets of weights for a given appraisal (at a rate of 3,000 per minute) and record the resulting total weighted scores for the options and the weights that produced them. Further details on the CRWG and weight elicitation in general are given in Sections 5 and 6.

3.9 Comparison of options (step 8)

At the end of Step 7, data in the two following formats are produced:

- economic information contained in the FCDPAG 3 spreadsheets;
- completed ASTs containing the qualitative, quantitative and scored impacts; and
- total weighted scores for each option.

The aim of this next stage is to bring these different types of data together to allow the performance of the alternative options to be compared.

In the absence of any other costs and benefits, a full MCA would usually examine whether one option scores more highly than another; the option with the highest weighted score being the 'best' option from the point of view of intangible benefits. However, in flood and coastal defence there are other (monetary) benefits and costs that must also be taken into account. As a result, the value of the intangibles denoted by a weighted score is only one part of the overall benefit-cost equation.

A system for integrating the economic valuation with the weighted scores was created by developing the existing summary worksheet from the FCDPAG 3 spreadsheets and adding to it.

The accepted methodology for identifying the preferred options and prioritising flood and coastal defence projects is based on maximising the benefit-cost ratio, where the benefits are the estimated reduction in tangible damages from the 'do-nothing' option.

For this approach to be extended to incorporate a weighted score for intangibles (over a range 0 to 100), we would need to maximise the expression:

{Monetary benefits (in £s) + Intangible Benefits (in £s)}/Monetary Costs (in £s).

Clearly, however, the value of intangible benefits is not a monetary value (i.e. in £s) but is a unitless weighted score in the range of 0 to 100. To permit an analysis of intangible benefits in £s (so that we can examine the maximisation of the benefit-cost expression), a valuation factor equivalent to the value of a single point on the index is required where this has been termed 'k'. Thus:

Intangible Benefits (in £s) = k x I

where: I = the total weighted score for the option given by the MCA
k = variable valuation factor (simply £/point and always >0)

Integrating this into the benefit-cost expression gives the following:

Overall Benefit Cost Ratio = B/C + (k I)/C

where B = monetary benefits (damages avoided) for each option
C = option monetary cost
I = the total weighted score for the option given by the MCA
k = variable valuation factor (simply £/point and always >0)

The effect of applying this expression is that selection of the preferred option can be based on both the monetary benefit-cost ratio and the intangible benefit-cost ratio. This is done by considering how much the intangible benefits must be worth (at least) in pounds (£) for an option to be preferred over the previous option.

Further details about the comparison of options stage is given in Section 6.

3.10 Testing the robustness of the choice (Step 9)

Testing the robustness of the choice should follow the guidance provided in FCDPAG 3 – economic appraisal and in FCDPAG 4 – approaches to risk (MAFF, 1999 and 2000b). These mostly deal with sensitivity testing relating to the CBA approach currently adopted. It can, however, be adapted to include the MCA-based component of the appraisal process.

The first step of the sensitivity analysis should be to determine those factors that would have an impact on the choice made. These could include uncertainty regarding the costs of options or the monetary benefits associated with a particular option, or they could relate to uncertainty surrounding the scores and weights.

Once the most important factors have been identified, the assessment of the robustness of those factors should be based on experience and judgement (MAFF, 1999). Even where it is not possible to quantify the uncertainty associated with each variable, it should be possible to reach a judgement about a reasonable range of possibilities to be considered. The possibilities can then be tested, by varying key assumptions and assessing the effect of any changes on the selection of the preferred option.

4. Case study criteria analysis and selection process

4.1 Overview

This section illustrates the process of identifying the criteria that were used for the selection of the case studies and how the final group of case studies was identified.

4.2 Analysis of selection criteria for the case studies

The MCA-based methodology specific to flood and coastal erosion risk management was developed with the aim of:

- widening the decision-making process;
- providing greater transparency on environmental and social issues;
- increasing the efficiency and effectiveness of stakeholder involvement; and
- leading to improved effectiveness of investment decisions.

In order to further develop the methodology and produce a practical and workable system, use was made of real time case studies. This task was carried out in two stages. In the first stage, four case studies were selected as the first trial cases. Another three cases were examined later, in the light of the results of this first step. This allowed for the methodology to be modified and/or improved as the case studies were undertaken.

It was considered important to carry out real time case studies for the following reasons:

- data would be readily available and/or knowledge of the area would be held by client/consultants working on the relevant projects;
- the main stakeholders would have been identified, forming an easily accessible group that can be used to elicit weights, if appropriate;
- a decision would not have been taken as to the preferred option on these schemes; hence, there would be no potential for the new methodology to contradict what has already been decided, reducing the chance of sending conflicting messages to stakeholders (including the general public); and
- conflicts and trade-offs would have been already identified allowing the use of a range of projects from straightforward to contentious in assessing the performance and added value of the methodology.

Of the case studies, and since the new framework would be applicable to both coastal defence and river management, it was suggested that four would illustrate the coastal/tidal situation, while the other four would cover appraisals of riverine projects.

The case studies were intended to test the methodology being developed, in particular with regard to the following:

- ability to be applied to all three levels of decision, i.e. High level plans and policies (SMPs and CFMPs), strategy level and scheme level;
- consistency across the three levels, i.e. the same general framework to be applied in all situations to ensure consistency across decisions but with the potential for expansion in particular circumstances. In addition, the case studies should also help to address:

  (i) the level of detail of the appraisal at different levels;
  (ii) the completeness of the list of impact categories and sub-categories chosen for flood and coastal management;
  (iii) the issue of consistency throughout the decision-making hierarchy when using the same categories of impacts at all levels but varying the levels of detailed information; and
  (iv) the levels of guidance that will be necessary for the qualitative and quantitative assessments of the impact of the several options of a project.
- applicability and repeatability, i.e. test the decision rules that are associated with the methodology, the choice of scores and weights and the applicability of the new appraisal approach by end users;
- levels and stages of stakeholder involvement, i.e. who are the most suitable stakeholders at each level? and what are the most suitable participation techniques? and
- format and presentation of the results, i.e. testing the flood and coastal management AST.

In this context, the following list sets out the main criteria that were used to choose the case studies. This list developed as the work progressed, but it was considered essential that each case study:

- would be representative of one of the three decision levels;
- would have a developed set of options;
- would have details of quantified costs and benefits;
- would have identified groups of stakeholders;
- would be representative of a high value/large project, or be representative of low value/small project;
- would be representative of a similar stretch of coast or river; and
- would be varied in the nature of impacts.

In addition, when choosing the case studies the geographical distribution of the cases and type of impacts (i.e. rural vs. urban) were also taken into account.

4.3 Selecting the first set of case studies

In order to identify suitable case studies, RPA canvassed a wide range of flood and coastal defence managers for interesting examples to test the MCA-based component to the appraisal process. The response to the request was fair and provided a reasonable set of projects from which a short-list of case studies could be drawn up:

- River Douglas flood defence strategy;
- Dymchurch coastal defence scheme;
- River Frome flood defence strategy;
- Pagham to East Head coastal defence strategy;
- River Chet flood alleviation scheme;
- Kelling Hard to Lowestoft shoreline management plan;
- Humber Estuary shoreline management plan;
- Upper Don flood defence strategy;
- Sandwich Bay coastal and tidal defence strategy; and
- Dungeness coastal defence scheme.

The case studies had to be representative of the three levels of decision-making. This meant that there would have to be one case study for High level, one for strategy level and one for scheme level. It was thought important to have two case studies at strategy level since there has been a tendency to move the funding decision to this level of decision-making. In addition, there would need to be two coastal projects and two river projects since the methodology is to be applied to both river and coastal flood defence.

From the short-list produced, there were only two projects that constitute a High level case study and they were both coastal, namely the Humber SMP and the Kelling Hard to Lowestoft SMP. Of these two projects, the Kelling Hard to Lowestoft SMP was selected because it constituted a pilot project in the development of the SMP procedural guidance being developed by the Government, it had a good record on consultation and RPA has a well established working relationship with the consultant in charge of the project.

The choice of coastal strategies was between the Pagham to East Head project and the Sandwich Bay project. Both schemes seemed to perform well against the chosen criteria, however, the track history of the Sandwich Bay project advised against its selection. In addition, the Pagham to East Head project involved a wider array of issues/impacts (related to conservation and recreation) making it a more interesting test of any methodology.

The choice for coastal scheme was between Dymchurch and Dungeness coastal defence schemes. The Dymchurch coastal scheme, which is currently being promoted, had a number of interesting issues associated with changing the agreed strategy, stakeholder involvement and integration between the different levels of decision-making, in particular in between the strategy and scheme level. Dungeness incorporated a major land feature belonging to the Ministry of Defence, which constituted an atypical case and, therefore, less interesting for research purposes. Also, there was more information available on the Dymchurch case study and, hence, it was decided to include this in the first round of case studies.

For the case study of a river strategy, there were three possibilities: the River Douglas, the River Frome and the Upper Don. Both the River Don and the River Frome include urban stretches. In addition, both consultant groups in charge had shown considerable interest in working with RPA in testing any MCA-based methodology.

Although the River Frome was at an earlier stage of development, it had the advantage of planning to use a MCA-based approach in its consultation. For this reason, the Frome was selected initially for the first round of case studies. However, as the work progressed, it became apparent that it would be impossible to pursue this project as a case study. The strategy had been suffering from some drawbacks that were not predicted at the beginning, which means that its progress was very slow and that it was no longer compatible with the MCA project time frame.

The Frome was substituted by the River Don strategy. This project had most of the characteristics that made the Frome a good case study. In addition, it was close to its finishing stages, which meant that the data would be readily available and we would be able to progress at an accelerated pace.

To complete the first set of case studies, the choice of a riverine scheme was reduced to the River Chet project. The River Chet was an interesting project because it involved a significant number of issues including both environmental and social impacts that would need to be addressed. Also, the scheme was local to RPA's offices and information was readily available.

In summary, the first set of case studies was:

- Kelling Hard to Lowestoft SMP;
- Pagham to East Head coastal strategy;
- Dymchurch coastal scheme;
- Upper Don flood defence strategy; and
- River Chet scheme.

4.4 Selecting the second set of case studies

The second round of case studies was started with the selection of three further case studies. The selection was based on the short list drawn up for the first round of case studies, taking into consideration the types of case studies already being investigated and suggestions received during steering group meetings.

Comments received during the advisory group meetings indicated a concern that all coastal projects selected had the Environment Agency as the statutory authority. As such, the Newbiggin-by-the-Sea strategy was selected on the basis that it was a project being managed by a coastal authority as a coastal protection project.

The Humber Estuary was chosen as a case study because, being an estuary, it included both riverine flood issues and coastal protection issues. Also, managed realignment was a very important factor, which in turn would raise interesting social and environmental issues. A vast amount of work has been carried out on the Humber, thus there were significant amounts of information available on this project, as well as a positive working relationship with the team in charge.

Finally, during discussions regarding the case studies, it was also highlighted that urban flood defence issues were being under-represented; therefore the River Douglas strategy was selected.

However, as work progressed, it became clear that it would be difficult to pursue this case study mainly because the project itself was progressing slower than initially expected. The River Douglas case study ended up being abandoned and 'substituted' by the River Don case study (from the first set); progress on this had also been impaired by delays but seemed to be moving relatively well at this time.

The three case studies pursued in the second round were:

- Newbiggin-by-the-Sea coastal defence strategy;
- Humber Estuary shoreline management plan; and
- River Don flood defence strategy.

5. Results from the first set of case studies

5.1 Introduction and overview

The first set of case studies had three main aims:

- to test the use of ASTs in the impact assessment stage of the appraisal;
- to test the applicability and robustness of the impact categories that form the backbone of the ASTs; and
- to screen out and develop scoring and weighting systems suitable for flood and coastal erosion risk management.

The following sub-sections go through the different steps of the MCA-based methodology and describe how they have been approached in the first set of case studies and how the case studies have influenced the development of the different appraisal tools.

As was referred to in the last section, the first set of case studies was composed of the following projects:

- Kelling Hard to Lowestoft SMP;
- Pagham to East Head coastal strategy;
- River Chet scheme; and
- Dymchurch coastal scheme.

Table 5.1 provides a brief description of each of the case studies. The appraisal reports using the MCA-based methodology can be found in Annexes B1 to B4 of this report.

Table 5.1 First set of case studies and brief description

Case study name	Brief description	Case study annex
Kelling Hard to Lowestoft SMP	The project area for the SMP is along the North Norfolk coast from Kelling Hard to Lowestoft Ness. Of the whole SMP, three management units were selected to cover as wide a range of issues as possible. They were: (i) Cromer (urban frontage); (ii) Winterton (rural frontage with important environmental assets); and (iii) Trimingham to Mundesley (mixed urban/rural frontage with cliffs designated as SSSI). This SMP has been identified as one of the three pilot regions to serve as work examples for the second round of SMPs that is being undertaken to assist in the development of the new SMP Procedural Guidance	B1
Pagham to East Head coastal strategy	The project is situated in the South East of England and extends from Pagham Beach in the east to East Head (entrance to Chichester Harbour) in the west. It includes a mix of sea defence and coastal protection. Of the whole of the Strategy, two management units were selected for the appraisal to cover as wide a range of issues as possible. They were: (i) Medmerry (mostly rural with relatively important environmental and historical assets); and (ii) East Wittering (urban frontage). Our interest in the Pagham to East Head Coastal Strategy was due to the fact that the initial strategy seemed to encounter significant problems in impact valuation and its integration in the decision-making process.	B2
Dymchurch coastal scheme	The stretch of coast between High Knocke and Dymchurch Redoubt lies within Shepway District in Kent, between St Mary's Bay and Hythe. The landscape is characterised by the massive Dymchurch wall and the three Martello Towers, which protect the town and surrounding settlements. Dymchurch is also recognised by its tourism interest, in particular its sandy beaches, which is being threatened by erosion. Our interest in the Dymchurch Scheme was in terms of stakeholder involvement and the integration between the different levels of decision-making, in particular between the strategy level and the scheme level.	B3
River Chet Flood Alleviation Scheme	The River Chet runs for approximately 3.5 miles, from the town of Loddon until it joins the River Yare, between Cantley and Reedham, in Norfolk. The river is narrow in places, wooded at first, then as it nears Hardley Cross it becomes more canal-like, with extensive grazing marshes. Our interest in the River Chet alleviation scheme was based on it being a local project, which has been facing problems relating to conflict between stakeholders. There seems to be significant controversy in relation to which options to consider for appraisal.	B4

It is important to note that these case studies were being developed in parallel to the methodology. Although they followed a similar approach (as presented in Figure 3.1), some of them tended to focus more on the development of specific tools being used within the assessment. For example, the Dymchurch coastal scheme was used to trial and further develop the ASTs, the Kelling Hard to Lowestoft SMP was mainly used as a first test of different scoring systems and the River Chet and Pagham to East Head coastal strategy case studies were used as first trials of the weight elicitation techniques. Nonetheless, the different tools being trialled in the specific case studies were then applied to the other case studies for further testing and fine-tuning.

5.2 Definition of problem, objectives and description of options (Step 1 and 2)

As stated in Section 3, the aim of this step is to make explicit the objectives of the assessment and to describe the management options carried forward to appraisal. For all of the case studies, this stage started with a definition of the case study itself. This included:

- an introduction to the project area, including a summary of its main features;
- an explanation of the background to the flood management or coastal defence problem;
- an introduction to the policy context specific to the project (including information such as its client, consultant in charge and history of the project); and
- a list of stakeholders and interested parties.

Following the presentation of the background to the project, the objectives and chosen management options were clearly stated.

This step was developed mainly using information provided by the client and consultant. Additional sources of information included:

- reports being prepared for the ‘traditional’ appraisal, such as stakeholder consultation reports, environmental and/or strategic impact assessment reports;
- reports prepared by third parties on the proposed project;
- in case the project was being revised, reports produced for the first version of the project; and
- any other information that might be considered useful.

In addition, one to one consultation with the project consultants and the client team provided valuable information.

It is worth noting at this point that the information presented in the case study specific reports is sometimes modified to fit the purpose of testing the MCA-based methodology (although they were kept as close to reality as possible). The case study specific reports should not be considered ‘authentic’ as they involve re-appraisals of the project.

For this same reason, the screening of unreasonable options (Step 2) was not undertaken in as a separate step, as information was not always available to allow RPA to describe the process.

5.3 Structuring the problem (Step 3)

The aim of this step of the approach is to break the problem into its component parts, identifying the set of impacts and associated criteria that will be used to make the decision.

With this aim in mind, a high level screening was undertaken to identify which impact categories were likely to be relevant to the area being assessed. It became apparent from the appraisal of the first few case studies that this stage would benefit from a structuring tool that would ensure consistency among the different projects being assessed and that would set out the structure of the future assessment.

For this reason, the appraisal summary table for high level screening (S-AST) was developed during the appraisal of the Dymchurch coastal scheme case study and then tested for usefulness and practicability in the remaining case studies.

The first step in development of the AST involved defining the impact types and categories that would form the framework for the appraisal process, both during the screening and during the main assessment of impacts. The list of impact types and categories had to be as comprehensive as possible, but had to stay within the remit of flood management and coastal defence and, most importantly, had to be manageable not only for practitioners but also for stakeholders. In short, the list of impacts considered had to strike a balance between completeness and workability.

The development of impact categories was completed mainly following guidance from the Flood and Coastal Defence Project Appraisal Guidance (FCDPAG) series (MAFF, 1999-2001), the Environment Agency Receptors and Resources Checklist (Environment Agency, 2000), the Integrated Policy Appraisal tool, the '*Prompt list of social issues likely to arise from Agency flood defence schemes*' (Environment Agency, 2001) and other water resource management methodologies. The idea was to create a framework that included and integrated all major appraisal tools that may be useful in flood management and coastal defence.

A list of the impact types and categories tested in the first round of case studies is presented in Table 5.2.

Table 5.2 Initial list of impact types, categories and subcategories for use in the MCA-based methodology

Impact category	Impact subcategory
Economic impacts	
Assets	Private property
	Public infrastructure
Public accounts & services	Emergency costs
	Clean-up costs
Agriculture	Land use change
	Agricultural output
	Damage to infrastructure
Navigation	Commercial/industrial navigation
	Leisure navigation
Competitiveness	Small businesses
	Large businesses
	Other
Public sector	Public sector
Environmental impacts	
Landscape	Topography
	Cultural
	Land cover
Water	Water quality
	Water quantity
	Flow dynamics
	Resource adequacy
Biodiversity	Physical habitats
	Conservation importance
Sea level rise	Sea level rise
Noise nuisance	Noise level
Historical environment	Heritage sites
	Archaeological sites
Social impacts	
Recreation	Formal recreation
	Informal recreation
Amenity	Residential amenity
	Commercial amenity
Public health & safety	Risk to life
	Stress/anxiety
	Other health and safety effects
Community	Sense of community
	Availability & accessibility to services
Distribution impacts	Impacts on vulnerable groups
	Social tensions
Cross-cutting impacts	
Regeneration	Regeneration
Policy integration	Local
	Regional
	National
Public participation	Local
	Regional
	National

In terms of ‘design’ (see Table 3.1, Section 3), the S-AST has cells to include the following types of information:

- the project name with an indication of the level of decision being taken;
- whether the impact category would be taken forward to the main assessment;
- if the impact category was to be taken forward, qualitative descriptions of the effects of the ‘do-nothing’ option for each of the impact categories, including any assumptions specific to the impact assessments or comments on their robustness and validity; and
- whether the valuation of the impact category would be carried out using monetary valuation or scoring.

The qualitative description of the ‘do-nothing’ option was introduced here because it would serve as a good basis for the future assessment of the different options and because it would have to be used later in the process.

It was clear from the application of the S-AST to the first set of case studies that:

- it was very useful in ensuring consistency and transparency across appraisals, since all case studies were appraised using the same checklist of impacts and, therefore, the likelihood of omission of impacts was greatly reduced; and
- it was very successful in providing an initial indication of the type of issues and information that would have to be dealt with and gathered for the main assessment of the project.

Nonetheless, from the use of the S-ASTs (and later on during the use of the MA-ASTs and the scoring exercise) in this first set of case studies, it became clear that the number and type of impact categories defined initially were making the process very complex and time consuming.

For this reason it was decided that the initial list of impact types and categories (Table 5.2) would be modified by removing some of the categories which, through further analysis, were deemed not as relevant in terms of flood management and coastal defence. This allowed the list to be collapsed, making the process simpler. The set of revised impact types and categories is presented in Table 5.3. This was then further tested in the second set of case studies.

Table 5.3 Revised list of types and categories of impacts

Types	Categories	Category description
Economic	Assets	Includes flood damages and/or losses relating to (permanent and temporary) private and public property such as residential, industrial and/or commercial property, caravan parks, public buildings (for example, schools, hospitals) sewage and water supply networks, pipelines, etc.
	Land use	Includes flood damages to land used for agricultural, industrial, urban, forestry and commercial fisheries purposes.
	Transport	Includes impacts to roads, bridges, railways and navigation.
	Business development	Includes regeneration/development and competitiveness. Regeneration includes impacts on the creation of sustainable communities, i.e. economic development and development or maintenance of social cohesion. Important indicators are: • creation (or not) of jobs; • enhancement of local environment; • enhancement of social and leisure opportunities; and • use of potential of existing natural assets. Competitiveness issues include impacts to businesses (their costs, investment, market structure, etc.).
Environmental	Physical habitats	Includes impacts to terrestrial (including coastal), aquatic and marine habitats, its conservation designations, its flora and fauna and its geomorphology.
	Water quality	Includes impacts on the biological and chemical quality, and litter of surface and groundwater water. Important indicators to consider are: • chemical and biological Good Quality Status grades; • river quality objectives; • consented and un-consented discharges; • biological and chemical sampling sites; • designated bathing waters; and • legislation, policies, strategies or plans relevant to site/receptor affected by impacts.
	Water quantity	Includes impacts on the water levels and water supplies, as well as flow dynamics (such as drainage, run-off, and sediment transport).
	Historic environment	Includes impacts on heritage, archaeological and geological important features.
	Landscape and visual amenity	Includes impacts on the appearance of the land (its shape, colour, and particular features), its conservation designations as well as its agreeable nature and usefulness.
Social	Recreation	Includes impacts on the processes or means of entertainment. It includes angling, informal recreation (walking, sunbathing, picnicking, sitting, swimming, etc.) and formal recreation (sports and other activities that require specific equipment).
	Health and safety	Includes impacts such as risk to life or serious injury, stress and anxiety (mental health and livelihood) and other health effects.
	Availability and accessibility of services	Includes impacts on availability and accessibility to public services such as education, housing, emergency and cleaning services, health, cultural facilities and other.
	Equity	Includes distribution impacts (consideration of interest of all groups of stakeholders), impacts on vulnerable groups (such as the elderly, children, etc.) and social tensions (rise of serious divisions and conflicts within the community).
	Sense of Community	Includes impacts on the local community, level of satisfaction with neighbourhood, social networks and community expectations.
Cross-cutting	Policy integration	Includes impacts on pre-existing policies and programmes, such as planning and environmental policies, at all levels.

