B3. Economic Decision Making[1]

B3.1 Introduction

The approach to decision making is likely to vary according to the number of impact categories/criteria that can be expressed (or not) in money terms. There are three possible variations:

- all impacts are expressed in money terms (this could also include those cases where all *significant* impacts are expressed in money terms);
- no impacts are expressed in money terms; and
- some impacts are expressed in money terms and some are not.

The level of decision being made (management decisions, restoration works, managed realignment/compensatory habitat) will determine the number of impacts that are to be considered (see Appendix B2.3). Of these, in most cases, it is likely that only a subset will be able to be valued in money terms (see also Appendix B2.5). It is likely to be necessary, therefore, to select a preferred option by comparing both monetary and non-monetary impacts.

The following sections provide further explanation on how decision making can be undertaken for each decision level, based on the terms in which impacts can be expressed (i.e. monetary or non-monetary terms).

B3.2 All impacts expressed in money terms

B3.2.1 Aggregating benefits

Where all impacts can be estimated in money terms, they can also be aggregated (by adding them together) to give an overall indication of the level of damages (or benefits) predicted. However, it is important that all of the benefits are calculated over the same time span. For example, some benefits may be one-off and may occur immediately, but others may be annual or may occur just once, but not until some time in the future. At a project level, the application of Cost-Benefit Analysis (CBA) techniques (including benefits transfer) requires that all future costs and benefits are converted into comparable units of value in present day terms. The means of achieving this is known as *discounting*. This allows the future stream of costs and benefits to be aggregated over time to give a total estimate of the net present value for a project or action.

The discounting procedure is based on the principle that more importance is placed on costs and benefits that occur now, than those that arise in the future. When discounting is applied to specific assets (machinery, etc.), it provides a means of taking into account the opportunity costs of capital investments and is a widely

[1] This Appendix has been produced by Risk & Policy Analysts

accepted and non-controversial technique. When applied to non-market goods and services, such as the environment, discounting is used to reflect the social rate of time preference (placing more importance on now than on the future). This process can be controversial and whether or not such a time preference exists towards the environment remains the subject of debate.

For all government related CBAs, the standard discount rate set by the Treasury should be used. This rate is currently 3.5% (but reduces in year 31 to 3% and in year 76 to 2.5%).

There are some important implications of discounting in the analysis of environmental impacts, which should be understood. The higher the discount rate used, the lower the importance placed on future costs and benefits. At any positive discount rate, costs or benefits which accrue more than 50 years into the future will have a very small present value. For example, at a rate of 3.5%, costs and benefits occurring in 25 years time will have only 42% of the value of those occurring today. Hence, activities with environmental benefits occurring well into the future are less likely to be favoured than those with near-term benefits; similarly, activities with high future environmental costs, but which yield near-term benefits, are more likely to be favoured than those with lower near-term benefits, but also lower future costs.

Once benefits and costs have been 'monetised' for a particular year, these are normally discounted across the number of years that those costs and benefits are expected to accrue. Discounting consists of calculating the present value (PV) of costs and benefits (this being required because a unit of money now is considered to have a different value to the same unit of money sometime in the future). The formula for calculating the PV is as follows:

$PV = 1/ (1+r)^n$ * *monetary value per year of costs and/or benefits*, where

r = interest rate; and
n = year in which benefits and/or costs accrue.

B3.2.2 Comparing options

Once the benefits have all been converted into comparable units, they can be aggregated to give total benefits. These can then be compared with the costs to give an indication of the economic worthiness of the project. There are a number of calculations that are used to help determine which option should be preferred:

- *Net Present Value* (NPV): calculated as the benefits minus the costs. A project is considered worthwhile if the NPV is greater than zero. The preferred option could also be the option with the highest NPV, although this is usually only the case where there are unlimited funds; and

- *Benefit-Cost ratio* (B:C): calculated as benefits divided by costs. A project is considered worthwhile if the B:C is greater than one. The preferred option is often identified as that with the highest B:C ratio.

When all impacts are presented in money terms (and where these impacts have been discounted and aggregated), the selection of the preferred option is based on (i) which option has the highest benefit-cost ratio and (ii), if the benefit-cost ratios of two (or more) options are the same (or very similar), which has the highest NPV.

B3.3 No impacts expressed in monetary terms

When none of the impacts have been presented in monetary terms, the choice of preferred option requires some degree of judgement. To retain transparency in decision-making it is important that these judgements are recorded. There are a number of recognised techniques available that allow judgements to be made and recorded when selecting between options whose impacts are presented in different units. Two methods are described here:

- *Pairwise comparison*: this provides an approach that is best used where there are only a small number of options and criteria across which a decision has to be made; and

- *Ranking techniques*: these techniques provide an approach that can be used across all levels of decision, but are most useful where there are a larger number of options and/or criteria to compare.