5.4 Impact assessment for the first set of case studies (Steps 4 and 5)

The main impact assessment stage of the MCA-based methodology is developed around the use of the appraisal summary table for the main assessment (MA-AST).

As was stated above, the MA-AST is a tabular summary of the main economic, environmental and social impacts of a proposed option, whether relating to a policy/programme, strategy or scheme. A MA-AST is produced for each alternative option, and it sets out simply and concisely the key consequences of the different options for tackling flooding and/or coastal erosion.

The concept of an AST originated as a means of improving the approach taken to assessing the impacts of road construction schemes (namely "*New approach to appraisal*" (DETR, 1998)), in response to criticism that environmental and social issues were not adequately taken into account. Since then, more recent guidance being developed by Defra, the Environment Agency and other governmental organisations, has been taking this concept on board, in particular in relation to water resource management, as a means of:

- recording impact information in a consistent manner;
- ensuring that a comprehensive range of impacts is considered within the assessment;
- deciding which impacts are most important to the end decision and demonstrating how this was reached; and
- providing a means for others to audit the assessment and accompanying decision-making process.

The aim of the MA-AST is to ensure transparency, i.e. to provide a structure in which all of the reasons for choosing a preferred option are set out in a clear and intelligible manner. In this way, the decision-making process transforms from a 'black box' to a more auditable process.

The MA-AST used in the first round of case studies is very similar in format to the one used during the High level screening and includes the same impact categories. However, it is extended to include cells for recording the following types of information (Table 3.2, Section 3):

- a description of the option being assessed and the defence standard being provided;
- a brief description the area being affected by the option;
- qualitative descriptions of the effects of the option for each of the impact categories, including any assumptions specific to the impact assessments or comments on their robustness and validity; and
- quantitative descriptions in physical or natural units of measure and/or monetary units of the effects of the option under each impact category,

including any assumptions specific to the impact assessments or comments on their robustness and validity.

For each of the case studies, a MA-AST was developed for each of the options being considered. The impact assessment of each of the options followed a stepped approach, moving from qualitative to quantitative assessment.

The qualitative assessment of impacts involved a description of the expected impacts of each option and a preliminary indication of their magnitude, size and severity. The quantitative assessment of the same impacts followed from their qualitative descriptions and it involved the quantification of the change of status using physical data as much as possible.

The need for such a stepped approach to the impact assessment became apparent from the start of the development of the case studies. At the beginning there was some tendency to jump straight into the quantitative assessment of impacts, in particular for those impacts that are easily quantified. However, it soon became clear that skipping the qualitative assessment meant that the process missed some effects, with emphasis on those that could be easily quantified. It constrained the assessment of the impacts because it also led to effects being considered from only one perspective. This made the whole process less transparent and robust.

As initially expected, the quantitative assessment proved more difficult than the qualitative assessment for some of the impact categories. This was for three main reasons:

- depending on the level of appraisal being undertaken, the detail and quantity of information available was variable, with more information being offered for the strategy and scheme levels than for the high level projects;
- some impact categories, in particular those relating to social impacts are more difficult to quantify by nature; and
- there was not enough information available.

This last point should not be used as an argument in favour of skipping the quantitative assessment all together. There were two different reasons for this lack of information:

- on the one hand, RPA did not have access to all of the information available on the project, only to that provided by the consultant and/or operating authority;
- on the other hand, the information available for the projects corresponded to that needed in the context of the current appraisal process, which does not include certain of the aspects being tested for this study under the MCA-based methodology. A good example of this is quantitative information relating to social impacts.

It should, however, be noted that although information on the majority of impact categories was present in the appraisal reports and other studies provided by consultants and the operating authority, the information was in many cases scant, sometimes not what was required and often not organised in a way that was easily accessible. Also, the type of information provided was not consistent throughout the different cases studies, with some projects giving significant amounts of information on specific effects, while others give incomplete information across a range of potential impacts.

In this respect, ASTs may provide a means of addressing such problems in the future. They offer a framework for the appraisal so that all impact categories are at least considered, both qualitative and quantitative information is taken into account, and the information is carefully organised so as to be easily accessible at any time during the appraisal. For those cases where no information is available, this fact can also be recorded.

It should also be noted that the use of ASTs and assessing impacts first qualitatively and then quantitatively does not necessarily mean that the process is more time and resource consuming. It became evident early on that if some of the original appraisals had been carried out using an AST and had considered a defined set of impact categories, it is likely that the information would had been collected in the same time and at the same cost. The difference is that it would have been more focused on the needs of the appraisal.

The use of ASTs therefore, proved to be fundamental in terms of consistency and transparency and efficiency across all of the case studies.

5.5 Tangible costs and benefits - using benefits transfer in the first set of case studies (Step 6a)

Once the impact categories relevant for the decision-making were identified and the effects of each option properly qualified and quantified, the next step of the approach was to evaluate those impacts. This was done either through monetary valuation techniques or, if this was not possible, using scoring and weighting techniques.

Once this stage was reached in the case studies, it was obvious from the screening exercise which impact categories were going to be evaluated using monetary valuation and benefits transfer and which were going to be evaluated using scoring and weighting.

Although the use of standard values is common practice when costing engineering and other capital works and the more traditional flood and coastal erosion risk management benefits, it is not standard practice in the assessment of environmental and social impacts.

During the preparatory work that led to the case studies, the applicability of benefits transfer methods was explored (for example, see RPA, 2003b).

Existing guidance documents (referred to in Section 3.6) cover a series of impact categories. Those with relevance to flood and defence were reviewed regarding the appropriateness of their use in this context. The impact categories reviewed included recreation, landscape, heritage and biodiversity, including non-use values.

During discussions on the development of the MCA-based methodology and consultation with stakeholders, it became apparent that the use of benefits transfer in relation to the valuation of ecology and conservation related impacts (i.e. non-use values) was contentious. Not only were there concerns over the validity of transferring values for such impacts but also in determining the population holding such non-use values. This is important as the aggregation of non-use values, even when these are 'small', across a large population could easily shift a policy or project decision. As a result, it has been agreed to exclude non-use valuation from this study.

Given the above, the benefits transfer values applied to the case studies were taken from the Multicoloured Manual (Penning-Rowsell *et al*, 2003), the Yellow Manual (Penning-Rowsell *et al*, 1992) and from the Benefits Assessment Guidance (RPA, 2003). The approach was used in the following way in the different case studies:

- for impacts on recreation in the Kelling Hard to Lowestoft SMP case study, the values for deterioration of the beach, deterioration of promenade and cliff erosion given by the multicoloured manual (Penning-Rowsell *et al*, 2003) were used;
- for impacts on recreation in the Dymchurch case study. In this project a contingent valuation study was commissioned in order to assign a recreation value to the beach;
- for impacts on recreation on the Pagham to East Head case study, the value for deterioration of the beach, seawall and groyne provided by the Yellow Manual (Penning-Rowsell *et al*, 1992) is used;
- for impacts on formal recreation in the River Chet case study, the value of recreational boating provided by Willis *et al* (1995) is used based on the approach set out in the Benefits Assessment Guidance (RPA, 2003); and
- for impacts on informal recreation in the River Chet case study, where the value per adult visit provided by Coker (1990) is used, again based on the approach set out in the benefits assessment guidance (RPA, 2003)

The following conclusions were taken from the use of benefits transfer in the appraisal of these case studies:

- the benefits transfer method is most useful in valuing impacts on recreation, both for river and coastal projects. This is because these are the studies that are more readily available and most acceptable. Existing valuations are less readily transferred for the other impact categories; and
- benefits transfer, in particular for impacts on recreation, seems to be the current practice, as there are more accessible guidelines for its use (for example, the Multicoloured Manual) and it is accepted by decision-makers as a valid form of assessment.

In the context of the current approach to project appraisal and of the integration of the MCA-based methodology into it, benefits transfer is particularly applicable to the valuation of recreation impacts (including angling). Its use reduces the amount of impact categories for which scoring and weighting is necessary and is consistent with current treasury guidance. It is not clear at this point whether the use of the benefits transfer method should be further explored for other impact categories such as landscape. This would require more in-depth research and constitutes a research project on its own.

5.6 Scoring of impacts for the first set of case studies (Step 6b)

5.6.1 Introduction

For those impacts that could not be valued in monetary terms, scoring was used to provide a way of allowing these impacts to be quantified, compared and aggregated, and most importantly, considered in the decision-making.

As previously mentioned in Section 2, in mathematical terms, a range of different approaches can be used in the scoring of impacts. Numerical ranges can be developed based on standard measurement units for different impacts and scores assigned against these. Alternatively, qualitative descriptors and associated scores can be used in cases where there are no natural units of measure. Owing to the flexibility of MCA systems, quantitative and qualitative descriptors can be used alongside one another.

In order to start testing different scoring systems, the Kelling Hard to Lowestoft SMP was selected as a pilot case study. The idea was to use this case study to select those scoring systems that seemed more appropriate and robust, and to then further test these using the other case studies.

In this context, four different scoring systems were applied to the case study:

- **Zero to 100:** a score of 100 is assigned to the best performing option for each category. The worst performing option is assigned a score of zero. All other options are scored relative to the best performing option.
- **Relative to 100:** the best performing option is given a score of 100. All other options are then scored relative to the best performing option such that the worst performing option is not fixed at a score of zero.
- **Likert Scale:** an approach that is similar to the analytical hierarchy Process (AHP) using a score of 1 for the worst option and all other options scored relative to this up to a maximum score of 9. The scores are assigned based on a series of qualitative descriptors (based on definitions given in DETR (2000) here modified to reflect their use in a scoring, rather than a weighting, system):

  1: equal impact;

3: moderately more beneficial;
5: strongly more beneficial;
7: very strongly more beneficial; and
9: overwhelmingly more beneficial.

Across unit system: an approach based on 1, above, but adapted for use across different geographic assessment units, with the aim being to highlight differences between units at the scoring level and which, as a result, may reduce the number of sets of weights required.

Table 5.4 presents an overview of the advantages and disadvantages of the four scoring systems, based on their practical application to the Kelling Hard to Lowestoft SMP.

Table 5.4 Advantages and disadvantages of scoring systems

Scoring system	Advantages	Disadvantages
1. Zero to 100	• reduces the number of options for which scores have to be derived • links the scores to a numeric basis (even one which is uncertain) and ensures that transparency is maintained	• where there are only two different options the scores are polarised (which may not always reflect the actual situation in terms of differences between the impacts) • where impacts can only be described in qualitative terms, it is difficult to find a basis upon which to score the impacts
2. Relative to 100	• allows better reflection of proportionality between all options in terms of their impacts • links the scores to a numeric basis (even one which is uncertain) and ensures that transparency is maintained	• where impacts can only be described in qualitative terms, it is difficult to find a basis upon which to score the impacts • requires relative scores to be derived for all options (except the best option)
3. Likert scale	• all scores for all categories are based on the same definitions, which avoids the need to find a numeric basis for assigning scores	• some options should score more than 9 to retain proportionality between options • difficult to determine a score based on the qualitative definitions used • difficult to ensure that the definitions are used in the same way for each category (e.g. 'strongly' more beneficial always relates to the same level of additional benefit from one category to the next) • difficult to maintain transparency and auditability when using the definitions as there is often no recordable basis for assigning one definition over another

Table 5.4 Advantages and disadvantages of scoring systems

Scoring system	Advantages	Disadvantages
4. Across unit system	• allows the scores to better reflect differences between the assessment units (this could be picked up by having different sets of weights for each unit – but use of a relative scoring system across assessment units will reduce burdens on stakeholders) • links the scores to a numeric basis (even one which is uncertain) and ensures that transparency is maintained	• where there are only two different options the scores are polarised (which may not always reflect the actual situation) • where impacts can only be described in qualitative terms, it is difficult to find a basis upon which to score the impacts • the units used to measure impacts in one assessment unit are not always the same as for another assessment unit, making comparisons and relative scoring more difficult

The scoring systems were then applied to the other three case studies, with this raising other issues that needed further consideration:

- removing subjectivity from scores when attempting to use non-numeric data as the basis for a numeric score;
- dealing with the relative importance of negative and positive aspects when determining an overall score for a category;
- ensuring that there is no double counting when using the same data to assign scores to different categories;
- accounting for small differences between options;
- comparing the relative importance of issues by unit;
- focusing on differences between options but retaining important information on key points when all options are the same; and
- accounting for uncertainty within data when assigning scores.

These key issues together with the first round of scoring systems and results were circulated to the project team for their consideration and to request possible answers. In addition, some of them were also addressed during the application of the different scoring approaches to the remaining case studies.

5.6.2 Removing subjectivity

Where there is little (or no) quantitative data to which the scores can be linked, it becomes very difficult to assign objective scores. This is highlighted by the approach to scoring 'landscape and visual amenity' for the Trimingham assessment unit within the SMP case study. Here, the score is based on the movement of caravans from their current site to agricultural land within the Norfolk AONB. Whilst this allows the 'best', 'worst' and 'intermediate' options to be identified, there is no objective way of scoring the 'intermediate' option.

The approach to scoring ‘water quality’ for the Dymchurch Scheme case study is another example of the difficulty in assigning objective scores due to lack of data. The water quality in Dymchurch will be affected by the flushing-out of floodwaters from urban and agricultural land. The impacts would depend on the frequency of flooding, on the type and amount of land being flooded as well as the volume of water being flushed-out to sea. However, no quantitative indicator was provided for comparing the impact of the different options being assessed. As a result, the scoring of options was solely based on the frequency of flooding, assuming that the fewer floods occurring, the less the water quality would be affected.

In terms of subjectivity within the scores, it is believed that this was more of an issue because RPA was not directly involved in the original appraisal of the projects used as case studies and therefore did not have access to all available information. The necessary information should be available where the need for it is realised from the outset of the appraisal, as much of the data would be relatively easy to collect alongside the information currently obtained. Nonetheless, there is still the possibility that data may not be available and subjectivity would continue to be a problem.

Also, this issue is directly linked to the level of detail required in the different levels of appraisal, i.e. policy, strategy or scheme level. The Kelling Hard to Lowestoft case study, for example, was a high level appraisal, therefore the required data and information was less detailed and more of a qualitative nature. This fact makes the use of a quantitative approach to scoring less applicable. Just like in the impact assessment stage, there may be a need to have different scoring approaches depending on the level of appraisal being carried out.

5.6.3 Relative importance of negative and positive impacts

Some categories could include both negative and positive impacts and identifying which option is ‘best’ and which is ‘worst’ relies on a judgement being taken as to the relative importance of the positive and negative impacts. The category where this occurred in the SMP case study was policy integration. For this category, the trade-offs between the positive and negative impacts reflect the overall trade-offs that need to be made (i.e. in the weighting). It was considered appropriate, therefore, to remove policy integration as a category that is scored and to use it as a potential method for identifying weights or to verify that the weights applied are appropriate.

In the River Chet case study, the assessment of options in relation to impacts on ‘physical habitats’ experienced similar problems. In the Chet, scoring the impacts of different options on habitats relied on making a judgement regarding which habitat is more important. The ‘do-nothing’ scenario would destroy freshwater dykes and wet woodland but, in the long term, create a washland habitat. On the other hand, an improve option would preserve the freshwater dykes and wet woodland, but would destroy the potential for the creation of a more natural washland habitat.

The best way to deal with this issue was to further divide the impact category into sub-categories, which could be scored independently. For example, in the River Chet case study, the ‘physical habitats’ impact category was further divided into freshwater dykes and wetland habitats. These two subcategories were then scored independently. The next step was two apply an importance weight (based, for example, on Biodiversity Action Plan targets) to each of the subcategories and then aggregate the results to achieve a score for the category as a whole. This process made the scoring much less judgement driven.

The importance weights applied could also be linked to the level of decision being made. For the policy level appraisal, for example, national policy priorities could be used, whilst at scheme level, local priorities, such as Local Habitat Action Plans, should be used.

5.6.4 Avoiding double counting

In some cases there were only a few categories for which quantitative information was directly available. For many others, it was necessary to use the data that were available to infer what the scores should be. This could have resulted in many categories being scored based on the same data. The key issue here is whether using the same data across different categories could result in double counting in that the same scores are applied two, three or four times. In the SMP case study for Trimingham, the same data were used to assign scores to ‘availability of services’, ‘equity’ and ‘sense of community’. By using the same data for scoring impacts across these three categories, the ‘best’ option scores 300 and the ‘worst’ scores zero. This increases the difference between the options such that the decision may change compared with the case where only one score was assigned. A similar situation occurred in scoring ‘equity’ and ‘sense of community’ for the Dymchurch case study. Both of these categories are indirectly influenced by physical loss of assets, jobs and business development.

The issue of double counting is partially exacerbated by the fact that, as above, RPA was not directly involved in the original appraisal of the projects used as case studies and therefore did not have access to all available information. In addition, if the MCA-based approach is applied from the start of the process then the necessary data will be available for scoring. However, there will still be situations were data and information will be scarce and these should also be considered. The different appraisal levels argument also applies here to a certain extent, as more detailed information will be available at the strategy and scheme levels.

In addition, if the MCA-based methodology starts being applied to flood and coastal erosion risk management, the number of projects being assessed in this way will increase and so will experience in collecting and assessing such impacts.

However, double counting still remains an issue in the appraisal and should be considered further.

5.6.5 Accounting for small differences

The Kelling Hard to Lowestoft SMP case study included three options for each assessment unit (‘do-nothing’, managed realignment and ‘hold the line’). For the Cromer and Winterton assessment units, two of these options were (effectively) the same (‘do-nothing’ and managed realignment[5]). This meant that there was a ‘best’ option and a ‘worst’ option and no ‘intermediate’ option. The scoring system was, thus, very simple to apply (with the ‘best’ option scoring 100 and the ‘worst’ option scoring zero). However, the differences between the ‘best’ and ‘worst’ options were often quite small and the application of a zero score to one option and a score of 100 to the other seemed to suggest a much larger difference. As a result, the weights that are applied will have a very significant effect on the choice of preferred option.

For the River Chet case study, the ‘do-nothing’ and ‘flooding to high ground’ options are, almost, the same option except that a few properties are protected and more work is undertaken to ensure safety with the managed ‘flooding to high ground’ option. In this case, the weights will also have a major role in determining the preferred option. However, the importance of the weights seems to be more sensible when dealing with a local defence scheme.

A small set of alternative options occurs generally only for the High level appraisals, i.e. in the cases of SMPs and catchment flood management plans (CFMPs). This is related to the fact that, at this level, the decision being made is whether to act or not to act, i.e. what the policy for the area should be. It is also true that at this stage of the decision-making cycle, the level of the information available is mostly qualitative and not very detailed. In this context, the best way to solve this issue is to apply a more qualitative approach to scoring, similar to the Likert Scale approach detailed in Sub-section 5.5.

A qualitative approach avoids the need to pinpoint scores to numeric information that is not always available. Because the score would be qualitative (i.e. no number would be attached to the score, only a descriptor), the proportionality problem could be sufficiently solved by giving precise definitions of each descriptor in the scoring system accompanied by examples that specify the magnitude of the score. The precise definition of each descriptor would also ensure that the scoring ‘range’ would be used in approximately the same way for each category, and from appraisal to appraisal. The transparency and auditability of such an approach would be ensured by the use of a Scoring AST, where the reasons behind assigning a score are recorded (see Sub-section 5.6.7, Reporting key information when options have the same impact, below).

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5 The only difference was in terms of health and safety where managed realignment would involve some works to reduce safety issues from the eroding promenade.

It is worth noting that a qualitative approach is most appropriate at the high level of decision-making only because the information available is not, and does not, have to be very detailed given the decision being made. A qualitative approach would not be appropriate at the strategy or scheme level, since at this stage the data and information available is much more detailed and therefore the scoring could be quantified much more robustly and accurately. Also, it is at these levels of appraisal that the investment decision is made, so the appraisal should be as accurate as possible and not based on qualitative information only.

5.6.6 Comparison of the relative importance of issues by unit

The Kelling Hard to Lowestoft SMP case study considered three different assessment units (Cromer, Winterton and Trimingham). Each assessment unit has very different characteristics (Cromer is urban, Winterton is an important environmental area and Trimingham has both urban and environmental assets). The ‘zero to 100’, ‘relative to 100’ and ‘Likert scale’ scoring systems (if applied separately to each unit) do not reflect proportionality between the geographic assessment units. Unless this is picked up in the weighting, it could result in an incorrect decision being made for some assessment units. For example, Cromer attracts 100,000 recreational visits per year while Trimingham attracts 30,000. The first two scoring systems would result in the best performing options for both assessment units for the category of recreation being assigned a score of 100. If recreational impacts were valued in monetary terms, however, there would be significant differences between the two units, such that the best performing option for Cromer would not have the same monetary benefits as Trimingham. This difference is respected in the across unit scoring system as the maximum score that Trimingham could be assigned for recreation may be 30 (since it attracts only 30% of the visits that are attracted to Cromer[6]).

The issue emerges when dealing with high level and strategy type of assessments. These are the two levels where the area assessed is usually divided into different assessment units so as to simplify the analysis.

It is thought that the ‘across units’ system would be able to deal with and respect the differences between the same impact across the units if the scoring approach used is of a quantitative nature. Hence, at the strategy level the comparison of the relative importance of impacts across the units would be solved.

If, however, a qualitative scoring system is applied, at the SMP and CFMP level for example, the application of the ‘across the units’ systems is less practical. On the one hand, correct application of a qualitative descriptor (rather then a

[6] Note this is a simplification since it assumes that benefits to recreation can be reflected totally by the number of visitors. In fact, the enjoyment of a trip to Trimingham may be greater (or less) than to Cromer such that the maximum score may be greater (or less) than 30. Without more information on this aspect, however, it has not been possible to take this into account in the scoring for the case study.

number) to a large number of options[7] is difficult and prone to inaccuracies. On the other hand, the scoring system will generally be composed of five or six descriptors, whilst the number of options can easily be double that. In this case the same descriptor would have to be applied twice or three times to options that although similar, would not have the same impact. However, it may be the case that respecting small differences between options does not constitute such an issue at the high level of appraisal. This problem needs to be further researched.

5.6.7 Reporting key information when options have the same impact

Where all options have the same impact for a particular category, no scoring is applied (as the scoring is used to reflect differences between options). However, in many cases there was important information related to the various categories that needed to be recorded. This is likely to be particularly true, where points have been raised by stakeholders. The use of appraisal summary Tables to record the reasoning and assumptions for scores can be used for this purpose and/or to provide a reason as to why scores are not assigned. This issue is also important when the score assigned to the different categories is the same, but the reasons behind the scoring may be slightly different. The Scoring AST is illustrated in Table 5.6.

Table 5.6 Table summarising scores and their justifications

Project name				
Category	**Opt. 1:**	**Opt. 2:**	**Opt. 3:**	**Justification of scores**
Economic impacts				
Assets				
Land use				
Transport				
Business development				
Environmental impacts				
Physical habitats				
Water quality				
Water quantity				
Historical environment				
Landscape and visual amenity				
Social impacts				
Recreation				
Health and safety				

[7] Although at the high level only a small number of options is considered, when the system is applied across all assessment units the number of options will increase exponentially as each set of options will have to be considered for each assessment unit.

Table 5.6 Table summarising scores and their justifications

Project name				
Category	**Opt. 1:**	**Opt. 2:**	**Opt. 3:**	**Justification of scores**
Availability and accessibility of services				
Equity				
Sense of community				

5.6.8 Accounting for uncertainty

The application of a numeric score to a category can suggest that the score is very certain. Some aspect of uncertainty can be included in how the scores are reported. For example, a score of 80 could be considered to indicate that the score is between 70 and 90, whereas a score of 81 could be taken to indicate that the score is between 80 and 82. However, in many cases interpretations of the scores will not adequately reflect the actual level of uncertainty.

Uncertainty can be introduced by using different data sources to assign scores to the options for the same category. For example, the scores assigned to the Trimingham assessment unit of the SMP case study for 'landscape and visual amenity' relate to the types of land use that are affected, with the movement of caravans being key to the scores, such that 'hold the line' scores 33[8]. If an alternative approach is used (the NERA Landscape Intrusion factor) and is it assumed that 'hold the line' would result in 'slight intrusion', the score assigned would be 60[9].

There may also be certain aspects of particular options that, if included or excluded, would change the score. For example, the Trimingham assessment unit of the SMP case study includes potential outflanking of defences if the 'managed realignment' option is implemented. Such an outcome has some risk attached to it, but this is not represented in the scores assigned at present. If there is, say, a 10% chance of outflanking occurring, the scores assigned to particular categories could be expected to be lower than if the risk was only 1%. There is currently no mechanism for explicitly including uncertain events within the scores.

The appraisal summary table used to describe the data sources and assumptions made when assigning the scores can also highlight the degree of uncertainty. For example, the score assigned to business development for the Trimingham assessment unit of the SMP case study was based on the number of trips made to the coast of North Norfolk, with a percentage of these assumed to visit Mundesley, and use of a multiplier associated with income from tourism and jobs provided. Here, there is uncertainty associated with the original

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8 The score of 33 is obtained by assuming that two of three land uses are affected, thus two-thirds (67%) of visual amenity is lost.

9 The NERA Landscape Intrusion Scale assumes that 'slight intrusion' would reduce visual amenity by 40%, such that the score for 'hold the line' would be 60 (NERA, 1998).

estimate of trips (even if based on counts, the number of trips would relate to that year only and by assuming it is relevant to all years introduces uncertainty), the estimate of the proportion of those trips that are to Mundesley and the estimated multipliers. Furthermore, there is uncertainty as to whether these data are appropriate indicators for assigning a score to business development. Recording these impacts makes the presence of uncertainty explicit, but it may not result in the uncertainty being taken into consideration in the end decision.

A similar situation was found in the Dymchurch case study. In this case, it is assumed that business development relies mostly on tourism and that tourism is mostly affected by the quality of the beach. The score is then calculated using quantitative data regarding beach visitors with reference to each of the options. The uncertainty in this case is associated with the extrapolations undertaken regarding the influences of tourism on business development and of the beach on the tourism industry.

The approach to scoring should also reflect the level of uncertainty emerging from the information used. So, for example, using a qualitative scoring system at the policy appraisal level seems more appropriate than using a quantitative method since the information is not as detailed as at the lower levels of decision. This approach does not necessarily reduce the uncertainty of the scoring but makes it more evident.

In relation to the introduction of uncertainty by using different data to assign scores to the options for the same category and by inclusion or exclusion of certain aspects of the options, no solution was found on a preliminary assessment of the problems. However, it may be necessary to include a more formalised way of taking account of risk and uncertainty within the scoring systems. This could involve the use of ranges of scores and sensitivity analysis in the same way that the impact of uncertainty on costs and benefits is examined.

5.7 Weight elicitation for the first set of case studies (Step 7)

5.7.1 Introduction

The purpose of weighting is to enable users to indicate the relative importance that should be assigned to different impacts within a category and to one category of impacts versus another. By developing weighting factors, which reflect how important the different types of effects are, it is possible to then weight and aggregate the scores into an overall index or measure of performance for a given option. In developing these weights, however, it is essential to remember that the aim here is to reflect the importance (or priority) that is attached to a particular type of impact.

This should be kept separate from the scoring exercise, which is aimed at indicating (more objectively) how large an impact is expected to be. In other words, the two should be kept separate to reflect the fact that minor changes may be viewed as more important than some major changes, because people are more concerned about the former type of change than the latter. However, in order for individuals to be able to express valid importance weights, they must have information on the scoring system being applied to each impact category. In particular, they must have information on what the maximum score relates to in terms of impacts and what the minimum relates to.

The use of weights within MCA is an aspect that is always debated as it introduces subjectivity. In order to avoid this, it is often argued that the impact scores should remain unweighted. Such arguments ignore the fact that failure to assign explicit weights to different impacts is the same as saying that all impacts are of equal importance. Such an assumption is unlikely to hold in reality, and can be particularly inappropriate where there are significant trade-offs between impacts.

The second issue when creating the weighting system is whose weights should be used. There are several different approaches that can be taken:

- allowing decision-makers to specify the weights;
- allowing independent experts to specify the weights;
- developing different sets of weights to reflect different stakeholder viewpoints;
- using survey techniques to develop a statistically representative set of weights; or
- calculating what weights would have to be applied to different impacts for one option to be preferred over another and discussing these with decision-makers and stakeholders.

The elicitation can be carried out either directly or indirectly. Direct elicitation involves consultation with the specific stakeholder groups; so for example, specification of weights by the decision-makers would involve consultation with Defra and/or the operating authority. Indirect elicitation involves gathering information that indicates the priorities/preferences of the specific stakeholder; so, for example, specification of weights for decision-makers would involve analysis of the strategic documents produced by the Government for the area, general policy statements, documentation stating Government priorities in particular issues, etc.

In the first set of case studies, both active and passive methods of eliciting weights were pursued:

- active methods, where the weights were elicited directly from the stakeholders, were used in the River Chet and the Kelling Hard to Lowestoft case studies; and
- passive methods, where weights were gathered indirectly from documentation and reports on the case study, responses/reports of stakeholders and any other records that might provide useful information, were applied to the Pagham to East Head case study.

The aim was to develop a reliable means of eliciting weights from individuals (as opposed to groups) that would permit an analysis of the degree of consensus on the relative importance of one impact versus another or, failing this, whether there was any difference in outcome between respondents' weights concerning the preferred option.

5.7.2 Weight elicitation in the River Chet case study

Weight elicitation for the River Chet case study was by means of a paper-based questionnaire. The starting point for the approach was a condensed version of the full pairwise comparison method regarded by some as being the most theoretically correct approach.

The full pairwise comparison method requires respondents to compare all categories of impact with one another, indicating which of the pair they believe to be more important, and by how much. Box 5.1 sets out the process that was used to elicit the weights. The design of this approach was aimed at ensuring that the weights respected the relative magnitude of the differences in importance (i.e. the proportionality in the differences between the priority) which people placed on one type of impact versus another.

Box 5.1 The elicitation of relative importance weights

The process of eliciting weights from respondents comprises four steps:

Present scoring systems and details of impacts associated with maximum and minimum possible scores;
Step 2: Rank and weight each of the sub-categories that make up a category;
Step 3: Rank and weight each of the categories;
Step 4: Review ranks and weights; and
Step 5: Provide optional documentation of reasons for ranks and any problems encountered.

Starting with Step 2, for each set of attributes, which makes up a category (e.g. the sub-categories making up a category), the process involves putting the named attributes in rank order of importance. For example, using five sub-categories A, B, C, D and E that, together, make up the category of ‘environment’, the respondent is asked to rank them in order of importance. The end result would be something similar to the following:

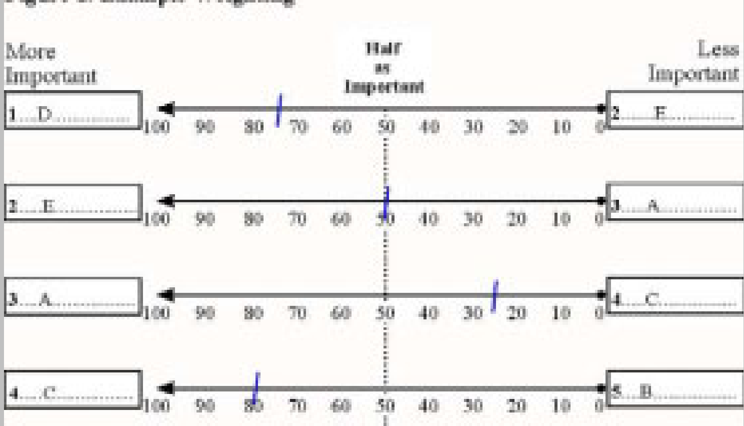
Sub-Category	Rank
A	3
B	5
C	4
D	1
E	2

The next stage is determining the ‘distance’ between each of the rank positions. This reflects how much more important one type of impact is over another. To do this, respondents were asked to undertake a series of pairwise comparisons:

how important rank 2 (E) is relative to rank 1 (D);
how important rank 3 (A) is relative to rank 2 (E);
how important rank 4 (C) is relative to rank 3 (A); and
how important rank 5 (B) is relative to rank 4 (C).

To make the process simple and understandable for the respondent, a recording form was provided for completion. Figure 1 provides an example completed form for the sub-categories A, B, C, D, and E that might make up the category of ‘environment’. The respondent is then asked to enter their rank order into the appropriate ‘boxes’ and to record the relative importance of each sub-category relative to the next highest ranking one by marking a slash on the measurement scale.

Figure 1: Example Weighting



Box 5.1 The elicitation of relative importance weights (continued)

From these pairwise comparisons, information was developed on individuals' views on the relative importance of each of the sub-categories. Once all responses were received, each set of pairwise comparisons is converted into weights for use in the scoring system. In each case, weights are calculated by 'awarding' a weight of 100 to the most important sub-category, i.e. that ranked number 1. Following the example above, this would be sub-category D. The next most important sub-category is then awarded a weight relative to this. From Figure A, E is 75% as important as D, so it receives a weight of 75. The next most important sub-category (A) is awarded a relative weight. In this case, as A is 50% as important as E it receives a weight of 50% of 75, i.e. 38. The process continues until weights have been calculated for each sub-category.

The Table provided below illustrates the resultant weights for the preferences expressed in Figure 1. These weights are then normalised, with this involving converting weights to a relative importance scale based on a percentage. The process involves totalling all of the weight values and expressing each value as a percentage of the total, making subsequent manipulation with the impact scores easier. The normalized weights for this example are also given below.

Sub-category	Relative importance	Meaning	Weight	Normalised LPF
D		D is most important	100	43
⇩	75			
E		E is 75% as important as D	75	33
⇩	50			
A		A is 50% as important as E	38	17
⇩	25			
C		E is 25% as important as A	9	4
⇩	80			
B		B is 80% as important as C	8	3

This type of analysis is required for every respondent/group. The resulting weights can then be examined individually or can be combined to develop a single set of weights. This can be achieved through numerous different approaches, with the simplest probably being the calculation of an average (mean or median) value for each attribute/sub-category. As there may be many variations between respondents as to the relative importance assigned to different attributes, the calculation and recording of the standard deviation will also be important as it provides useful information on the degree of agreement.

A condensed pairwise comparison approach was used because the number of comparisons that would have been required using the full approach would have been too time consuming and would have been impacted on the number of responses received (see Box 6.1).

Table 5.5 provides an example diagram for a simple five-category analysis using the full approach. As can be seen from the Table, 10 sets of pairwise comparisons would be required to complete the response.

Table 5.5 Full weight elicitation for impact categories A-E

	A	B	C	D	E
A	=	Elicit	Elicit	Elicit	Elicit
B		=	Elicit	Elicit	Elicit
C			=	Elicit	Elicit
D				=	Elicit
E					=

The condensed approach seeks to reduce the number of comparisons that have to be made and, thus, to speed up the process for the respondent. The approach requires respondents to first rank categories of impact and then to indicate the importance of one factor relative to another down the rank order. Thus, for five categories, four comparisons are required initially, the difference in weights between the remaining categories being inferred mathematically, see for example Table 5.6.

Table 5.6 Condensed weight elicitation for impact categories A-E

	A	B	C	D	E
A	=	Elicit	***Infer***	***Infer***	***Infer***
B		=	Elicit	***Infer***	***Infer***
C			=	Elicit	***Infer***
D				=	Elicit
E					=

However, both the full and condensed approaches may provide inconsistent results, but for different reasons. In the full approach, inconsistencies may arise because the weight apportioned between some comparisons may be inconsistent with the weights implied by other comparisons. Thus, if the respondent has indicated that Category A is twice as important as Category B and Category B is as important as Category C, an entirely consistent set of data would also record that Category A is twice as important as Category C. Such an entirely consistent result is rarely delivered from the full approach, requiring a means of dealing with the inconsistent responses.

The condensed version does not suffer from this particular type of inconsistency because entirely consistent results are inferred mathematically from the subset of comparisons. However, the risk with this approach is that the respondent is not aware of the effect of his/her initial choices on the derivation of the inferred preferences.

In previous attempts using this approach we have noticed a tendency for some respondents to place a disproportionate amount of weight on the more important categories to the detriment of the less important ones.
To combat this tendency but maintain a less time consuming approach, respondents in the River Chet case study were asked to compare their top

ranked impact category with the middle ranked category; and their middle ranked category with the bottom ranked category. In effect, the idea was to complete some of the data points that would otherwise have been inferred. This is illustrated in Table 5.7, which shows the sets of comparisons that are elicited and inferred using this approach.

Table 5.7 Calibrated condensed weight elicitation for impact categories A-E

	A	B	C	D	E
A	=	Elicit	***Infer* and Elicit**	*Infer*	*Infer*
B		=	Elicit	*Infer*	*Infer*
C			=	Elicit	***Infer* and Elicit**
D				=	Elicit
E					=

The approach provides two sets of weights per respondent. The first is the initial set, which denotes the relative distance between the importance of the different categories, and the second set, which provides verification of the relative distance between the top, middle and bottom ranked categories. Ideally, the gradient of weight down the categories should be the same or similar. Where they are not, this suggests that the respondent has allotted weights disproportionately; but under this approach, the data from the second data set (which provides the overall gradient) can be used to calibrate the first.

The data can be combined to provide a corrected response lying between the two data sets. This is achieved simply by reducing the gradient of the initial response so that it lies mid-way between the initial full response and the second (partial) response. However, the proportionality of weights allotted to neighbouring ranks is the same in the corrected response as in the initial response.

5.7.3 Weight elicitation in the Kelling Hard to Lowestoft SMP case study

The condensed approach was also used for the Kelling Hard to Lowestoft case study. However, a different solution to the problems of potential inconsistencies was applied here.

Rather than using a second set of responses to adjust each respondent's initial choices 'after the event' (as in the River Chet case study), respondents were asked to complete an electronic questionnaire (by e-mail and at workshops) that graphically displays the outcome of a respondent's choices on the eventual weights through the use of a pie chart. The respondent is required to check that the pie chart actually reflects their priorities and, if it does not, to make changes to their weights until it does.

5.7.4 Weight elicitation in the Pagham to East Head coastal strategy

An alternative approach was taken in this case study to develop relative impact weights. Instead of eliciting them directly from stakeholders, the aim here was to see if it would be possible to derive weights from formal responses to consultation provided in the Strategy Report. From analysis of the project consultation documents, however, it was decided that the information was inadequate for these purposes. In particular, the questions forming the basis for consultation did not provide sufficient distinction between the different options in terms of their trade-offs. Respondents were not required to 'vote' for a single option, thereby revealing priorities. Instead, they could indicate a preference for several options, delivering similar but varying outcomes.

Although deriving weights from the consultation documents was not feasible in this case, it should be possible to seek responses to consultation in a manner that would provide rankings at least on different priorities, if not relative weights.

5.7.5 Conclusions from the weight elicitation exercise

Flexibility and robustness

Respondents found the paper-based questionnaire used on the River Chet case study useful but time consuming. In addition, while logically justifiable, the use of a subset of results to calibrate full results may not have a sound theoretical basis, particularly since the respondents are not able to check that they agree with the eventual weights. Whilst there is, of course, the option to calculate weights and then return the results on paper for agreement by the respondent, administratively and practically this could be a difficult task. It should be noted, however, that the effect of both the original and calibrated weights on the MCA approach were analysed and the outcome (in terms of which option was justified) was almost identical (although this should be viewed as a feature of this case study rather than a general rule).

The electronic approach used in the Kelling Hard to Lowestoft SMP case study would seem to offer the best balance between time, robustness and theoretical correctness. The approach is quick to set up and adaptable. From the point of view of gathering and processing a large number of responses, the flexibility to provide questionnaires by e-mail and the Internet offers great advantages, especially since the responses are returned in the form of calculated weights on a spreadsheet, reducing the data entry required by the surveyor.

In terms of ease of use, we have received a number of comments from respondents concerning the time taken to complete it and levels of satisfaction with the results. None of these comments was outwardly critical of the time taken and most expressed the sentiment that the questionnaire was easy to complete once they understood what was required. Many who commented noted that since their response could be revised again and again, it was beneficial to understanding what was required and the implications of the choices made. A number of respondents also noted that they had revised their response a number of times before being happy that the weights reflected their priorities.

From a theoretical perspective, the key advantage of the electronic approach is that, while it maintains the reduced number of comparisons associated with the condensed approach (adding simplicity and reducing time), it effectively generates numerically consistent data points for the remaining comparisons on the basis of the response and asks the respondent to check and agree these. As such, from a theoretical perspective it requires the respondent to compare all impacts with all others within the bounds of a consistent data set. Thus, it is unlikely to suffer from the inconsistencies apparent with other approaches.

Data handling, consensus and outcomes

One of the potential advantages of using individual questionnaire responses rather than focus groups is that a consensus on, for example, rank order does not have to be forced. Each (informed) individual may record their own preferences without reference to a group and the restrictions that may be placed on them by the rest of that group. A potential disadvantage is that the discussions and conflict resolution that occur in focus groups do not take place and, for wider use, consideration might be given to either providing greater information (in the form of advocacy) or using the approach after a public meeting/focus group.

In terms of the analysis of the weights for both case studies, the first objective was to examine all responses for each questionnaire to identify the level of consensus between the respondents. A lack of consensus between respondents will be apparent when there is little consistency between responses concerning the position or weight that is applied to the individual categories.

Across the entire set of responses for each case study, there was no or very little consensus between respondents. There was, however, an obvious division of the responses into a number of different stakeholder 'types' representing different interests, although even here there was no agreement. Clearly, for ease of application, it is desirable to have one set of weights that represents a consensus on priorities. It is for this reason that some focus group approaches seek to force a consensus on weights. However, the eventual consensus may not actually represent the priorities of anyone. This is highlighted by the results of the individual responses for the case studies, which indicate that there is little consensus on relative priorities across different stakeholder types and, therefore, a forced consensus would be a false one.

However, the individual response approach, still needs to use the data to calculate a result. An obvious solution might be to take the average weight for each category across all responses, alongside the standard deviation to give a range of possible values for sensitivity analysis. This could be viewed as being democratic, however, the resulting weights are highly sensitive to the sample population and the proportion of different people with different views and agendas. In effect, as with a democracy, the result is a function of the opinions of the population that votes and the outcome may be no better than the forced consensus described above.

In the case studies, the solution to this analytical problem was to maintain a focus on the purpose of the appraisal, which is to identify how well each option performs compared to the others (and hence which option performs best). Thus, the approach taken was to combine each individual's set of weights with the scores for the different options to generate the total weighted score for each option, for each respondent.

Through this approach it was found that, even though there was no identifiable consensus on the relative importance of different categories of impact, once all of the results were processed, there was clear agreement on the outcomes concerning the relative performance of options.

Workability and efficiency

One of the objectives of the evaluation of a MCA-based approach to flood and coastal erosion risk management was to increase the efficiency and effectiveness of stakeholder involvement. It was envisaged that weight elicitation would help complete this part of the stakeholder consultation, which is obligatory in the current appraisal process.

In this context, a significant effort was made to select projects that would be underway so that issues such as stakeholder consultation would not constitute an obstruction to the development of the case studies. However, the reality turned out to be significantly different from what was originally expected. The use of a case study approach to research running in parallel with the real project proved to be complicated, in particular in relation to stakeholder consultation.

At the end of the first set of case studies it was decided that further research into stakeholder involvement methodologies would be difficult. Instead the second set of case studies should centre on streamlining the weight elicitation process, by focusing it on those issues that actually influence the outcome of the analysis.

6. Results from the second set of case studies

6.1 Introduction and overview

The second set of case studies had five main aims:

- finalising the definition of the objectives and management options step of the MCA-based process, in the light of the conclusions from the first round of case studies;
- finalising the list of impact categories that form the backbone of the appraisal process;
- further developing the scoring approach in order to resolve the issues that emerged from the first trial;
- further developing the weight elicitation approach, by focusing it on the issues that actually influence the appraisal; and
- developing the approach for comparison of options, by combining the monetary valuation with the weighted scores.

As discussed in Section 4, the second set of case studies was comprised of the following projects:

- Humber Estuary shoreline management plan;
- River Don flood defence strategy; and
- Newbiggin-by-the-Sea coastal defence scheme.

Table 6.1 provides a brief description of each of these case studies. The appraisal reports using the MCA-based methodology can be found in Annexes B5 to B7 of this report.

Table 6.1 Second set of case studies and brief description

Case study name	Brief description	Case study annex
Humber Estuary SMP	The Humber Estuary is located in the North East of England. Of the whole SMP, Management Unit 6 was selected for the appraisal. Management Unit 6 runs from South Ferriby Cliff to North Killingholme and is mainly comprised of medium grade agricultural land for up to 3km inland. The main settlement in the area is Barton-upon-Humber. Clay pits immediately behind the defences between Chowder Ness and New Holland are important environmental and recreation sites, with some designated for their environmental value. There are also a number of small industrial areas, including New Holland Dock. Our interest in the Humber Estuary was based on it being an estuary, including both riverine flood issues and coastal protection issues. Also, managed realignment is a very important factor, which in turn would raise interesting social and environmental issues.	B5
River Don strategy	The lower reaches of the River Don run from Doncaster to Goole through an extensively engineered channel. The very high tide levels, which can be experienced in the Lower Don, mean that large areas are at risk from flooding. Consequently, there is a long history of extensive engineering improvements, which have been carried out as a matter of necessity to sustain and protect life and property. Our interest in the River Don Defence Strategy was based on it involving urban issues, where equity and social factors are important, as well as environmental issues, which are not always easy to take into account in the appraisal of options to reduce flood risk.	B6
Newbiggin coastal scheme	Newbiggin-by-the-Sea is situated on the Northumberland coastline within Wansbeck District Council's boundary and it faces Newbiggin Bay. Main features at this frontage are a narrow sandy beach, the Southwest Promenade on the south side of the frontage and the Bridge Street sea wall. The entire bay is at risk from erosion, and part of the village is a flood risk zone. Our interest in the Newbiggin Strategy is based on its significant number of social and recreational impacts. It seems that although some of these impacts cannot be valued in monetary terms (through CBA) they can play an important role in the decision-making process. Also, it represents a project being managed by a coastal authority as a coastal protection project.	B7

6.2 Definition of objectives and description of options (Steps 1 and 2)

In the light of the conclusions from the first round of case studies, it was decided to add an extra layer of detail to this initial step of the appraisal, in particular in what relates to the issue of co-ordination with other policies and planning initiatives. It is worth noting that these particular developments have not been included in the case study reports themselves.

The inclusion of an impact category related to policy integration in the assessment stage of the MCA-based approach gave rise to some applicability issues, not just to the robust quantification of the impacts, but also in the scoring and weighting stages of the appraisal. Although policy integration is a fundamental criterion when assessing the impacts of different options, it does not lend itself well to evaluation particularly at strategy and scheme level.

For this reason, it was decided that the ‘policy integration’ impact category would be removed from the final list of categories, and instead, its relevance would be highlighted during the definition of the objectives and management options to the project being appraised. This is also in line with the flood and coastal defence appraisal guidance series (Maff, 1999-2001), and other government guidance, such as the draft practical guide to strategic environmental assessment (ODPM, 2004) and the shoreline management plans guidance for coastal authorities (Defra, 2001).

A project, be it a policy, strategy or scheme, may be influenced in various ways by other plans or programmes, or by other policy and legislation laying down objectives for the area. For example, large-scale statutory plans (such as local authority structure plans, shoreline management plans, catchment flood management plans and management schemes for special areas of conservation (SACs)) or large non-statutory plans (such as national biodiversity action or coastal habitat management plans) may have already been developed for the area and their objectives must be taken into account in the appraisal process.

Following the presentation of the background of the project and the definition of the objectives and management options, a list of policies, plans or programmes relevant for the area being appraised should be developed and the relationships between them and project being assessed identified.
This is important not only to respect objectives that might take precedent over the flood and coastal erosion management objectives being defined but also so that the synergies between projects can be explored. In some cases, key issues may already have been dealt with in other plans or policies. Also, such plans and policies may contain relevant data and analysis that can be used to help establish the appropriate boundaries or the time frames.

As a result, the recently published draft practical guide to the strategic environmental assessment (ODPM, 2004) suggests the use of a summary table to document the results of the policy integration exercise. The table (Table 6.2) contains cells to record the requirements of other plans, programmes or objectives concerned, the constraints or challenges they pose, and how the project being appraised might take account of them.

Table 6.2 Relationships with other policies, plans, programmes or objectives of concern

Name of policy/plan/programme/objective	Objectives and requirements of the policy/plan/programme/objective	How objectives and requirements will be considered
Source: ODPM, 2004		

6.3 Structuring the problem (Step 3)

One of the issues left to be solved, from the first set of case studies was related to finalising the list of impact categories that would form the backbone of the appraisal process. As mentioned in Sub-section 5.3, during the use of the ASTs it became apparent that the set of impact categories could be further developed.

The set of impact categories (Table 5.3) was sent for inspection and scrutiny to relevant experts. The main issue arising from this revision was the potential for double counting between impact categories. For example, the same issue may be assessed under assets (economic impact of loss of public buildings) and availability and accessibility of services (social impact of loss of public buildings).

Careful attention was given to the issue of double counting during this stage of further developing the MCA-based methodology. It is believed that the fact that the impact categories are classified into four different impact types (economic, environmental, social and cross-cutting) will differentiate between the perspectives that should be appraised in each category. In addition, if guidance is clear and precise, the probability of double counting should be greatly reduced.

Other questions were also raised in relation to the actual definition of the impact categories. For example:

- does the ‘land use’ impact category refer to use only or does it also reflect impacts on land quality? The answer to this question is that it refers mainly to land use and its productivity. However, impact on land quality is also accounted for as it will have a direct affect on output;
- does the ‘physical habitats’ impact category include biodiversity (flora and fauna)? The answer to this question is yes; explicit reference to this has now been included in the definition;
- regarding the water quantity category, are impacts on flow dynamics an issue? The answer is that it is more of a natural processes issue. For this reason a new category of environmental impact – ‘natural processes’ - has been included in both the S-AST and the MA-AST;
- regarding the category ‘landscape and visual amenity’, should impacts on conservation designations be included in this category or should they come under the ‘physical habitats’ category? Under the landscape category the reference is to landscape conservation designations, such as Area of Outstanding Natural Beauty (AONB), rather than nature conservation designations like Special Area of Conservation (SAC) which would come under ‘physical habitats’; therefore, they should be included in the relevant category;
- regarding the category of landscape and visual amenity, will the inclusion of impacts on the usefulness of the landscape and amenity mean double counting with impacts on recreation? This is correct and therefore the reference to the impacts on usefulness is now used only under recreation; and
- no explicit reference is made to impacts on noise, air and climate, and waste and resource use. Should these be added as two extra impact categories? The answer to this question is that these impacts are either not considered as relevant for flood and coastal defence or are already included in other

impact categories, such as health and safety (noise, air and climate) and water quality (waste).

In addition, the problems arising from including ‘Policy Integration’ as an impact category were also resolved as explained previously.

The final set of impact categories and definitions included in the MCA-based methodology is presented in Table 6.3.

Table 6.3 Revised types and categories of impacts included in the S-AST and MA-AST

Types	Categories	Category description
Economic Reflect impacts that affect goods and services that can be readily valued or that affect the local, regional and national economy.	Assets	Includes flood damages and/or losses relating to (permanent and temporary) private and public property such as residential, industrial and/or commercial property, caravan parks, public buildings (for example, schools, hospitals) sewage and water supply networks, pipelines, etc.
	Land use	Includes flood damages to land used for agricultural, industrial, urban, forestry and commercial fisheries purposes.
	Transport	Includes impacts to roads, bridges, railways and navigation.
	Business development	Includes regeneration/development and competitiveness. Regeneration includes impacts on the creation of sustainable communities, i.e. economic development and development or maintenance of social cohesion. Important indicators include: • creation (or not) of jobs; • enhancement of local environment; and • enhancement of social and leisure opportunities. Competitiveness issues include impacts to businesses (their costs, investment, market structure, etc.).
Environmental Reflect impacts that affect the natural and built environment.	Physical habitats	Includes impacts to terrestrial (including coastal), aquatic and marine habitats and biodiversity, its conservation designations, and its flora and fauna.
	Water quality	Includes impacts on biological and chemical quality of surface and groundwater water. Important indicators to consider include: • chemical and biological GQS grades; • river quality objectives; • consented and un-consented discharges; and • designated bathing waters.
	Water quantity	Includes impacts on the water levels and water supplies (such as drainage and run-off).
	Historic environment	Includes impacts on heritage, archaeological and geological features.
	Landscape and visual amenity	Includes impacts on the appearance of the land (its shape, colour and particular features), its landscape designations as well as its agreeable nature.
	Natural Processes	Includes impacts on flow dynamics, sediment transport, geomorphology, etc.

Table 6.3 Revised types and categories of impacts included in the S-AST and MA-AST

Types	Categories	Category description
Social Reflect impacts that affect the general public and their way of life.	Recreation	Includes impacts on the processes or means of entertainment. It includes angling, informal recreation (walking, sunbathing, picnicking, sitting, swimming, etc.) and formal recreation (sports and other activities that require specific equipment).
	Health and safety	Includes impacts such as risk to life or serious injury, stress and anxiety (mental health and livelihood) and other health effects, such as those created during the construction phase of the project (noise and air pollution, for example).
	Availability and accessibility of services	Includes impacts on availability and accessibility to public services such as education, housing, emergency and cleaning services, health, cultural facilities and other.
	Equity	Includes distribution impacts (consideration of interests of all groups of stakeholders), impacts on vulnerable groups (such as the elderly, children, etc.) and social tensions (rise of serious divisions and conflicts within the community).
	Sense of community	Includes impacts on the local community, level of satisfaction with neighbourhood, social networks and community expectations.

6.4 Impact assessment for the second set of case studies (Step 4 and 5)

6.4.1 Summary MA-AST

From the analysis of the appraisal reports for the first set of case studies, it became apparent that given the size of the MA-ASTs they would be better included in the report as an annex rather than as part of the main report for practical reasons. Although this does not undermine the importance of the completed ASTs, it does leave the main report with a reporting gap.

For this reason a summary MA-AST (summary MA-AST) was introduced to this step of the appraisal. .

The summary MA-AST intends to summarise, in one table, the key information from the assessment of each of the different options in relation to each impact category considered relevant for the assessment. The type of information that should feature in the summary MA-AST is presented in Table 6.4, overleaf. As can be seen from the Table, the key information should be of a quantitative nature as far as possible, should focus on the differences between the options, and should be able to give the reader a good overview of the impacts of the different options.

Table 6.4 Key information that should feature in a typical summary MA-AST

Impact category	Key information about each option
Economic impacts	
Assets	No. of properties affected

Table 6.4 Key information that should feature in a typical summary MA-AST

Impact category	**Key information about each option**
Land use	Area of agricultural fields affected
Transport	Length of roads and railways affected
Business development	No. of non-residential properties (NRPs) affected
Environmental impacts	
Physical habitats	Area affected
Water quality	Length of water bodies affected
Water quantity	Length of water bodies affected
Natural processes	Area undergoing natural processes
Historical environment	No. of Scheduled Ancient Monuments and listed buildings affected
Landscape and visual amenity	Area of land affected
Social impacts	
Recreation	No.of visitors affected
Health and safety	Population affected (based on number of properties affected)
Availability and accessibility of services	No.of services (hospital, school, medical centre, etc) affected
Equity	Population within vulnerable groups affected
Sense of community	Population affected (based on number of properties affected)

The summary MA-AST for the Humber Estuary SMP case study is presented in Table 6.5 overleaf, as an example. It should be clear that the summary MA-AST does not intend to substitute the MA-AST. The summary MA-AST should be used as a reference and it should not form the basis for the outcome of the assessment, as it does not give a detailed picture of impacts.

Table 6.5 Summary of the main assessment AST (Summary MA-AST)

Project name:	**Humber Estuary shoreline management plan**				
Description of area affected:	Management unit 6 (South Ferriby Cliff to North Killingholme)				
Impact category	**Option 1: Do-nothing**	**Option 2: Maintain**	**Option 3: Sustain**	**Option 4: Improve 1:50**	**Option 5: Improve 1:100**
Economic impacts					
Assets	Inundation would write off 1,730 residential properties and 103 non-residential.	Almost 2,000 residences and more than 100 industrial properties would be flooded intermittently.	Assets will be protected.	Assets will be protected.	Assets will be protected.
Land use	1,221ha of agricultural land written off by year 99.	1,221ha of agricultural land flooded.	Impact on agricultural land following a breach.	Small impact on agricultural land following a breach.	Small impact on agricultural land following a breach.
Transport	Loss of A15 (including access to Humber Bridge), A1077, railway line and local access roads. Navigation channels in estuary could also be affected.	The A15, A1077, railway line and local access roads will be flooded fairly regularly. No impact on navigation channels.	Roads and railways protected but flooded every 20 years, which may lead to serious disruption.	Roads and railways and navigation channel would be protected.	Roads and railways and navigation channel would be protected.
Business development	Loss of so many residential and non-residential properties will mean that the area is no longer viable for many businesses.	Almost all businesses will be affected at some time by flooding.	The impacts on future business development only significant for businesses whose investment planning exceeds 20 years.	Business development should be largely unaffected.	Business development should be largely unaffected.
Environmental impacts					
Physical habitats	Loss of 8 SNCIs, 6 Wildlife Trust sites and landward SSSI/SPA/Ramsar site. Development of new intertidal habitat.	Designated sites would be flooded fairly frequently. Loss of 60ha of intertidal habitat as a result of coastal squeeze.	Loss of 60ha of intertidal habitat as a result of coastal squeeze.	Loss of 60ha of intertidal habitat as a result of coastal squeeze. Potential impact on integrity of SPA.	Loss of 60ha of intertidal habitat as a result of coastal squeeze. Potential impact on integrity of SPA.
Water quality	Flooding of agricultural land and STW will result in reduction in water quality. Loss of 19 discharge points.	Water quality will generally be maintained, but release of pollutants every 10 years.	Water quality will generally be maintained but release of pollutants every 20 years.	Water quality will generally be maintained.	Water quality will generally be maintained.
Water quantity	Impact on aquifer. Loss of 7 abstraction points.	Protection of water abstraction and discharge points.	Potential saltwater contamination of aquifer related to sea level rise. Protection of abstraction and discharge points.	Protection of aquifer abstraction and discharge points.	Protection of aquifer abstraction and discharge points.

Table 6.5 Summary of the main assessment AST (Summary MA-AST)

Project name:	**Humber Estuary shoreline management plan**				
Description of area affected:	Management unit 6 (South Ferriby Cliff to North Killingholme)				
Impact category	**Option 1: Do-nothing**	**Option 2: Maintain**	**Option 3: Sustain**	**Option 4: Improve 1:50**	**Option 5: Improve 1:100**
Natural processes	Natural migration of intertidal habitats.	Landward migration of intertidal habitats will be prevented.	Landward migration of intertidal habitats will be prevented.	Landward migration of intertidal habitats will be prevented.	Landward migration of intertidal habitats will be prevented.
Historical environment	Loss of areas of high archaeological potential, 1 SAM and listed buildings.	SAM and listed buildings flooded on a regular basis. Archaeological sites likely to be affected.	SAM and listed buildings flooded every 20 years.	SAM and listed buildings flooded every 50 years.	SAM and listed buildings flooded every 100 years.
Landscape and visual amenity	Change from rural agricultural to mudflats, saltmarsh and open water.	Landscape generally maintained. Visual impact where crest levels are raised by up to 0.6m.	Landscape generally maintained. Visual impact where crest levels are raised by up to 0.6m.	Landscape generally maintained. Visual impact where crest levels are raised by up to 0.9m.	Landscape generally maintained. Visual impact where crest levels are raised by up to 0.9m.
Social impacts					
Recreation	Loss of Barton Clay Pits recreation area and visitor centre.	Fairly frequent flooding may affect facilities at Barton Clay Pits.	Facilities at Barton Clay Pits will be protected.	Facilities at Barton Clay Pits will be protected.	Facilities at Barton Clay Pits will be protected.
Health and safety	Uncontrolled risk to people.	Risk to people would be 'high'.	Risk to people would be 'moderate'.	Risk to people would be 'low'.	Risk to people would be 'low'.
Availability and accessibility of services	Significant reduction in services and access to them.	Services flooded fairly frequently, with impact over time due to flood frequency.	Services would be protected.	Services protected and only flooded very infrequently.	Services protected and only flooded very infrequently.
Equity	Impacts on area with deprivation index of 3,556.	Frequency of flooding may affect job distribution.	Flooding 1 every 20 years is unlikely to affect people.	Area likely to retain current or improved status.	Area likely to retain current or improved status.
Sense of community	The loss of properties and jobs will result in loss of sense of community.	Risk to sense of community high due to frequency of flooding.	Risk to sense of community would be low due to frequency of flooding.	Sense of community would be largely unaffected.	Sense of community would be largely unaffected.

6.4.2 Information detail and the different levels of decision

Another conclusion from the first set of case studies was that, depending on whether the project was a high level policy, a strategy or a scheme, the information and data provided was in varying quantities and detail. This fact was evident, even considering that RPA did not have access to all of the information available, and was to be expected.

As indicated in FCDPAG 1 (MAFF, 2001), for high level plans project appraisal takes a broad approach, sufficient to build a guiding framework within which layers of smaller scale strategies or schemes can be developed. It adds that at each level of appraisal, all of the potential impacts of options are considered to an appropriate level of detail and geographical scale.

The completion of the MA-ASTs for the different case studies demonstrated that at the SMP level, most information was of a qualitative nature, in line with the necessary level of detail for the appraisal. There was, nonetheless, some quantitative information. For the strategy and scheme levels, quantitative data was more readily available, making the whole assessment much less subjective and more reliable.

It was also concluded that the number of MA-ASTs that needed to be completed was bigger for the policy projects than for the strategy and schemes, due to the various sizes of the area under assessment. However, this factor was counter-balanced by the fact that at the higher levels of decision-making, there is the need for less detailed information to be recorded in the ASTs at this stage.

However, the quantitative assessment of impacts should not be neglected at the policy level of appraisal. A quantitative assessment should always be attempted, even if the data used is less accurate. This can help highlight the gaps in information that need to be filled before the strategy and scheme levels of the project can be undertaken.

6.5 Scoring of impacts for the second set of case studies (Step 6b)

6.5.1 Introduction

From sub-section 5.6, four major concerns still remain. The subjectivity issue, double counting and across unit comparisons of options were only partly resolved and, there was still the concern over how to address uncertainty.

During the development of the second set of case studies it was recognised that the subjectivity and double counting issues could be further resolved by linking the category score to the damages that would be caused by a flood. This was done to some degree in the existing scoring systems, but there was a need to bring in the length of time over which the damages extended. Thus, if the scoring system could reflect not only the area or number of assets affected but also the time that it takes for recovery after a flood, the scoring system could be more directly related to the damages of a flood. In this way, the estimated damages would better reflect the consequences of a flood.

This highlighted a further point: that the consequences of a flood are related to the size of a flood. Such an approach would result in a risk-based approach, where the risk combines the probability of a flood event occurring and the consequences of that particular event. The use of probability and consequences in this manner is exactly the same as the use of probability and damages in the Average Annual Damage (AAD) worksheets of the FCDPAG 3 spreadsheets. Thus, the damages of each flood event could be calculated using the same (mathematical) approach as the calculation of monetary damages, and a greater integration between the current approach to appraisal and the proposed MCA-based methodology would result.

The AAD worksheet allows the average damages to be calculated by considering damages caused over a number of different return period flood events. The worksheet itself allows damages on eight different events to be entered, from which the average damages can be calculated. This approach was extended into a scoring system by calculating the average annual damages for all options. The worst option (that with the highest level of damages) is assigned a score of zero while the best option (that with the lowest level of damages) is assigned a score of 100. The intermediary options are then assigned a score in relation to the level of damages caused by that option and the proportion that this represents of the worst and best options.

Thus, a new scoring system was developed and trialled on the Humber Estuary case study. This scoring system is related to the number of characteristics affected for each category and the recovery time required to return to pre-flood conditions, hence, it is given the acronym ‘ChaRT’.

6.5.2 The ChaRT scoring system

The Humber Estuary case study was used to develop the ChaRT scoring system based on characteristic recovery time. The aim was to reflect the impacts of a flood on each category, with the scores calculated numerically using a more flood-focussed basis. The ChaRT scoring approach was further tested on the Newbiggin Coastal Defence case study, although it had to be amended so that it could be applied to a situation where damages are caused by erosion, not flooding. It is worth noting at this point that although the Humber Estuary is referred to as an SMP, throughout its real time development it has been approached as a Strategy. For this reason, sufficiently detailed quantitative information was available for the development of a quantitative scoring system.

The scores for the Humber case study were assigned using ‘recovery times’ as the basis for the measurement. ‘Recovery time’ is defined as the minimum time required between events for impacts on that category to be reduced to zero. From this definition, it can be deduced that if a flood occurs before there has been time for full recovery, the impacts of an option would be much greater than if the next flood event occurs several years after full recovery has been achieved. Using a ‘recovery time’ basis for the scoring approach, allows the standard of defence provided by each option to be directly reflected in the score.

For each category, it is necessary to determine two factors in order to be able to assign a score:

- characteristic of the category that is affected by flooding; and
- recovery time of that characteristic.

The characteristic is a measure of the amount of a particular category affected and could relate to an area, a number, etc. The recovery time is linked to the number of years after the flood that the effects would continue to be felt.

Once these two factors have been identified (or estimated), the scores can be calculated automatically using the same approach as is used in the Asset AAD worksheet of the FCDPAG 3 spreadsheets. An indication of the factors that could be used to score each of the 15 categories, are given below. These are only preliminary factors and further research to develop more accurate and robust indicators is needed.

6.5.3 The categories, their characteristics and recovery times (ChaRT)

For the economic impact categories, the characteristics and recovery times are:

- *Assets:* in most cases, assets will be valued in monetary terms (as damages under ‘do-nothing’ and damages avoided for the do-something options). Where a score is applied, the same numeric bases would be used, i.e. number of residential and non-residential properties (NRPs) affected under different return period flood events. The time to recovery would be based on the time it takes for a property to be repaired such that it can be lived in or worked from;
- *Land Use:* for land use, the characteristic would be hectares of land affected under different return period flood events. The recovery time would then be the time taken for agricultural land to be fully useable again and for yields to return to their pre-flood levels;
- *Transport:* the characteristic for transport would be length (km) of roads, railways, etc. affected under different return period flood events. The recovery time would be the time taken to return the transport infrastructure to full (pre-flood) use; and
- *Business Development:* for business development, the score needs to reflect the indirect impacts of a flood on non-residential properties. Thus, the characteristic would be the number of NRPs affected. The recovery time would be determined by the time it would take for an affected business to return to its pre-flood levels of production, output, etc. Such an

approach would allow impacts such as lost markets to be included in the scoring.

For the environmental impact categories, the characteristics and recovery times are:

- *Physical habitats:* for physical habitats, the characteristic would need to be linked to the number of sites and/or area affected by flooding. The recovery time would then need to be linked to the time it would take for the conservation interest (or value) to return to pre-flood level. This does not necessarily mean that the original site would have to return to its pre-flood condition as there may be occasions when a change in habitats may increase conservation value (e.g. where saltmarsh and/or mudflat are created on previously agricultural land);
- *Water quality:* the characteristic could relate to the number of waterbodies (rivers, lakes, etc.) or their length. The recovery time would then need to reflect the time required for the water quality to return to its pre-flood level;
- *Water quantity:* as for water quality, the number of waterbodies (including aquifers) would form the characteristic. The recovery time would need to reflect the time required for water sources to be available in their pre-flood condition;
- *Natural processes:* the natural processes category does not lend itself to being easily scored on a characteristic recovery time approach. However, it could be based on the hectares or tonnage of land that would be undergoing natural processes, while the recovery time could be linked to the time it would take for natural processes to be regenerated. In this way, it would be similar to the approach used in the ‘erosion’ worksheet of the FCDPAG 3 spreadsheets, with the recovery rate based on the ‘delay’ in the onset of erosion;
- *Historical environment:* the characteristic would be related to the number of sites (e.g. Scheduled Ancient Monuments) while recovery time would be the number of years required to return the site to its pre-flood condition. There is the potential for importance to also be taken into account as a multiplier of the number of sites (i.e. three sites of international importance (3 x 5) and two sites of local importance (2 x 2)); and
- *Landscape and visual amenity:* as for natural processes, landscape and visual amenity are difficult to place in the characteristic recovery time approach. However, the number of hectares changed/affected by the flood could be used as the characteristic; recovery time would then be based on the time for the landscape to regenerate. This approach would allow potential improvements in landscape quality to be incorporated into the scoring system. For example, a change from an intensively farmed landscape to a more natural saltmarsh/mudflat landscape may take 5 years to occur. Here the ‘recovery’ time would be taken as 5 years.

For the social impact category, the characteristics and recovery times are:

- *Recreation:* where recreation is not valued, the characteristic would be based on the number of recreational sites affected, numbers of visitors affected, etc. Recovery time would be the time required for recreational use to recover to pre-flood levels. As with some of the other categories, the type of recreation could change, it is the quality of the recreational experience that the score should attempt to capture;
- *Health and safety:* the characteristic would need to relate to the population whose health may be affected. This is likely to be linked to the area flooded. Recovery time would be linked to the time required for the health of those affected to return to pre-flood levels;
- *Availability and accessibility of services:* the characteristic would be linked to the number of services affected and would include hospital, schools, utilities, etc. The recovery time would then be the amount of time required for those services to return to pre-flood levels of operation:
- *Equity:* equity has to relate to changes in the vulnerability of particular groups, hence, populations within these more vulnerable groups would be an appropriate characteristic. The time taken for these groups to recover to the pre-flood level of relative deprivation, etc. would provide an estimate of recovery time; and
- *Sense of community:* the population of the area would give an indication of size of the community affected, although this may not reflect community activities such that participation in particular events may be a more appropriate characteristic. Recovery time would need to be linked to the time that it would take to restore activities in the community.

The characteristics and recovery times used to estimate the ChaRT scores for the Humber case study are given in Table 6.7, as an example.

Table 6.7 Basis for the characteristic and recovery times for the Humber MU6

Category	Characteristic used	Recovery time used
Economic impacts		
Assets	Valued in monetary terms	
Land use	Hectares of agricultural fields affected by different return period events	3 years for return period events of <1 in 50; 5 years for floods with a return period of >1 in 50. Represents the time taken for yields to return to pre-flood levels
Transport	Length of roads and railways affected (in km) affected by different return period events	0.5 years for return period events of <1 in 20 years and 1 year for events >1 in 20. Represents the time taken for infrastructure to be repaired and disruption reduced to pre-flood levels
Business development	Number of non-residential properties (NRPs) flooded under particular return period events	1 year for events of <1 in 50 and 2 years for events >1 in 50. Represents the time required for the NRPs to return to pre-flood levels of production and output
Environmental impacts		
Physical habitats	Separated into number of freshwater and intertidal habitats affected under	5 years for events of <1 in 50 and 10 years for events >1 in 50. Represents the time taken for the

Table 6.7 Basis for the characteristic and recovery times for the Humber MU6

Category	Characteristic used	Recovery time used
	different return period flood events	conservation value to return to pre-flood levels
Water quality	Hectares of agricultural fields affected by different return period events (source of contaminants to water)	0.5 years for events of <1 in 50 and 1 years for events >1 in50. Represents the time required for salinity to be reduced and for pre-flood water quality to be re-established
Water quantity	Number of waterbodies whose water quality would be affected under different return period events	1 year for events of <1 in 50 and 3 years for events >1 in50. Represents the time required for salinity to be reduced such that water can be abstracted
Natural processes	Length of coastline affected (km) by change in ability to function naturally (this category is independent of probability of flood events)	5 years to recover to natural situation if defences are removed
Historical environment	Number of Scheduled Ancient Monuments and listed buildings flooded under different return period flood events	5 years to recover to pre-flood conditions for all return period flood events
Landscape and visual amenity	Area of Management Unit that would be flooded	1 year for events <1 in 50 and 3 years for events >1 in 50. Represents the time for the landscape to return to its pre-flood state
Social impacts		
Recreation	Number of recreational sites affected under different return period events and split into freshwater and intertidal	5 years for events <1 in 50 and 10 years for events >1 in 50 to reflect importance of conservation value to recreation quality
Health and safety	Population flooded under different return period events (based on number of properties flooded)	1 year for events <1 in 20, 3 years for events between 1 in 20 and 1 in 50 and 5 years for events >1 in 50. Represents the time required for people's health to recover to pre-flood levels
Availability and accessibility of services	Number of services flooded under different return period events	1 year for events <1 in 50 and 2 years for events >1 in 50. Represents the time required for services to return to pre-flood levels of operation
Equity	Population within most vulnerable groups flooded under different return period events (those with long-term illness, in ethnic groups other than white and migrants)	3 years for events <1 in 50 and 5 years for events >1 in 50. Represents the time required for recovery of the most vulnerable groups
Sense of community	Population flooded under different return period events (based on number of properties flooded)	2 years for events <1 in 50 and 4 years for events >1 in 50. Represents the time required for the knock-on effects of flooding to be minimised such that sense of community can be restored

Table 6.7 highlights the importance of the flood event on the score. This means that the scores assigned are effectively a measure of the risk of flooding, where the characteristic recovery time represents the consequence and the estimation of the ChaRT score brings in the probability of flooding through the use of average annual damages (AAD).

6.5.4 Calculating the scores

As indicated above, the ChaRT scores were estimated in the same way as the average annual damages are calculated using the FCDPAG 3 spreadsheets. This is an appropriate approach as the number of characteristics affected multiplied by the total time spent 'in recovery' gives an indication of damages for each category. The AAD calculation brings in the probability of flooding by considering the damages that would occur under eight different return period events, as shown in Figure 6.1, where the events are 1:3, 1:5, 1:10, 1:20, 1:50, 1:100, 1:300 and 1:500.

Figure 6.1 Approach to scoring based on AAD worksheet

	Average waiting time (yrs) between events/frequency per year									
	3	5	10	20	50	100	300	500	infinity	
	0.333	0.200	0.100	0.050	0.020	0.010	0.003	0.002	0	
Land Use										**Annual Damage**
Area	122.1	488.4	757.02	818.07	989.01	1147.74	1184.37	1221		
Recovery	100	60	30	15	10	5	1.666667	1		
Do-nothing	12,210	29,304	22,711	12,271	9,890	5,739	1,974	1,221	92	6682.58
Maintain low	0	0	22,711	12,271	9,890	5,739	1,974	1,221	92	2449.78
Maintain high	0	0	0	12,271	9,890	5,739	1,974	1,221	91.575	746.49
Sustain	0	0	0	0	9,890	5,739	1,974	1,221	91.575	255.65
Improve 1:50	0	0	0	0	0	5,739	1,974	1,221	91.575	57.84
Improve 1:100	0	0	0	0	0	0	1,974	1,221	91.575	10.02

The damages for each flood event are calculated by multiplying the area affected (for the 1:3 event this is 122.1 ha) and the time spent in recovery (100). The time spent in recovery is calculated by dividing the time period over which the appraisal is being undertaken (here 100 years) by the return period event (3 years for the 1:3 event) and multiplying by the recovery time (for the category of Land Use this is 3 years for the 1:3 event). This is done for each return period event. The damages occurring under each option differ according to the standard of defence that the option provides. Hence, for do-nothing, damages are incurred under all return period events. For sustain, however, the standard of defence provided is 1:20 such that damages only occur on events that are greater than 1:20. The first damages are, thus, entered into the 1:50 cell. Damages occurring between the 1:20 and 1:50 event are included as a result of the calculation of AAD, which uses the following formula:

$$AAD = \frac{(damages_{1\ in\ 50} + damages_{1\ in\ 20})}{2} \times (probability_{1\ in\ 20} - probability_{1\ in\ 50})$$

The same calculation is used for damages occurring between each return period event, up to infinity. The damages are then summed to give the AAD.

The next stage is to use the range of AAD to set the scores for that category. This is done by setting 'do-nothing' as the 'worst' option (as it has the highest damages), and assigning it a score of zero. The 'best' option is 'improve 1 in 100' (as it has the lowest damages) and is assigned a score of 100. The scores for the remaining options are calculated using the following formula:

$$Score = 100 - \frac{(damages_{option} - damages_{best\ option})}{((damages_{worst\ option} - damages_{best\ option}) \div 100)}$$

For 'sustain', the score for land use is calculated as:

$$Score = 100 - \frac{(255.65 - 10.02)}{(6682.58 - 10.02) \div 100}$$

$$Score = 100 - 3.68 = 96.32$$

To reflect some of the uncertainty within the scores, they are given to the nearest whole number, such that 'sustain' would score 96.

Table 6.8 presents the ChaRT scores for the Humber case study based on the characteristics and recovery times shown in Table 6.7.

Table 6.8 ChaRT scores for Humber case study (MU6)

Category	Do-Nothing	Maintain	Sustain	Improve 1:50	Improve 1:100
Land use	0	80	96	99	100
Transport	0	70	96	99	100
Business development	0	88	98	100	100
Physical habitats - freshwater	0	86	98	100	100
Physical habitats - intertidal	100	20	3	0	0
Physical habitat overall (freshwater: 25%; intertidal: 75%)	100	23	3	1	0
Water quality	0	76	96	99	100
Water quantity	0	89	99	100	100
Natural processes	0	87	99	100	100
Historical environment	0	87	99	100	100
Landscape and visual amenity	0	74	94	99	100
Recreation - terrestrial	0	86	98	100	100
Recreation - intertidal	100	20	3	0	0
Recreation overall (terrestrial: 40%; intertidal: 60%)	100	24	3	1	0
Health and safety	0	81	97	99	100
Availability and accessibility of services	0	88	98	100	100
Equity	0	88	98	100	100
Sense of community	0	87	98	100	100

The scores given in Table 6.8 show that the 'do-something' option generally has scores that are very close to 100. This indicates that doing something is much better than doing nothing, which is also borne out from the MA-ASTs. Also, the damages estimated in monetary values are much closer to the best option (improve 1:100) than they are to the 'do-nothing' option, as shown in Table 6.9, below. If these damages were represented as a score, the scores would be as shown in Table 6.9.

Table 6.9: Damages in monetary terms and in ChaRT scores for the asset impact category for the Humber Estuary case study

Category	**Do-Nothing**	**Maintain**	**Sustain**	**Improve 1:50**	**Improve 1:100**
Damages in monetary terms (£k)	164,163	20,881	2,781	556	247
Damages in ChaRT scores	0	87	98	100	100

This suggests that the use of more arbitrary approaches to assigning scores may over-estimate the differences between options.

6.5.5 Sensitivity of the scoring system

It is possible to test the sensitivity of the scores to changes in the characteristic, recovery time and standard of defence by changing the input data. When this is done for the Humber Estuary case study, it is found that the scores are not very sensitive to changes in either the characteristic or the recovery time. This may reflect the nature of the management unit, where most categories are affected by flooding on all return period events.

Changing the characteristic

Three changes are made to the characteristic for land use:

- doubling the area affected on each flood event;
- multiplying the area affected on each flood event by 10; and
- making the area affected on each flood event the same (whole area of 1,221 ha).

The results of these changes are given in Table 6.10.

Table 6.10 Sensitivity of the scores to changes in the characteristic

Category	**Do-Nothing**	**Maintain**	**Sustain**	**Improve 1:50**	**Improve 1:100**
Appraisal	0	80	96	99	100
Doubled characteristic	0	80	96	99	100
Multiply characteristic by 10	0	80	96	99	100
Characteristic same for all return period events	0	90	99	100	100

Table 6.10 shows that the score does not change if the damages remain proportional between the options, regardless of the size of the area affected. If, however, the area affected is the same for all return period events, the scores for all of the do-something options increase. This is because the damages under do-nothing are greatly increased such that the relative differences in damages of the do-something options are reduced. Thus, the worse the do-nothing option, the higher the scores of doing something.

Changing the recovery times

Three changes are made to the recovery times:

- doubling the recovery times;
- halving the recovery times; and
- making the recovery times the same for all return period events (3 years).

The results of these changes are given in Table 6.11.

Table 6.11 Sensitivity of the scores to changes in the recovery times

Category	Do-Nothing	Maintain	Sustain	Improve 1:50	Improve 1:100
Appraisal	0	80	96	99	100
Doubled recovery times	0	76	96	99	100
Halved recovery times	0	80	96	99	100
Recovery time same for all return period events	0	81	98	100	100

Table 6.11 shows that, the scores change slightly as a result of the changes. Doubling the recovery times increases damages for all events, but the most significant effect is on ‘maintain’, where the score decreases to 76 (from 80). This is because the damages of the more common events have a larger effect on the AAD, such that the damages for ‘maintain’ increase in proportion to the damages under ‘improve 1:100’. This relative change causes the score for ‘maintain’ to decrease. Conversely, as the recovery times are reduced or made the same for all options, the difference in damages between ‘maintain’ and ‘improve 1:100’ is reduced, such that the score for ‘maintain’ increases slightly. However, despite these changes, the maximum change is four points (for ‘maintain’) again showing that very large changes in the recovery times are required to significantly affect the scores.

Changing the standard of defence

Three changes are made to the standards of defence offered by the 'do-something' options:

- all options reduced ('maintain' is reduced to 1:10 at the start of the period and 1:3 at the end of the period, 'sustain' is reduced to 1:10, 'improve 1:50' is reduced to 1:20 and 'improve 1:100' is reduced to 1:50);
- all options increased ('maintain' is increased to 1:50 at the start of the period and 1:10 at the end of the period, 'sustain' is increased to 1:50, 'improve 1:50' is increased to 1:100 and 'improve 1:100' is increased to 1:300); and
- highest 'do-something' option only is increased ('improve 1:100' is increased to 'improve 1:300').

The results of these changes are presented in Table 6.12.

Table 6.12 Sensitivity of the scores to changes to the standards of defence

Category	Do-Nothing	Maintain	Sustain	Improve 1:50	Improve 1:100
Appraisal	0	80	96	99	100
All options reduced	0	51	90	97	100
All options increased	0	94	99	100	100
Highest do-something option only increased	0	80	96	97	100

Table 6.12 shows that the scores are much more sensitive to changes in the standards of defence provided by the options than to changes in the characteristics or recovery time. This is interesting since it shows that the assessment of a different set of options would give a different set of scores. If the aim of the flood and coastal defence appraisal is to identify the most appropriate standard of defence for a particular area, then the use of a scoring system based on characteristics and recovery time, which reflects the intangible damages for different standards of defence, should provide a basis for including intangible benefits in a similar manner to the way in which tangible benefits are taken into account.

6.5.6 Conclusions about the ChaRT system

In relation to the approaches to scoring tested in the first round of case studies, the ChaRT scoring system appears more robust. Firstly, it is based on readily available information, much of which is already collected for use in the economic appraisal; secondly, because the scores are calculated based on damages from different flood events, they are more directly related to flood and coastal defence. Also, the fact that the scores are calculated using the same approach as is used to estimate AAD makes it more consistent with the current approach used to estimate monetary damages. And, finally, each option is scored on the same basis, such that the difference in scores is a direct reflection of the difference in the standard of defence provided by that option.

The ChaRT scoring system also addresses many of the key issues raised in Sub-sections 5.6.1 to 5.6.7:

- subjectivity is removed by basing scores on a measurable characteristic. Recovery times may introduce some subjectivity at present, but as this is time-based it can be estimated and, over time, there is the potential for research and/or recording of recovery after flood events that would reduce subjectivity;
- negative and positive aspects can be sub-divided and scored individually. Weights can be assigned to the positive and negative aspects if an overall score is required for the category;
- double counting can be eliminated by careful use of characteristics and the consideration of primary, secondary and indirect effects as the basis for the recovery time;
- to assign scores to each option, it is necessary to identify the characteristics flooded on each return period event and the recovery time following a flood for each return period event (if this is expected to differ). The scores are then calculated automatically. If two (or more) options are the same, they will have the same damages and, hence, the same scores; and,
- as the scores are calculated using a spreadsheet, uncertainty within the characteristic and recovery times can be investigated by changing the input data. This will give an indication of the sensitivity of the scores to uncertainty. An assessment of changes to the characteristic and recovery times for the Humber Estuary case study shows that the scores that are calculated are not very sensitive to changes to either the characteristic or recovery time. This means that uncertainty, in particular on recovery times, will not have a large effect on the score assigned to each option. The scoring system is sensitive to the standard of defence offered by an option, however, such that it provides a good basis for including the impacts of different options in a project appraisal.

However, there are still some shortcomings with this approach, some of which would require further research and investigation before it could be applied:

- not all of the categories can be directly related to a characteristic and/or a recovery time. This is particularly true of the social categories such as ‘equity’ or ‘sense of community’. However, initial methods of capturing these impacts within the scores have been determined;
- there is, at present, little information upon which to base the estimates of recovery times;
- ‘do-nothing’ damages are not capped, i.e. it is assumed that damages occur for up to a maximum of 100 years and that communities (etc.) do not

move out of the area, such that the damages of ‘do-nothing’ may be over-estimated;

- it is not straightforward to estimate the characteristic or recovery time when ‘do-nothing’ is the ‘best’ option. This may occur where ‘do-nothing’ provides the most sustainable solution, such as for natural processes or physical habitats. It is possible, however, to calculate damages as for the other categories and then set ‘do-nothing’ as the best option, such that it scores 100 and the scores for the other options are calculated as 100 minus the score if ‘do-nothing’ was the worst option. For example, an option that would score 75 when ‘do-nothing’ is the worst option would score 25 if ‘do-nothing’ were the best option (100-75); and
- the ChaRT scoring system is most useful at the strategy level of appraisal or at the high level appraisal when significant amounts of quantitative information is available. At these levels the decision to be made is whether action is needed and which standard of defence should be provided. At the scheme level the decision is how to achieve the standard of defence defined in strategy. For this reason the differences between the options being appraised will mostly be related to *‘modus operandi’* rather then level of defence provided. In terms of characteristic and recovery times this may mean that all options of a scheme will have similar scores. Hence, the ChaRT scoring systems is less amenable to scoring schemes.

Application of the scoring system to additional project appraisals should allow the impact of many of these shortcomings to be investigated. As more appraisals are undertaken, appropriate approaches to all categories may be identified. Review of records from previous floods and/or monitoring of recovery of characteristics following future floods should help inform recovery times. Additional appraisals would also allow further investigation into the potential for capping ‘do-nothing’ damages and/or further developing the scoring system so that positive impacts can be adequately included.

6.6 Findings from the scoring workshop

In order to further explore the approaches to scoring being proposed, a workshop was organised to allow stakeholders to express their views as to preferred methods.

The workshop was held on the 1st October 2004 in London and had the following objectives:

- to discuss how impacts within MCA can be robustly and consistently scored;
- to review the scoring systems created to date; and
- to generate recommendations on the type of approach that could be carried forward.

A more detailed account of the participants and the activities undertaken is presented in Annex C of this Report. The following paragraphs present a summary of the conclusions.

The workshop was successful in highlighting the problems that surround the different scoring approaches. However, it did not give a clear indication of which approach should be preferred. Although the groups applying the 'relative to 100' scoring system ended up scoring the options between zero and 100, this was probably because the options selected for the exercise were quite different to each other and wide-ranging (with the 'do-nothing' option often having very significant negative impacts whilst 'improve 1:100' had very small negative impacts). Nonetheless, it appears that the 'zero to 100' approach is preferred over the 'relative to 100' approach.

There was still the issue of how to introduce the concept of probability into this approach. The ability of the 'ChaRT' type approach to incorporate risk into the scoring process was seen as an advantage by some, even if in need of further development and only applicable to some of the impact categories. It was clear, however, that carrying out the scoring exercise in a group gave the practitioners greater confidence in the exercise.

This means that there were three possible quantitative scoring approaches. These are:

- the 'zero to 100' scoring system;
- the 'ChaRT' scoring approach, in particular for the strategy level of appraisal; and
- a 'scoring by committee' approach (based on either the 'zero to 100' or ChaRT).

It is believed at this stage that it would be better to go forward with all three scoring methodologies, being aware of their advantages and disadvantages. The decision about which scoring systems to apply should therefore be left until after the MCA-based approach is trialled in pilot projects. Only when trying different scoring systems in real time situations, where the people applying them are aware of all the flood and coastal issues and concepts, can one really tell which system or combination of systems is preferred.

'Scoring by committee' is introduced here as a new approach to the scoring exercise based on the findings of the workshop. This showed that participants were generally more confident about the scores assigned once they had had the opportunity to discuss the issues amongst themselves. It was also recognised that expert opinion (e.g. from English Heritage, with regard to the historic environment) would be required to determine whether the scores are justifiable.
The 'scoring committee' would be composed of the consultants in charge of the appraisal and experts on different impact categories as required. The committee should not include stakeholders, as the objective here is to assess the impacts of the different options and not to weigh up the priorities. In addition, the scoring

could be undertaken using either the ‘zero to 100’ or the ‘ChaRT’ scoring system, discussed above.

Under this approach to scoring, the issues of availability of objective information, double counting, the reflection of both small and large differences between options, proportionality and uncertainty would continue to be the same as those attached to the scoring technique used (being quantitative and/or qualitative).

Although this system could provide a higher confidence in the scores it would not necessarily make them more reliable or accurate. It would, however, provide a forum for discussion about the different impacts of the options, which in turn means that the scores are more likely to reflect all aspects of the problem rather then being limited to one or two aspects. Nonetheless, extra attention should be given to the definitions of the impact categories to make sure that everyone in the committee is reflecting on the same issues. This system may also make the scoring more transparent and potentially more robust, in particular in those cases where quantitative information is scarce. The approach to ‘scoring by committee’ also constitutes a good learning process as it explores all aspects of the impacts of each option.

Nonetheless, the ‘scoring by committee’ approach could be more costly both in terms of time and money. The question is whether this extra expenditure is balanced by the creation of more robust and accurate results. Also, there is always the danger that a consensus may not be reached. This problem could be partially dealt with by defining ranges of scores that can be further tested in

sensitivity analysis. The ‘scoring by committee’ approach also does not solve the issue of inclusion of a more risk-based approach to the scores under the ‘zero to 100’ system, however it makes it more likely that risk will be taken into account as at least one person on the committee will consider this problem.

6.7 Weight elicitation for the second set of case studies (Step 7)

6.7.1 Development of new weight elicitation concepts

From the first set of case studies it became apparent that further research into the stakeholder involvement methodologies would be difficult. For this reason it was decided that, in the second set of case studies, the research efforts should focus on streamlining the weight elicitation process, in particular by trying to focus it on the issues that really make a difference in selecting the preferred option.

Through observation, it became evident that there are often occasions where one option will always be preferred over another regardless of the relative weights placed upon the categories. In some cases, this is due to one option always scoring less across every category or because only one or two scores are marginally higher with the rest being less.

In such cases, it was considered that the gathering of weights may be an unnecessary 'formality' and that, rather than ask the question 'what are the relative weights for these criteria?' at the outset, useful information may first be gained from considering 'what are the lowest, highest and average weighted scores for each of the options that are theoretically possible?' and then considering the mathematical and logical feasibility of this range of scores on the basis of the weights needed to deliver them.

Table 6.13 provides a simple example to demonstrate the basic principles. The table presents hypothetical scores for two options (1 and 2) against five criteria (A, B, C, D and E). As can be seen from these, Option 2 performs worse than Option 1 in all cases except under Category B (where it scores much more highly) and Category C (where it scores the same).

Table 6.13 Example of basic principles

Category	Option 1	Option 2	Weighted score option 1	Weighted score option 2	Magnitude of weight_{ABCDE} for total option 1 score to be minimised	Magnitude of weight_{ABCDE} for total option 1 score to be maximised
A	80	40	80 x Weight_A	40 x Weight_A	Weight_A = Very Low	Weight_A = Very High
B	10	80	10 x Weight_B	80 x Weight_B	Weight_B = Very High	Weight_B = Very Low
C	70	70	70 x Weight_C	70 x Weight_C	Weight_C = Immaterial	Weight_C = Immaterial
D	60	20	60 x Weight_D	20 x Weight_D	Weight_D = Very Low	Weight_D = Very High
E	55	45	55 x Weight_E	45 x Weight_E	Weight_E = Low	Weight_E = High
			Total Score Opt 1	**Total Score Opt 2**		

To obtain a total score for the value of benefits, one multiplies the category scores by a weight expressing their relative importance compared to the other categories. However, a simple visual inspection of the data in Table 6.13 reveals that, if the total score for Option 1 is ever going to be smaller than that for Option 2, the relative weight applied to Category B is going to have to be very large compared to the weights for the other categories.

It is important to understand here that, once scoring for an appraisal is complete, the unweighted scores for each of the options under each of the criteria are static and constant. As a result, it is only variations in the weights applied to these criteria that produce variations in the total weighted scores for the options (i.e. not the unweighted scores themselves).
From these basic principles, we have developed the concept of Constrained Random Weight Generation (CRWG) to identify answers to the following questions for each Option's scores:

i. ***what is the maximum possible score for an option?*** which provides information on the maximum possible score for the option (see Table 6.13, for Option 1);

ii. ***what is the minimum score for an option?*** which provides information on the minimum possible score for the option (see Table 6.13, for Option 1); and

iii. ***what do the weights have to be to achieve such a minimum score?*** which provides information on which category must be more important than which and by how much.

6.7.2 Mechanics of the approach

The CRWG is a piece of software developed by RPA. The way the CRWG works is simply to randomly generate sets of weights for a given appraisal (at a rate of 3,000 per minute) and record the resulting total weighted scores for the options and the weights that produced them[10].

Beginning with entering all of the scores onto a master score sheet, the process of undertaking a simple CRWG analysis is as follows:

1. select the Option that is the focus for an analysis (and the option to compare it against);

2. run the CRWG to generate a few thousand random weights and associated weighted scores for the selected option;

3. from the dataset of random weights and associated weighted scores, the CRWG provides information on the absolute minimum, maximum and average total weighted scores for the option (and incremental scores for an incremental analysis);

4. the CRWG also divides the whole dataset into three different range sets for further examination, as illustrated in Figure 6.2. These are the low weight range, the average weight range and the top weight range;

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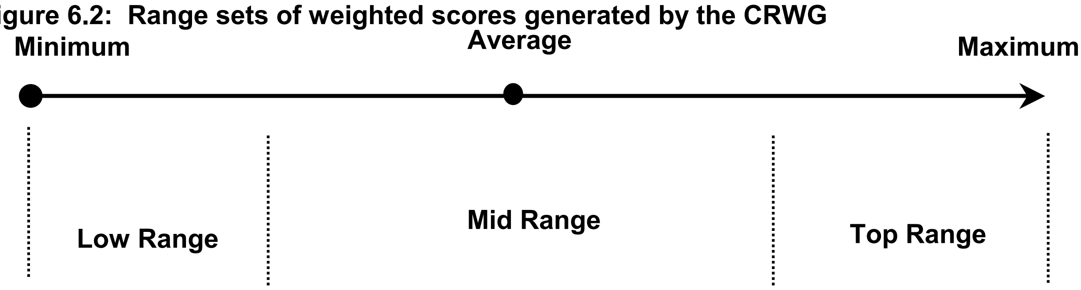
[10] The CRWG can also be used in a number of other ways, incorporating decision criteria discussed in later sections.

Figure 6.2: Range sets of weighted scores generated by the CRWG



5. set the CRWG to capture only sets of weights delivering total weighted scores in the lower range of total weighted scores (or incremental scores) and re-run random weight generation; and

6. store the outputs and repeat with each of the ranges.

The three sets of results are then entered into an adjusted standard FCDPAG 3 appraisal sheet. Table 6.14 provides an example drawn from the Pagham to East Head case study (East Wittering assessment unit) showing calculations for the incremental intangible benefit of the 'improve' option.

As can be seen from the table, the CRWG has calculated that the possible range of total weighted scores for the 'improve' option. Here it can be seen that there are no incremental intangible benefits of moving from 'sustain' to 'improve'. As such, the CRWG records the incremental intangible (scored) benefits as a negative value (reflecting that there is always an intangible dis-benefit from moving to the Improve option regardless of the weights). In this particular example, then, there is no combination of weights for the 'improve' option that provide for an intangible incremental benefit (and in this case the CRWG tells us that the option could not be justified by monetary or intangible benefits whatever the weights gathered from an elicitation).

Table 6.14: Example Data (Pagham to East Head - East Wittering Case Study)

	Sustain			Improve		
Total PV costs for appraisal PVc	3,000,000			8,000,000		
Total PV benefits PVb	18,500,000			18,630,000		
Average benefit/cost ratio	6.17			2.33		
Incremental benefit/cost ratio	-			0.03		
Required incremental B/C ratio				3		
	Min	**Ave**	**Max**	**Min**	**Ave**	**Max**
Total weighted score	-	-	-	70.8	91.6	98.2
Scored intangible incremental benefit of moving to the next Option (CRWG)	-	-	-	-7.9	-2.1	-0.4

In other situations, the outcome may not be so clear. For example, it may be that an option may be justified if the mid and higher range weighted scores are used (for analysis methods see Section 8), but be unjustified if the lower range weighted scores calculated by the CRW Generator are applied.

In such cases, it is necessary to examine the sets of weights to determine which set (lower, mid, or higher) seems most reasonable to apply. The CRW Generator provides a number of analyses and outputs to examine trends within each set of weights for this purpose. In general, at the mid range weighted score, there tends to be no observable trend in the data. It is only when looking at the lower and higher range weighted scores and associated weights that one is able to identify the key weighting factors responsible for the lowest and the highest scores.

Figure 6.3 provides an example of one of the outputs for the lower and higher range scores for the Improve Option recorded in Table 6.14 for the Pagham to East Head case study. For each magnitude of weight, the Figure plots the percentage frequency that each criterion in the data set has this weight. In the case of the East Wittering 'improve' option, two sets of criteria show a clear trend: the type level data (i.e. economic versus social versus environmental versus cross-cutting Issues); and the categories under the environment type impacts (i.e. physical habitats versus natural processes versus historical environment versus landscape and visual amenity).

From the Figure it can be seen that low weighted scores for the option are associated with a high level of weights applied to the environment impacts. Similarly, low scores are also associated with high weights applied to the category of Landscape and Visual Amenity under the Environment Type Impacts. As might be expected, the reverse is true for high scores for the Option (i.e. high scores associated with low weights for Physical Habitats impacts and Landscape and Visual Amenity). The data for the mid range (not provided here) shows no trend and all criteria have the same distribution of weights.

Clearly, the context of the particular situation guides whether or not one can tend towards the lower or higher end of the weighted score spectrum. Thus, in the example, if environmental impacts are indeed likely to be more important than the other types of impacts, one might tend to assume that the actual weighted score for the option lies between the lower bound and the mid bound estimate. Similarly, if the opposite were true, one might tend to assume the weighted score was between the mid bound and the upper bound estimate. However, if the decision requires greater precision (which often it may not) and there is uncertainty over the actual importance of the environment category relative to the others, then clearly one can consult on the relative importance of just a subset of the criteria to determine the outcome. In this example, one may only need to elicit the relative weight of environment versus the other types of impacts (i.e. economic, social and cross-cutting) and landscape and visual amenity versus the other environmental impact categories (i.e. physical habitats, water quality and quantity, natural processes and historical environment) rather than all of the categories versus all of the others.

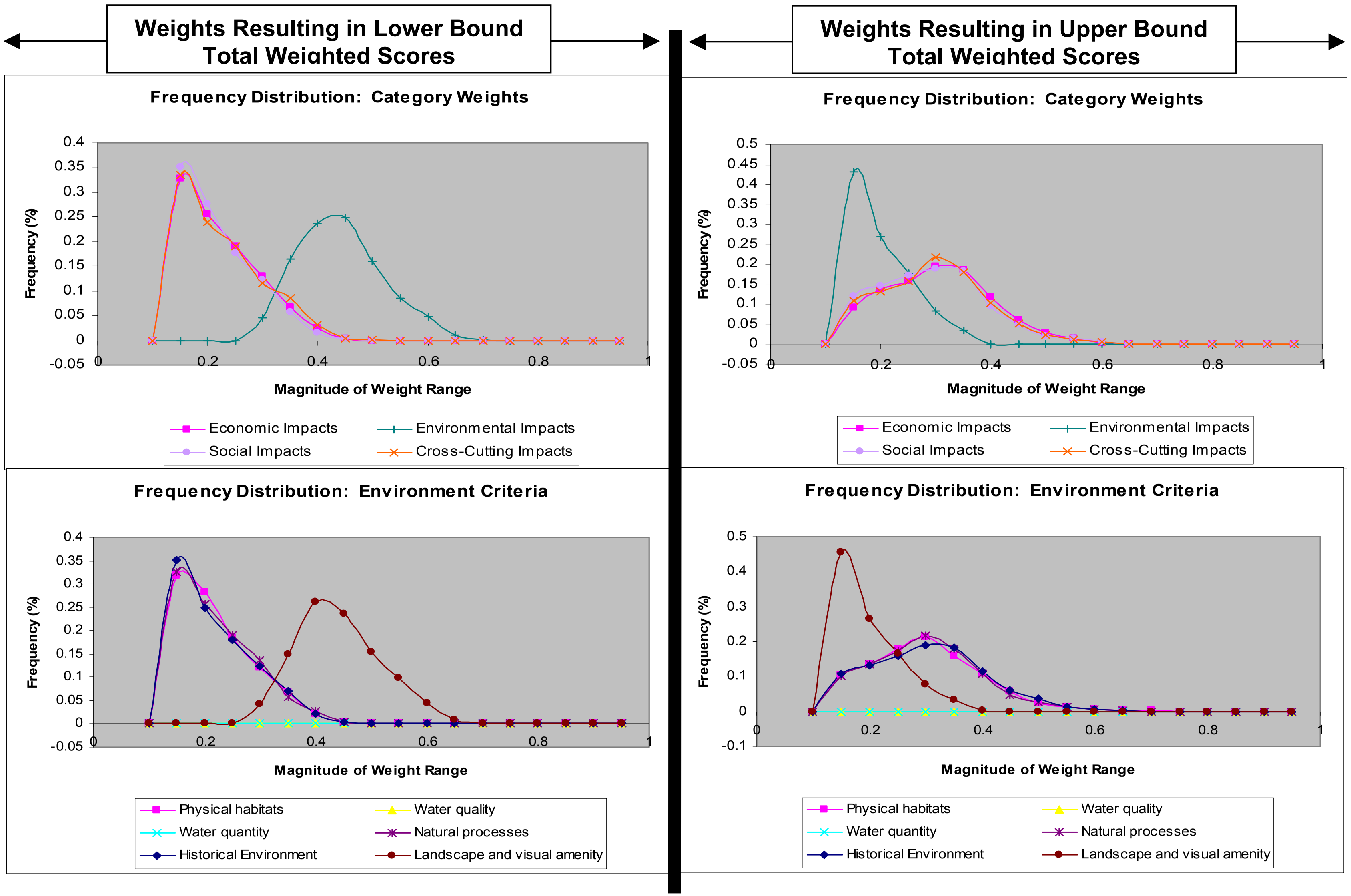
6.7.3 Conclusions from the application of CRWG

From the discussion above and application to the case studies, a number of advantages of applying the CRW generator (plus weight elicitation where necessary) have been identified. These advantages are associated with either eliminating or (at very least) reducing the need to conduct extensive weight elicitation exercises. This is because the CRW generator makes it possible to determine whether:

- a given option will never be justified whatever the weights (for example, if the option can only ever achieve a negative incremental score and does not achieve the necessary monetary incremental benefit-cost ratio, then it cannot be justified);
- a given option is definitely justified (for example, where the monetary incremental benefit-cost ratio already suggests that it is justified and, regardless of the weights, the option also always has a positive incremental score); or
- there remains uncertainty over whether the option is justified, which requires further investigation and potentially some weight elicitation. In these cases the elicitation exercise can be much reduced and focus only on those criteria that actually make a difference to the outcome (i.e. rather than all of the criteria at once).

In all of the case studies where the CRW generator was applied, it was found that a decision on the preferred option could be made without the need for further elicitation. In the vast majority of cases, this was because the CRW Generator identified options within the first two categories described above, demonstrating with certainty that no set of weights (elicited or randomly selected) would change the outcome.

Figure 6.3 Distribution of weights required to produce Lower Bound and Upper Bound total weighted scores



6.8 Comparison of options (Step 8)

6.8.1 Background

As has been described in Section 2, one of the key reasons why MCA techniques have been used in only a small number of flood and coastal defence applications is the absence of any logically rigorous decision rule comparable to that of economic efficiency underlying the use of CBA.

The weighted summation technique provides an overall weighted score of performance across all attributes, collapsing all the information on 'intangible' impacts into a single unitless measure of performance. While there may be similarities in principle, however, the intangible costs and benefits are still not expressed in the same unit as the monetary costs and benefits.

Comparing costs in monetary terms with benefits in unitless terms enables one to make a decision as to which option is the most cost-effective. However, this is not the same as identifying whether one option is justified on the basis of the value of the benefits compared to the costs. For flood and coastal defence appraisal, then, there is a need to consider how one can best aggregate and compare options using a logically rigorous decision rule comparable to that used in CBA.

6.8.2 Derivation of decision rules

In the absence of any other costs and benefits, a full MCA would usually examine whether one option scores more highly than another; the option with the highest weighted score being the 'best' option from the point of view of intangible benefits. However, in flood and coastal defence, there are other (monetary) benefits and costs that must also be taken into account. As a result, the value of the intangibles denoted by a weighted score is only one part of the overall benefit-cost equation.

The accepted methodology for prioritising flood and coastal defence projects is based on maximising the benefit-cost ratio, where the benefits are the estimated reduction in tangible damages from the 'do-nothing' option.

For this approach to be extended to incorporate a weighted score for intangibles (over a range 0 to 100), we would need to maximise the expression:

{Monetary Benefits (in £s) + Intangible Benefits (in £s)}/Monetary Costs (in £s).

Clearly, however, the value of intangible benefits is not a monetary value (i.e. in £s) but is a unitless weighted score in the range of 0 to 100. To incorporate the weighted scores into the decision-making process, therefore, it is necessary to consider what the magnitude of any additional benefit would have to be and whether the weighted scores indicate whether any additional benefits are likely to be delivered.

This simply requires consideration of two factors. The first is the magnitude of the additional benefit required (if any) to maximise the benefit-cost ratio upwards to meet the necessary criterion (given by FCDPAG 3). Thus, using an example, for a given option with benefits of £10,000 and costs of £11,000, the benefit-cost ratio would be 0.9. Clearly, this means that, for the option to achieve a benefit-cost ratio of 1 (and be justified in this example) additional benefits equal to (or greater than) £1,000 would be required to justify the option.

The second consideration is whether the weighted scores indicate that there are additional benefits that have not been valued in monetary terms and, if so, the magnitude of these benefits as weighted scores. Comparison of the magnitude of weighted scores with the magnitude of the additional benefits required (in £s) then allows one to calculate what the implied value of one point of the scoring index would have to be in order for the option to be justified or preferred over another and, in turn whether this is likely to be reasonable or not. Throughout the analyses, we have named the implied value of a point 'k' (expressed in units of implied £ per point on the index). In this way, the following relationship is being utilised:

Intangible Benefits (in £s) = k x I

where: I = a weighted score for the option given by the MCA
k = variable valuation factor (simply £/point and always >0)

Where integrating this into the benefit-cost expression provides the following:

Overall Benefit Cost Ratio = B/C + (k I)/C

where: B = monetary benefits (damages avoided) for each option
C = option monetary cost
I = a weighted score for the option given by the MCA
k = variable valuation factor (simply £/point and always >0)

Applying this logic to the decision context permits the development of the following preliminary decision rules for different situations:

Simple situations

- if an option achieves the necessary monetary incremental benefit-cost ratio and the weighted scores indicate that are also additional intangible benefits then the option is definitely justified; and
- if an option does not achieve the necessary monetary incremental benefit-cost ratio and the weighted scores indicate that there are no additional intangible benefits then the option is definitely not justified.

Table 6.15 provides an example of how the weighted scores and consideration of required additional benefit can be used in these situations.

Table 6.15 Decision rules for simple situations

	Do-nothing	Maintain	Sustain	Improve
Return period		1:10	1:50	1:150
Total PV costs for appraisal PVc	-	£500	£1,400	£4,000
PV damage PVd	£15,000			
Total PV benefits PVb		£2,000	£5,000	£12,100
Average benefit/cost ratio		4.00	3.57	3.03
Incremental benefit/cost ratio			3.33	2.73
Required incremental B/C ratio			1.5	3
Required additional benefits to meet criterion			-£1,650[11]	£700
Weighted score	5	10	60	50
Scored intangible incremental benefit of moving to the next option (CRWG)		5	50	-10
Comment			Justified without extra benefit	Not Justified
Implied additional benefits per point (k) to meet criterion			N/A	N/A

Situations where an option does not achieve the necessary benefit-cost criterion

If an option does not achieve the necessary monetary incremental benefit-cost ratio but the scores indicate that there are additional intangible benefits (that have not been valued), then further consideration should be given as to whether the implied value of these scored benefits (i.e. k per point) is likely to be unreasonably high or not. If unreasonably high, the option is not justified. If not unreasonably high, the option may be justified.

Table 6.16 provides an example of how the weighted scores and consideration of required additional benefit can be used in these situations. This is done in steps:

1. from the example, both of the 'improve' options require an incremental benefit-cost ratio of 3 (relative to the 'sustain 1:50' option);

[11] The required additional benefits to meet criterion is calculated by using the formula to calculate the incremental benefit-cost ratio, fixing the incremental B/C to the required level to obtain the necessary benefits to achieve the criterion. Then, by subtracting the required benefits to achieve the criterion from the total benefits of the option, the required additional benefit to achieve the criterion is obtained. If the required additional benefits happen to be negative, then this means that the benefits achieved by the option are higher than the required to achieve the criterion. This information will be useful later on in the analysis.

2. neither option achieves this on the basis of monetary benefits and costs alone and both would require additional intangible benefits to achieve the criterion of 3;

3. comparison of incremental weighted scores with the required additional benefits suggests that, as the ‘improve 1’ option only has an intangible (scored) incremental benefit of 2, the value of one point on the scoring index (k) would have to be much larger than that required for the ‘improve 2’ option;

4. in addition, of the two ‘improve’ options, ‘improve 2’ is the preferred option since, whatever value per point (k), ‘improve 2’ will always perform better because it will always have the higher incremental benefit cost ratio (all the points on the scoring index being directly proportionate to one another); and

5. the remaining decision is whether or not a value of >£10 per point on the index (k) is reasonable or not and, thus, whether the ‘improve 2’ option is likely to be justified. This requires a ‘reasonableness test’, which is described later as the final decision rule.

Table 6.16 Considerations where option(s) do not achieve the necessary benefit-cost ratio

	Do-nothing	Maintain	Sustain	Improve 1	Improve 2
Return ceriod		1:10	1:50	1:150	1:150
Total PV costs for appraisal PVc	-	£500	£1,400	£4,000	£3,500
PV damage PVd	£15,000				
Total PV benefits PVb		£2,000	£5,000	£11,500	£11,000
Average benefit/cost ratio		4.00	3.57	2.88	3.14
Incremental benefit/cost ratio			3.33	2.50	2.86
Required incremental B/C ratio			1.5	3	3
Required additional benefits to meet criterion			-£1,650	£1,300	£300
Weighted score	5	10	60	62	90
Scored intangible incremental benefit of moving to the next option (CRWG)		5	50	2	30
Comment			Justified without extra benefit	Justified when value per point (k) exceeds	Justified when value per point (k) exceeds
Implied additional benefits per point (k) to meet criterion			-	£650	£10

Situations where an option achieves the necessary benefit-cost criterion

If an option achieves the necessary monetary incremental benefit-cost ratio but the scores indicate that there are intangible **dis-benefits** (i.e. costs or negative additional benefits to meet the criterion), then further consideration may need to be given to whether the implied value of these scored dis-benefits (i.e. k per point) is likely to be sufficiently high as to reduce the benefit-cost ratio to a level below the criterion or to one which changes the relative preference of the options. Thus, if the value of a point on the scored dis-benefits (k in pounds) needs to be unreasonably high, then the option is very likely to be justified. If the value of a point on the scored dis-benefits (k in pounds) is not unreasonably high, then the option may not be justified.

Table 6.17 provides an example of how the scores and consideration of required additional benefit can be used in these situations. From the example, both of the 'improve' options require an incremental benefit-cost ratio of 3 (relative to the 'sustain 1:50' option). Both options achieve this on the basis of monetary benefits and costs alone, with the 'improve 2' option having the higher incremental monetary benefit-cost ratio of the two and, from the traditional approach, being the preferred option.

Table 6.17 Considerations where option(s) achieve the necessary benefit-cost ratio

	Do-nothing	Maintain	Sustain	Improve 1	Improve 2
Return period		1:10	1:50	1:150	1:150
Total PV costs for appraisal PVc	-	£500	£1,400	£3,900	£3,900
PV damage PVd	£15,000				
Total PV benefits PVb		£2,000	£5,000	£14,000	£14,500
Average benefit/cost ratio		4.00	3.57	3.59	3.72
Incremental benefit/cost ratio			3.33	3.60	3.80
Required incremental B/C ratio			1.5	3	3
Required additional benefits to meet criterion			-£1,650	-£1,500	-£2,000
Weighted score	5	10	80	79	15
Scored intangible incremental benefit of moving to the next option (CRWG)		5	70	-1	-65
Comment			Justified without extra benefit	Justified as long as k per point no greater than	Justified as long as k per point no greater than
Implied additional benefits per point (k) to meet criterion			-	£1,500	£31

However, both options have intangible incremental dis-benefits (relative to the 'sustain' option and recorded as negative benefits) that offset the monetary benefits to some degree. The decision context here, then, is whether the value of the scored intangible dis-benefits is sufficient to change perspectives on the preferred option.

From the Table it can be seen that the magnitude of the intangible dis-benefits would have to equal £1,500 and £2,000, for the ‘improve 1 and 2’ options respectively, for the incremental benefit-cost ratio to be reduced to the criterion. Taking consideration of the incremental scores, which suggest dis-benefits of 1 and 65 for ‘improve 1 and 2’ respectively, this means that ‘improve 1’ is justified as long as the value of a point on the index (k) is not in excess of £1,500 (1,500÷1). However, the ‘improve 2’ option is justified as long as the value of a point on the index (k) is not in excess of £31 (£2,000÷65).

The first part of further investigation is to assume that both options are justified and, thus, that the value of a point on the index (k in pounds) is somewhere between £0 and £31. This can be combined with incremental costs, benefits and scores to calculate the overall incremental benefit-cost ratio in each case. Table 6.18 provides an example of this. As can be seen from this Table, the key consideration in making a final decision between the options is whether or not the value of a point on the index (k in pounds) is above or below £7, since, above this value, the ‘improve 2’ option is no longer the preferred option, as the incremental B/C ratio of ‘improve 2’ becomes lower than for ‘improve 1’. This, along with the question as to whether a point on the index is higher than £1,500 (the point at which the’ improve 1’ option is no longer justified) requires further consideration as part of the final reasonableness test.

Table 6.18 Identification of the preferred option on the basis of costs, benefits and scores

	Improve 1		Improve 2	
Incremental monetary benefits	£9,000		£9,500	
Incremental monetary costs	£2,500		£2,500	
Scored intangible incremental benefit of moving to the next option (CRWG)	-1		-65	
Value of a point on the scoring index (k in £s per point)	**Value of intangible benefit***	**Incremental BC ratio**	**Value of intangible benefit***	**Incremental BC ratio**
£0	£0	3.59	£0	3.72
£1	-£1	3.59	-£65	3.70
£2	-£2	3.59	-£130	3.68
£3	-£3	3.59	-£195	3.67
£4	-£4	3.59	-£260	3.65
£5	-£5	3.59	-£325	3.63
£6	-£6	3.59	-£390	3.62
£7	-£7	3.59	-£455	3.60
£8	-£8	3.59	-£520	3.58
£9	-£9	3.59	-£585	3.57
£10	-£10	3.59	-£650	3.55
* as these are all dis-benefits, the value is reflected as a negative benefit				

6.8.3 The final decision rule – the test of reasonableness

As can be seen from the examples given above, in some cases the decision rules enable the identification of the preferred option with certainty that there are no intangible costs or benefits that may act to change preferences.

However, there are also examples where it is possible that the intangible costs and benefits may act to change which option is the preferred option, or indeed, whether an option can be justified.

In these, more complex, situations the determination as to which is the preferred option depends on the value (in pounds) that is given to the intangible scores and, therein, the intangible costs and benefits of an option. Continuing the example from Tables 6.17 and 6.18, the selection of the preferred option (Improve 1 or 2) depends on whether a point on the index is given a value (k in pounds) of more or less than £7 per point.

Clearly, what the value of a unitless point (k in pounds) is may seem a highly abstract concept. However, it is important to note that the decision on the preferred option does not require determination of what the actual value of a point on the index is. Rather, it is a question of reasonabless and identification of what the value of a point (k in pounds) probably is not.

To facilitate this, in determining the reasonableness of a k value, use can be made of the following simple logical facts:

- the benefits and incremental benefits of all options are all expressed on the same unitless scale running from 0 to 100;
- on this index, a weighted score of 100 reflects maximum intangible benefit against all of the benefits that have been considered for all criteria in the scores;
- this, in turn, reflects the total 'value' of all intangible assets that have been considered in the scoring;
- as such, an individual point on the scoring index (from 0 to 100) reflects one hundredth of the total 'value' of the intangible assets in the scoring system; and therefore
- 100 times (x) the value of a point (k in pounds) under consideration provides the implied total value of the intangible assets considered in the scoring system in pounds.

Returning to the example, then, the consideration of whether 'improve 1' is preferred over 'improve 2' actually depends on whether the intangible assets considered in the scoring system are likely to be more or less valuable than £700.

Depending on the situation and what the scores relate to, this may be a fairly clear-cut decision. For example, if (one of) the intangible assets at stake represented preservation of a 2 ha nature reserve, it would be fairly clear that the value of just one of the assets was likely to exceed £700.

To help with this test of reasonableness, some knowledge of the likely economic value of intangible assets in general is useful. To this end, a series of look-up tables can be used to help the decision maker identify the value of similar types of assets and consider whether or not the ‘decision threshold’ value under consideration is reasonable or not.

Table 6.19 sets out some examples of the financial or economic value associated with different impacts or activities.

Table 6.19 Comparator values for comparison with the value of total k required

Impact type and category	Comparator value			Source
Economic impacts				
Assets	Likely to be valued			
Land use	**Good drainage**	**Bad drainage**	**Very bad drainage**	Based on typical financial gross margins from grassland (Penning-Rowsell *et. al.*, 2003).
	£600 to £1,400 per ha	£300 to £400 per ha	£200 per ha	
	Good drainage	**Bad drainage**	**Very bad drainage**	Based on typical financial gross margins from arable (wheat) (Penning-Rowsell *et al*, 2003).
	£550 per ha	£440 per ha	£270 per ha	
Transport	Railway disruption costs: £80 per minute			Penning-Rowsell *et al* (2003).
Business development	Indirect damages based on direct damages: - farming: 28% of direct losses - infrastructure: 30%-50% of direct losses - industrial and commercial: 30% of direct losses			Based on paper for Yangtze River, but which includes estimates of indirect damages from worldwide studies (including UK, US and Australia). www.yantze.sagric.com
Environmental impacts				
Physical habitats	**Habitat type**	**Value of recreation**		
	Coastal grazing marsh	£800 to £1,200 per ha		Penning-Rowsell *et al* (2003).
	Coastal lagoons	£4,200 to £57,000 per ha		
	Reed beds	£2,800 to £7,300 per ha		
	Saltmarsh	£1,100 to £90,000 per ha		Spurgeon J (1998)
Water quality	Cost of removing nutrients: £40 to £4,000 per kg (low cost relate use of constructed wetland, high costs to sewage works at limit of technology)			O’Sullivan (2002)
Water quantity	Replacement of Public Water Supply resource: £1.8 million/Ml/day Costs to farmers from loss of water source: £3.50/m^3 Costs to industry from replacement of own			RPA (2002)

Table 6.19 Comparator values for comparison with the value of total k required

Impact type and category	Comparator value		Source
	source with Public Water Supply: £0.75/m^3		
Natural processes			
Historical environment	Relocation costs: £150,000 to £200,000 (Grade 2* structure to Martello Tower) £3.20 per household per year for flood protection		RPA (2003)
Landscape and visual amenity	Preservation of ESA landscape (from conversion to more intensive agriculture): - general public: £3.05 per household per year - visitors: £14.80 per household per year - residents: £21.90 per household per year		RPA (2003)
Social impacts			
Recreation	**Change**	**Value (loss)**	
	Deterioration in beach, promenade	£2.34 to £3.74 per visit	Penning-Rowsell *et al* (2003).
	Cliff erosion, very reduced access	£1.89 to £4.84 per visit	
	Breach, reduced access	£2.82 to £3.72 per visit	
	Change	**Value (gain)**	
	Nourishment of beach	£1.08 to £1.49 per visit	
	Rock groynes/rock	£1.06 to £1.61 per visit	
	Managed retreat	£1.30 per visit	
	Renewed seawall, access onto all beach	£8.40 per visit	
Health and safety	Spend per household per year on: - health: £3,600 - law and security: £1,160		Government's Pre-Budget Report 2003 and based on 25 million households.
Availability and accessibility of services	**Average speed**	**Cost to health (per mile)**	Based on value of a life of £1 million and an increased risk of death from a heart attack for each 5 minutes extra travelling time to a hospital.
	10 mph	£15,000	
	20 mph	£7,500	
	30 mph	£5,000	
	40 mph	£3,750	
	50 mph	£3,000	
	60 mph	£2,500	
Equity			
Sense of community	Grants for community activities approx. £15 per household per year		Based on grants from the Community Fund of the Lottery and Awards for All in 2003.

7. Summary of the methodology applied to the three levels of appraisal and other issues

7.1 Introduction

The objective of the case studies was to further develop and test a MCA-based methodology with regard to the following points:

- its ability to be applied to all three levels of decision, i.e. high level plans and policies (SMPs and CFMPs), strategy level and scheme level;
- its consistency in application across the three levels, i.e. can the same general framework be used in all situations, having the potential to be expanded whilst always having regard for consistency across decisions. In addition, the case studies were to address:
  - the level of detail of the appraisal at different levels;
  - the completeness of the list of impact categories and sub-categories chosen for flood and coastal management;
  - the issue of consistency throughout the decision-making hierarchy when using the same categories of impacts at all levels but varying the levels of detailed information; and
  - the levels of guidance that will be necessary for the qualitative and quantitative assessments of the impact of the several options of a project.
- its applicability and repeatability, i.e. test the decision rules that are associated with the methodology, the choice of scores and weights and the applicability of the new appraisal approach by end users;
- the levels and stages of stakeholder involvement, i.e. who are the most suitable stakeholders at each level? And, what are the most suitable participation techniques? And,
- the format and presentation of the results, i.e. testing the flood and coastal management AST.

The second set of case studies explored and in some cases resolved the methodological issues arising from the application of the suggested MCA-based methodology, in particular with regard to the use of scoring and weighting techniques. It became apparent, however, that given the practical differences that exist in the appraisal of projects at each of the three planning levels of appraisal, the methodology would have to take slightly different forms, depending on what type of decision is being made.

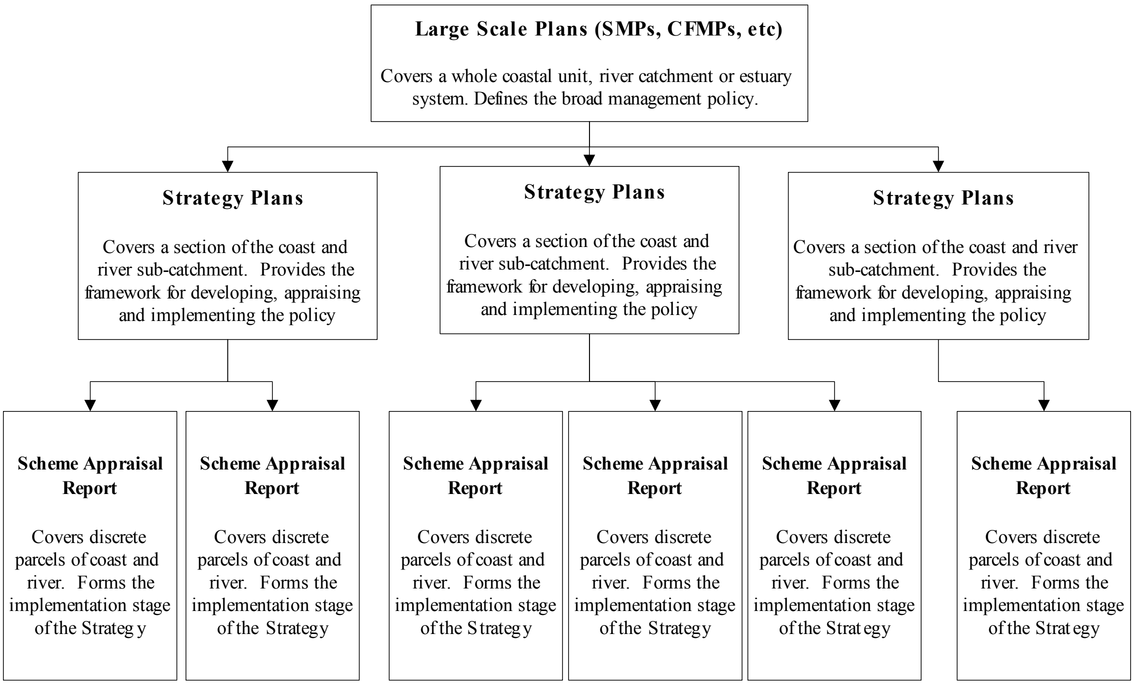
This section first focuses on the issues arising from the application of the MCA-based methodology throughout the appraisal hierarchy. This is a particularly important issue given its links to the national project prioritisation scoring system (see Section 8)

The section then moves on to describe how the remaining aims set out for the case studies were achieved.

7.2 Hierarchy of flood and coastal erosion planning

The planning and implementation of flood and coastal erosion risk management policy is, ideally, carried out through an integrated approach from a high level, through a strategy level and finally at the scheme level (the construction or implementation phase). This forms the strategic planning framework within which flood and coastal defence is managed. This hierarchy of plans is illustrated in Figure 7.1

Figure 7.1 Hierarchy of flood and coastal erosion



7.3 Appraisal at each planning level

Project appraisal is an iterative process both between and within each of these planning levels. Within a level, the process of identifying and appraising options is undertaken to identify the option that best satisfies the objectives. Between levels, it may be necessary to revisit the preferred policy or strategic decision in the light of further information.

Appraisal is undertaken at all three levels, with the level of detail required being appropriate to the decision to be made at that level. There is no guidance to define what is 'appropriate' and it is left to the operating authority and project group to decide this. However, the use to which the different levels of plan are put may provide some indication as to what is 'appropriate'. Large-scale plans are necessarily at a high level and information needs to be sufficient to set policy, not just for flood and coastal defence, but also to inform others with an interest in coastal management, such as local authority planners. Defra will not approve the plan but will acknowledge the plan as setting the policy within which strategy plans are to be developed.

The strategy plan level is the one where the investment decision is made either by the operating authority or Defra or both. There is, therefore, a requirement for information to be more detailed than in the high level plan, so as to provide a robust case for investment. At this level, the strategy is either agreed in principle by Defra (with approval at the scheme stage) or approved.

The scheme level of appraisal, if the strategy has only been agreed, will need to be sufficiently detailed to provide a robust business case. However, if the strategy has been approved, then the investment decision has already been taken and the appraisal should focus on the construction and implementation details of alternative options at the more local level.

This indicates that the detail of the appraisal carried out at the strategy and scheme levels are, therefore, broadly the same. Damages associated with the options being appraised will need to be assessed in order to obtain approval for funding. Although there will be more local information within the appraisal at the scheme level than at the strategy level, this will be associated more with the details of design and implementation (such as routes for construction traffic, timing of works, etc.).

The experience from the case studies confirms the above. It shows that the detail increases as one moves down the hierarchy in the following way:

- for high level plans the information available was a mixture of qualitative and quantitative data. It is likely, however, that in the future with the implementation of the new procedural guidance for production of SMPs (which uses the Modelling and Decision Support Framework – MDSF) (Defra, 2004) that more quantitative data will be available at this level of decision; and
- for strategy and scheme levels of appraisal, much more detailed, quantitative data was available.

7.4 Applying the MCA-based methodology to each planning level

In order to respect the different levels of detail across the three levels of appraisal, some differences in the application of the MCA-based appraisal tools are suggested. These differences are particularly related to the scoring and weighting procedures, as well as in the comparison of options (the decision rules) and are linked to the level of detail of the appraisal. Focusing on the additional steps introduced by the MCA-based component, Table 7.1 illustrates how each step differs between the three levels of appraisal.

Table 7.1 Description of the MCA-based approach for each level of the appraisal hierarchy

	High level plans	Strategy plans	Scheme appraisal reports
Step 1 and 2 **Definition of objectives and description options**	The **objectives** at this level should focus on defining in broad terms the management policy for the area. They should focus on defining, in general terms, the risks to people and the natural and historical environment within the study area; to identify the preferred policies for managing these risks; and to identify the consequences of such policies. The generic **policy options** available to high level planners are: • hold the existing defence line; • advance the existing defence line; • managed realignment; • limited intervention; and • no active intervention.	The **objectives** at this level of appraisal should be aimed at creating the framework for developing and implementing the broad management policy developed at high level. The objectives should be established jointly through consultation with all stakeholders and address the problems and key issues specific to the area of study (identified during Step 1). They should not presuppose any specific solution. The **options** should be considered (Step 1 of the methodology). They should cover an appropriate range of structural and non-structural solutions. Besides the 'do-nothing' option, these should include different standards of protection, alternative alignments (managed realignment, for example), alternative timings of work, and different approaches to the solution of the problem.	The **objectives** at this level of appraisal should be aimed at the successful implementation of the strategy, local monitoring and further investigation. The objectives should be established jointly through consultation with all stakeholders and address the problems and key issues specific to the area of study (identified during Step 1). In general, the high level and strategy plans for the area have already identified the general policy, as well as the standard of defence to be provided. At the scheme level the differences between the **options** will focus on operational and implementation differences (different approaches to the solution), alternative timings of work, issues of industry and local sustainability, etc.
Step 3 structuring the problem (S-AST)	Using the S-AST, identify the relevant impact categories, proceed with the qualitative assessment of the 'do-nothing' option and define evaluation method. It is also expected that the information available will be to a lesser degree of detail, which may have implications in selecting the method for evaluating of the impacts (monetary or scoring).	Using the S-AST, identify the relevant impact categories, proceed with the qualitative assessment of the 'do-nothing' option and define the evaluation method. The information available will have a higher degree of detail, which may mean that there will be less need for scoring. However, scoring should be undertaken for all impacts not valued in money terms.	Using the S-AST, identify the relevant impact categories, proceed with the qualitative assessment of the 'do-nothing' option and define the evaluation method. The information available will have a higher degree of detail, but there may still be a need to score those impacts that would vary across options.

Table 7.1 Description of the MCA-based approach for each level of the appraisal hierarchy

	High level plans	Strategy plans	Scheme appraisal reports
Step 4 and 5 qualitative and quantitative assessment of impacts (MA-AST)	The impact assessment should develop an MA-AST for each of the management options being considered, following a stepped approach and moving from qualitative to quantitative assessment. The number and size of the MA-ASTs for this level of appraisal is likely to be considerable, since the high level plans usually cover a big study area, which is divided into a significant number of assessment units. At this level of appraisal, quantitative information may not available.	The impact assessment should develop an MA-AST for each of the management options being considered, following a stepped approach and moving from qualitative to quantitative assessment. In addition, this step also entails the completion of a Summary MA-AST summarising the key information from the assessment. The number and size of the MA-ASTs for this level of appraisal should be smaller, as the area covered is smaller and therefore there are less assessment units to consider. At this level of appraisal, data and information gathering should be focused on quantitative information; it should try to focus on filling in the information gaps identified at higher level plans.	Developing an MA-AST for each of the management options being considered, the impact assessment should followed a stepped approach, moving from qualitative to quantitative assessment. In addition, this step also entails the completion of a Summary MA-AST, summarising the key information from the assessment. The number and size of the MA-AST for this level of appraisal should be smaller, as the area covered is smaller and there should be only one or two assessment units to consider. At this level of appraisal, data and information gathering should be focused on quantitative information; it should try to focus on filling in the information gaps identified in the strategy level plan as well as on local information.
Step 6a determination of tangible benefits and costs of options	For those categories being valued in monetary terms the guidance provided by FCDPAG 3 – Economic Appraisal (MAFF, 1999) should be followed, using the traditional CBA-based approach.	For those categories being valued in monetary terms the guidance provided by FCDPAG 3 – Economic Appraisal (MAFF, 1999) should be followed, using the traditional CBA-based approach. At the strategy level, the use of benefits transfer methods becomes more relevant, given the level of detail required in the assessment, and the use of such methodologies should be pursued.	For those categories being valued in monetary terms the guidance provided by FCDPAG 3 – Economic Appraisal (MAFF, 1999) should be followed, using the traditional CBA-based approach. At the scheme level, the use of benefits transfer methods becomes more relevant, given the level of detail required in the assessment, and the use of such methodologies should be pursued. However, the specificity of the area being assessed may mean that it is more difficult to apply such transfer methodologies and new evaluation studies may need to be commissioned.

Table 7.1 Description of the MCA-based approach for each level of the appraisal hierarchy

	High level plans	Strategy plans	Scheme appraisal reports
Step 6b scoring impacts	In selecting the scoring approach used in high level appraisals, two factors should be considered: the level of detail of the information available; and the number of assessment units being considered. If the information available is, in its majority, of a qualitative nature, the scoring approach should also be of a qualitative nature. In this case, a descriptive approach is likely to be more appropriate. However, the drawbacks of such an approach should be taken into account. When the information available is not so detailed but, nonetheless, quantitative in its majority (this is more likely to be the case in the future given the recent published procedural guidance on SMPs (Defra, 2004)), a quantitative approach to scoring should be pursued. In addition, because the number of assessment units being considered is likely to be significant, it may be preferable to adopt the across unit scoring approach. This will maintain proportionality between the units. At a high level of appraisal, there is also the possibility of skipping the scoring exercise and using ranking methods (see weight elicitation and comparison of options, below). It should be noted, however, that this approach could have disadvantages in terms of consistency with other levels of decision.	In selecting the scoring approach used in strategy level appraisals, three factors should be considered: the level of detail of the information available; the number and likely incremental nature of the options being assessed, with a focus on the standard of defence provided; and the number of assessment units being considered. At this stage the use of a quantitative scoring system where the best performing option scores 100, the worst performing option scores 0 or 1 and all other options are scored relative to these is preferred. This is because the scoring system ensures a good spread of scores and reduces the effort required to assign scores to all options. Also, the impacts caused by the options are likely to be very different such that a range of scores from 0 to 100 is likely to reflect the overall range of impacts. A scoring system based on 100 as best and all other options scored relative to this could also be applied. From the quantitative scoring approaches, the ChaRT Scoring System is suggested if it can be developed so as to reliably reflect 'recovery' across all impact categories. This is because it is a more robust approach and is consistent with the approach taken to the CBA. The scores are calculated based on damages from different flood events, and the scores directly reflect the standard of defence provided by each option.	The approach to scoring selected for the scheme level of appraisal should follow the same reasoning as for the strategy appraisal. However, at this level, the standard of defence to be provided has already been defined, thus, the differences between the options are more related to implementation and operation issues, such as different defence solutions, different materials used, etc. At this stage the use of a quantitative scoring system where the best performing option scores 100, the worst performing option scores 0 and all other options are scored relative to these is preferred. This is because the scoring system ensures a good spread of scores and reduces the effort required to assign scores to all options. However, the difference between options are likely to be less marked, when compared to the strategy appraisal level, making this type of scoring approach more difficult to apply. Nonetheless, the difficulty of application of scores should be balanced by the existence of more detailed information. Furthermore, if ChaRT is applied at the strategy level it should also be applied at this level for consistency.

Table 7.1 Description of the MCA-based approach for each level of the appraisal hierarchy

	High level plans	Strategy plans	Scheme appraisal reports
Step 7 Weight Elicitation	The weight elicitation step of the appraisal should focus on two main factors: how to undertake the elicitation, and from whom should the weights be elicited. It is suggested that the weight elicitation exercise should be undertaken using the condensed approach to full pairwise comparisons, based on an electronic questionnaire. At the high level appraisal the weights should be elicited from correspondingly high level stakeholders. These include operating authorities, planning authorities, Defra, English Nature, Countryside Agency, Internal Drainage Boards, etc. If an approach based on ranked objectives is adopted for the selection of the preferred option, weight elicitation should take the form of a ranking exercise. Such an approach is suggested in the recently published procedural guidance for SMPs (Defra, 2004). A similar approach was also used in the Humber Estuary Appraisal Process (the original, not the case study), where stakeholders were asked to select, from a total of 131 objectives, the 15 most important ones to rank these in order of importance.	The weight elicitation step of the appraisal should focus on two main factors: how to undertake the elicitation, and from whom should the weights be elicited. It is suggested that an attempt to reduce the weight elicitation exercise to a minimum should be made. This could be done through the use of CRWG. The approach should focus the weight elicitation on the issues that really matter to the decision. The general principles of the exercise should be explained to stakeholders, and the analysis undertaken with their full knowledge. It suggested that the weight elicitation exercise should be undertaken using the condensed approach to full pairwise comparisons, based on an electronic questionnaire. At the strategy level, the weights should be elicited from 'mid' level stakeholders. These may include the same types of organisations as at the high level but representing interest at the regional level. They also should include representatives of the activities (economic and otherwise) relevant to the area. It is worth noting that the appraisal at the strategy level follows from the high level policy defined previously, therefore, already incorporates the concerns of the high level stakeholders.	The weight elicitation step of the appraisal should focus on two main factors: how to undertake the elicitation, and from whom should the weights be elicited. It is suggested that an attempt to reduce the weight elicitation exercise to a minimum should be made. This could be done through the use of CRWG. The approach should focus the weight elicitation on the issues that really matter to the decision. The general principles of the exercise should be explained to stakeholders, and the analysis undertaken with their full knowledge. It suggested that the weight elicitation exercise should be undertaken using the condensed approach to full pairwise comparisons, based on an electronic questionnaire. At the scheme level, the weights should be elicited from local stakeholders, i.e. organisations and individuals representing the local interests. It is worth noting at this point that the local stakeholder weights will potentially be overridden by national stakeholder weights when it comes to prioritising scheme development at the national level.

Table 7.1 Description of the MCA-based approach for each level of the appraisal hierarchy

	High level plans	Strategy plans	Scheme appraisal reports
Step 8 Comparison of Options	The comparison of options at the high level of appraisal will depend upon the type of scoring and weight elicitation approaches selected. If a quantitative approach to scoring has been adopted, weighted scores can be calculated and the decision rules derived for the MCA-based approach to appraisal can be applied. If, however, ranking methods are used, the comparison of options is more subjective, and determined by their relative ranking across the most important objectives and all other objectives. Ranking of objectives can also be used to indicate the relative importance of the impact category to which they are related. This information can help in the comparison of options.	At the strategy level, the scoring approach will be quantitative, which means that the decision rules derived for the MCA-based approach to appraisal can be applied.	At the scheme level, the scoring approach will be quantitative, which means that the decision rules derived for the MCA-based approach to appraisal can be applied.
Step 9 testing the robustness of choice	Testing the robustness of the choice of options should follow the guidance provided in FCDPAG 3 – Economic Appraisal and in FCDPAG 4 – Approaches to Risk. These mostly deal with sensitivity testing relating to the CBA approach currently in use. It can, however, be adapted to include the MCA-based component of the appraisal process. This should include the testing of changes in the scores assigned to different impacts and the testing of different stakeholder weights.	Testing the robustness of the choice of options should follow the guidance provided in FCDPAG 3 – Economic Appraisal and in FCDPAG 4 – Approaches to Risk. These mostly deal with sensitivity testing relating to the CBA approach currently in use. It can, however, be adapted to include the MCA-based component of the appraisal process. This should include the testing of changes in the scores assigned to different impacts and the testing of different stakeholder weights. If the ChaRT scoring system is used, sensitivity testing should focus on changes in the characteristic, recovery times and standard of defence provided by the options.	Testing the robustness of the choice of options should follow the guidance provided in FCDPAG 3 – Economic Appraisal and in FCDPAG 4 – Approaches to Risk. These mostly deal with sensitivity testing relating to the CBA approach currently in use. It can, however, be adapted to include the MCA-based component of the appraisal process. This should include the testing of changes in the scores assigned to different impacts and the testing of different stakeholder weights. Since the scheme level appraisal is looking at the best solution to the flood and coastal defence problem, sensitivity analysis should also focus on assumptions surrounding the options themselves, such as costs.

7.5 Other issues

7.5.1 Consistency across the three levels

The general framework for the MCA-based methodology is provided by the AST and the set of impact types and categories it includes.

As it is described in Table 7.1, the various degrees of detail required for each of the three levels of appraisal is considered by adopting slightly different approaches at the different steps of the methodology. These different forms of application of the MCA-based tools take into account the need for consistency across the different levels. This is particularly important at the strategy and scheme level where funding decisions and prioritisation occur.

For all of the case studies, it was found that the proposed set of impact categories covered all the impacts arising from the different project options and at the three levels of decision-making. It was also found that it might be necessary to subdivide the category into sub-categories specific to particular issues raised in a case study, in order to capture all perspectives/angles of the impact being appraised. This was more important at the lower levels of decision-making, where more detailed information was being assessed. This use of the same impact categories ensures horizontal consistency, i.e. consistency across appraisals at the same level of decision.

Transparency is tackled by the use of ASTs throughout the appraisal. They offer a framework for the assessment so that all impact categories are at least considered, both qualitative and quantitative information is taken into account, and the information is carefully organised so as to be easily accessible at any time during the appraisal.

For example, during the high level screening stage of the appraisal, the use of the S-ASTs was found very useful in ensuring consistency and transparency across appraisals, since all case studies were appraised using the same checklist of impacts and, therefore, the likelihood of omission of impacts was greatly reduced. In addition, an AST for scoring ensures that the justifications for the scores being given to each impact category under each option are clearly stated.

7.5.2 Applicability and repeatability

Testing the decision rule

Tests of the decision rule that is proposed here indicate that it can be applied alongside the current rule and adds to the decision. The new decision rule is based on the current decision process, as illustrated by FCDPAG 3, and adds to it when appropriate. In this context, it was often found that the preferred option would be changed if a MCA-based approach were carried out during the appraisal. This is because, once the economic arguments for the choice of one option over another were exhausted, consideration turned to whether the intangible benefits would be 'valuable' enough to swing the choice of options. When the option being appraised was close to the set threshold needed for it to become the preferred option and there were significant intangible impacts, then the decision was changed. Otherwise, the economic argument for the decision dominated option selection.

In this way, the overall approach retains the robustness of CBA, whilst being more comprehensive, integrated and transparent in relation to environmental and social impacts.

Choice of scoring units

It was decided that for reasons related to consistency across the different levels of appraisal and to the national priority scoring system, the units of measure for each impact category presented in Table 7.2 would be adopted for scoring purposes. These units of measure are still being evaluated for robustness and practicality, and may need to be further developed in the future.

Table 7.2 Units of measure for each impact category used in the scoring exercise.

Impact category	Units of measure
Economic impacts	
Assets	Number of properties affected
Land use	Hectares of agricultural fields affected
Transport	Length (in km) of roads and railways affected
Business development	Number of non-residential properties (NRPs) affected
Environmental impacts	
Physical habitats	Hectares affected
Water quality	Length (in km) of water bodies affected
Water quantity	Length (in km) of water bodies affected
Natural processes	Hectares undergoing natural processes
Historical environment	Number of Scheduled Ancient Monuments and listed buildings affected
Landscape and visual amenity	Hectares of land affected
Social impacts	
Recreation	Number of visitors affected
Health and safety	Population affected (based on number of properties flooded)
Availability and accessibility of services	Number of services (hospital, school, medical centre, etc) affected
Equity	Population within vulnerable groups affected
Sense of community	Population affected (based on number of properties flooded)

Different scoring systems have different degrees of applicability and the choice between them should strike a balance between the level of information available and the robustness and easiness of use.

In terms of repeatability, and given the subjective nature of scoring for many of the impacts, it is believed that the use of a scoring AST, where the reasons and assumptions behind the scores are recorded, allows for a sufficient degree of repeatability, similar to that found in the current appraisal approach. In this respect, the ChaRT scoring system is the most advantageous.

In addition, this is an issue that will be further explored and resolved as experience in assigning scores is gained in flood and coastal erosion risk management.

Applicability by end users

The MCA-based methodology does not seem to offer any major difficulties for end users. On the contrary, the use of ASTs throughout the appraisal process enables the user to organise the information in a more focused and easy to find way. This fact alone assures repeatability and auditability.

The proposed approach to appraisal uses little additional information to that currently necessary; it only requires more structure and focus. Therefore, there is no reason to believe that the application of such a methodology is more resource and time consuming. Even the weight elicitation exercise, which arguably is an additional task to the process, should not require significant extra expenditure of resources. If the weight generator tool can be further refined and made more user-friendly, it could help to focus the exercise on those issues that really can have an impact on the final decision-making.

7.5.3 Levels and stages of stakeholder involvement

The case studies proved beyond any doubt that the weighting stage of the MCA-based methodology is the most controversial in the appraisal process.

Three different weight elicitation processes were tested in the case studies:

- *inference of weights from consultation responses:* this was unsuccessful where it was tried. For this type of approach to be applied in the future, the consultation would have to be structured in a manner aimed at eliciting particular types of information from stakeholders. In particular, it would need to gather information on the rank order that people would assign to different types of impacts, and gain further information on acceptable and unacceptable trade-offs;

- *a paper-based questionnaire:* this was found to be time consuming and administratively complicated;

- *an electronic questionnaire:* this was found to be much more practical and adaptable and advantageous in administrative terms. In addition, the electronic approach to weight elicitation was easier to exploit by stakeholders and useful since it allowed stakeholders to revise their responses and, in so doing, learn about their own preferences.

It is important to point out here that weight elicitation represents one task to be included in the current consultation process undertaken during the appraisal. Therefore, the most appropriate weight elicitation technique to use should be decided in the context of the rest of the consultation exercise.

In relation to whose weights should be elicited, it will depend on the level of appraisal being undertaken. As referred above (see Table 7.1):

- at the high level of appraisal, the weights should be elicited from correspondingly high level stakeholders. These include operating authorities, planning authorities, Defra, English Nature, Countryside Agency, Internal Drainage Boards, etc.;
- at the strategy level of appraisal, the weights should be elicited from 'mid' level stakeholders. These should include representatives regional authorities, the activities (economic and otherwise) relevant to the area, the regional environmental interests, etc.; and
- at the scheme level, the weights should be elicited from local stakeholders, i.e. organisations and individuals representing the local interests. It is worth noting that the local stakeholder weights will potentially be overridden by national stakeholder weights when it comes to prioritising scheme development at the national level.

In general, a MCA-based approach allows greater stakeholder involvement in the sense that stakeholder view points and concerns have the potential to directly influence decision-making though weight elicitation.

7.5.4 Format and presentation of the results

The use of ASTs as the framework for the MCA-based methodology is a key aspect of the approach. Four main Appraisal Summary Tables (ASTs) are used:

- the High Level Screening AST (S-AST);
- the Main Assessment AST (MA-AST);
- the Summary MA-AST; and
- the Scoring AST.

All of these achieve three main functions:

- they structure and organise the appraisal – this is mainly achieved by the S-AST and MA-AST, the first in providing an initial indication of the type of issues and information that would have to be dealt with and the second by ensuring a stepped approach to the assessment (qualitative and quantitative) and by organising the information collected in a way that it is focused on the issues at hand and easily accessible;

- they ensure consistency across the three levels of appraisal and across appraisals – this is mainly achieved by making sure that the same impact categories are assessed, both qualitatively and quantitatively, in all appraisals, even if the level of detail of the assessment increases as one moves down the hierarchy; and
- they ensure the transparency and auditability of the appraisal process as all information used and assumptions made in the appraisal are recorded in the ASTs.

8. How the MCA-based approach improves decision-making

The new MCA-based methodology developed for this study sits within the current economic appraisal approach set out in the FCDPAG series and extends it to allow for the inclusion of intangible costs and benefits. Starting with the process presented in FCDPAG 3 - economic appraisal (MAFF, 1999), the MCA-based methodology adds new steps and enhances some of the existing steps.

The main objective of the methodology developed was to improve the current approach by including in the appraisal process those impacts that cannot be valued in monetary terms, in particular social impacts. The MCA-based methodology, as presented in this report, is successful in achieving this objective as social impacts form an important part of the MCA component of the methodology. For this reason alone, even considering some of the potential drawbacks from the proposed approach for which further research is likely to be required, the MCA-based methodology represents a step forward towards the greater inclusion of environmental and social impacts into the appraisal process.

However, the MCA-based methodology does not only have to be more inclusive when compared with the current approach to appraisal. It also has to help a decision maker make better decisions in flood and coastal erosion risk management. It is believed that this objective is also achieved. The best way to illustrate this is by running through the MCA-based approach proposed, and highlighting how each new or modified step contributes to better decision-making. The new methodological approach to economic appraisal including a MCA-component is presented in Figure 8.1.

The 'new' methodology is based on the same four stages as the current approach, namely Define, Develop, Compare and Select, each of which includes various procedural steps.

The 'Define' stage of the approach is not changed in relation to the current method. During this stage, the same process of defining the problem and identifying all the possible options (Step 1) is followed.

In the 'Develop' stage, the elimination of unreasonable options (Step 2) also follows the procedure set out in the current government guidance. The next step of Definition of objectives and management options (Step 3) is not significantly changed but the MCA-based component of the approach needs to start being considered. For example, at the high level of appraisal (when defining the objectives of the project) attention should be given to the type of information that is likely to be required for the scoring and weighting exercise undertaken later in the process. Also, the issue of policy integration is considered at this stage.

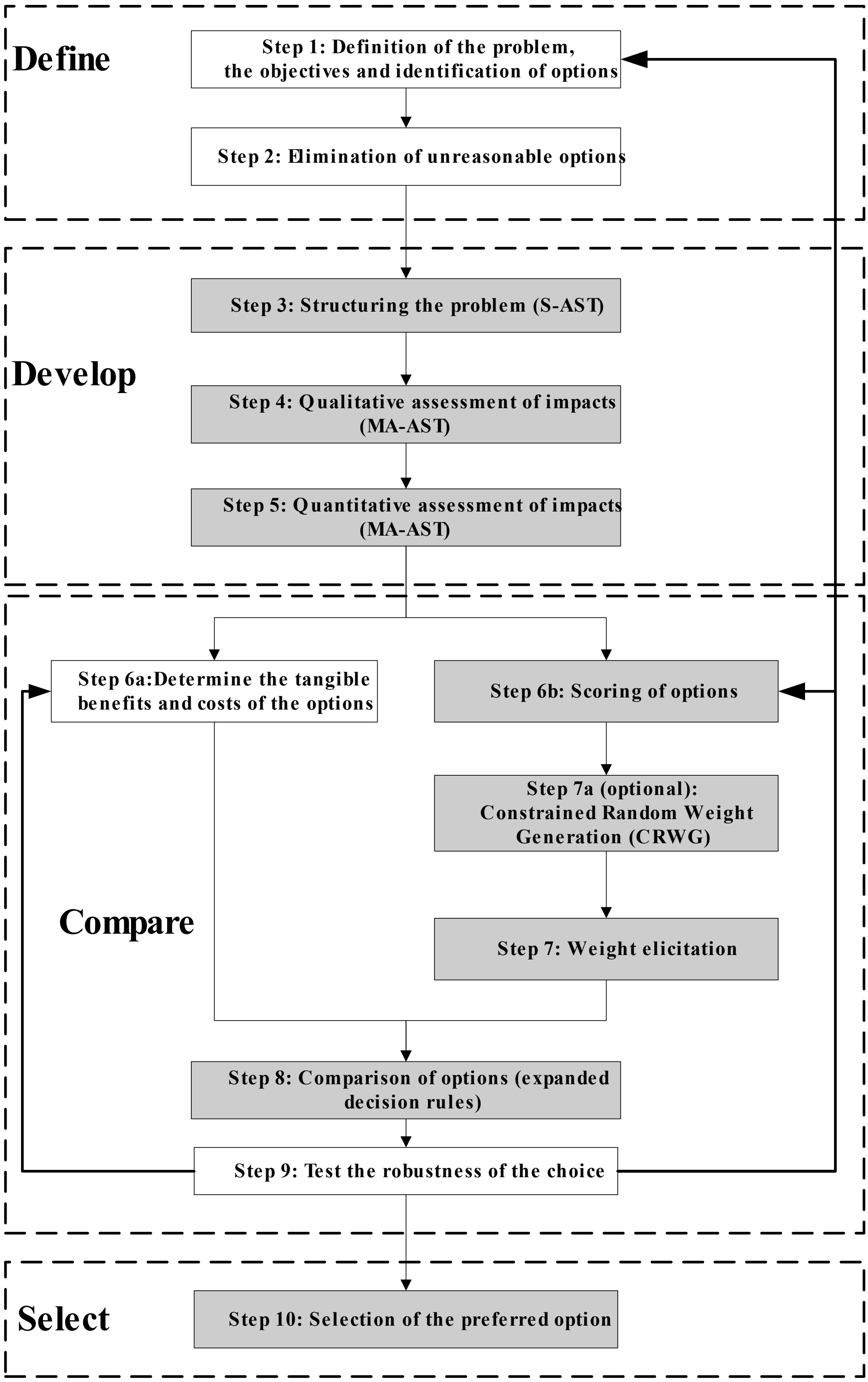


Figure 8.1 New methodological approach to economic appraisal including the MCA-based component

It is in Step 3 of the process that the MCA-based methodology starts providing added value to decision-making. By introducing the use of a high level screening AST (S-AST), a comprehensive checklist of impacts has to be considered from the initial stages of the appraisal. This checklist is used in all appraisals, at all levels of the flood and coastal defence planning hierarchy, ensuring consistency across and throughout appraisals. Also, the possibility of omission of a significant impact is greatly reduced. Because of this, a new level of structure and formality is added to this stage of the appraisal. By proceeding in the manner proposed, the appraisal is focused on those impact categories that are relevant to the study being undertaken, is organised in such a way as to make clear the type of information that will be required in the more detailed assessment and initiates consideration of which assessment methods will need to be applied later on in the process (e.g. qualitative description, economic valuation and/or scoring). In addition, the completion of the S-AST can be used as a tool for instigating the consultation process that runs in parallel with the appraisal process.

The use of Appraisal Summary Tables (ASTs) in the main assessment of the project (i.e. MA-AST, in Step 4 and 5), provides an extra layer of structure and organisation which can only improve decision-making. The use of ASTs allows all impact information to be recorded in a consistent manner as well as creating an audit trail, fundamental for the justification of the decision taken. In other words, it provides a structure in which all of the reasons for choosing a preferred option are set out in a clear and intelligible manner, transforming the inclusion of intangible benefits in the decision-making process from a 'black box' to a more transparent process.

Another important advantage of the use of the MA-AST is that it offers a framework that encourages:

- the consideration of all impact categories;
- the consideration of both qualitative and quantitative information; and
- the careful organisation of information so as to be easily accessible at any time during the appraisal. For those cases where no information is available or impacts are uncertain, this can also be recorded.

In addition, the process of assessing impacts firstly qualitatively and then quantitatively does not necessarily mean that the process is more time and resource consuming. The information required in the MCA-based approach is in quantity very similar to that necessary in the current approach. However, its collection is more focused and organised.

Step 6a of the approach to appraisal (determination of tangible benefits and costs of options) is not changed from the current approach. It does, however, benefit from the 'new' approach, since the information required to place an economic value on damages and damages avoided is recorded in a consistent and accessible manner.

The scoring and weighting steps of the MCA-based methodology are without a doubt the major addition to the appraisal process.

The scoring exercise (Step 6b) aids the decision-making process by encouraging the quantitative evaluation of impacts that cannot be valued in monetary terms. It promotes consideration of differences in magnitude and size of the impacts and reflection of the uncertainties that surround the assessment of such impacts. It induces the learning and thought process that can only make the final decision more robust and inclusive. It is often considered that scoring of impacts is more subjective than assigning monetary values to impacts. However, careful recording of all assumptions made, including the basis for all scores, and the use of a scoring system that is based on consistent information and definitions (including in the case of the ChaRT scores, an approach based on risk (probability and consequence)) has the advantage of moving the subjectivity forwards in the appraisal. In this way, the reasoning behind the numbers assigned are fully available to decision-makers and can be considered as part of the decision, rather than being hidden behind a series of figures (as can sometimes be the case with monetary valuation of impacts).

The weight elicitation step (Step 7) increases the level of stakeholder involvement. This is done, by integrating the stakeholders' expressed concerns and preferences into the assessment of the different impact categories. Providing stakeholders with a means of considering the trade-offs and conflicts that could arise from a flood defence project can also have the advantage of encouraging early co-operation, reducing polarisation of viewpoints.

Finally, in Step 8 (comparison of options) a mathematical expression and associated decision rules were developed to allow for the integration of different types of data so that the performance of the alternative options can be compared. This includes a formalised mechanism for judging whether the additional monetary benefits required to move to a higher option (i.e. the level of additional benefits needed to increase the incremental benefit-cost ratio) are reasonable or not. The judgement is made based on the weighted score related to the intangible benefits, the difference in weighted score from one option to the next (higher) option and the assumptions and information recorded in the AST. In this way, the decision-making process is based on all of the information collected during the appraisal, making the selection of a preferred option a more transparent and auditable process and potentially increasing the confidence of stakeholders that any impacts they identified have been fully considered.

In conclusion, the 'new' methodological approach to appraisal successfully integrates the rigour of CBA, particularly in regard to demonstrating that the chosen option is a good use of resources, with a framework where the social and environmental issues are explicitly included in the decision-making process. It does this in a way that all of the information collected during the appraisal, including input from stakeholders, feeds into the selection of a preferred option in a manner that is fully transparent and auditable. Thus, the decision-maker is able to base the selection of the preferred option on the most comprehensive information available at the time of the appraisal.

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