B3.3.1 Pairwise comparison

Pairwise comparisons are often used as a means for conveying information to decision makers on the degree to which one option outperforms another across a range of decision criteria. No attempt is made to incorporate any judgements as to the relative importance of different magnitudes of impact or of the different criteria.

The first stage in undertaking pairwise comparisons involves listing the criteria or impacts and comparing options in pairs against each of these, indicating a preference for one option over another. The results are then recorded in a table, such as Table B3.1, to illustrate which alternative performs better or worse for each of the criteria. An overall preference is then identified, or the information is used to highlight the trade-offs involved in selecting one option over another. Ultimately, the information is provided to decision makers who must make a judgement on the relative importance to be assigned to the different criteria and, thus, to determine the ‘best’ option.

Table B3.1 THE USE OF PAIRWISE COMPARISONS					
Option	**Preferred Option**				
	Appreciation	**Knowledge**	**Products**	**Ecosystem Services**	**Costs**
A versus B	A	A	B	A=B	A
A versus C	A	A	C	A	A=C
B versus C	B	B=C	B	B	A

From the above comparisons, the preferred options are, in terms of:

- Appreciation: Option A is preferred to both options B and C
- Knowledge: Option A is preferred, B and C are equal
- Products: Option B is preferred to both options A and C
- Ecosystem Services: Options A or B are preferred as both are equal and higher than C
- Costs: Options A and C are preferred as they have the lowest level of costs

The results of the pairwise comparisons in Table B3.1 suggest that options A and B consistently outperform option C. Thus, option C can be eliminated. The choice of preferred option is then between A and B. A is preferred in terms of 'appreciation', 'knowledge', and 'costs' and is equal with B in terms of 'ecosystem services'. B is preferred in terms of 'products'. Unless 'products' is considered significantly more important that 'appreciation', 'knowledge' and 'costs', Option A would be selected as the preferred option.

Although this approach is readily applied to problems with only a few options or criteria, undertaking the comparisons and ensuring consistency becomes increasingly complex as the numbers of criteria and options increase. It is unlikely to be useful, therefore, above the 'management' decision level (see Appendix B2.3 and Figure 5.1).

B3.3.2 Ranking methods

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 or a decision maker's opinion) are used to decide on the order of preference for different options or impacts. So, for example, if there were five options and a numerical scale was being used, the 'best' option would receive a ranking of 1 and the 'worst' a ranking of 5.

This method obviously provides a simple means of evaluating the performance of different options over a range of different criteria. However, when used on their own, they provide little information on the degree or magnitude of any differences in impact between options. They, therefore, 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. This latter problem has led to the tendency for people to add ranks (or trends) together, a mathematical operation which is invalid unless it is assumed that: the decision makers will place an

equal value on impacts falling under the various criteria (i.e. that impacts on consumers are equally important to changes in environmental risks); 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 saltmarsh management options or, more broadly, flood and coastal defence options.

Ranking may be more useful at the 'restoration' and 'realignment/compensatory habitat' levels of decision, although it may become complex where the options provide very different levels of benefits.

Table B3.2 provides the results of a ranking exercise (based on an Appraisal Summary Table) for three different options for restoration works.

Table B3.2 ranks each option. The outcome of which is that Option 1 is not better than Options 2 and 3 for most categories. Only in terms of 'soil provision' does it outrank Option 3. This means that the decision will be between Options 2 and 3. Option 3 only outranks Option 2 in terms of 'knowledge' (environmental monitoring, educational resource, and natural science research). Option 3 is ranked equal to Option 2 for 'distant appreciation', 'social development' and 'global life support'.

At this point, it is necessary to consider the costs. Option 2 has costs of £1.5 million while Option 3 has costs of £1.0 million. This means that the decision-maker has to decide if the additional benefits that Option 2 presents over Option 3 are 'worth' £0.5 million. However, Option 3 has additional benefits over Option 2 in terms of 'knowledge'. Therefore, it is also important to consider which the most important benefits are. In this case, it is known from discussion with local stakeholders that 'ecosystem services' are most important feature (and are the driving forces behind the decision to 'do something'). Option 2 would provide benefits over Option 3 in terms of 'flood and erosion control', 'soil provision', 'pollination', and 'habitat provision'. However, for the purpose of this example, the decision maker determines that the additional benefit of Option 2 over Option 3 is uncertain and does not consider this to be worth the additional £0.5 million. Hence, Option 3 is selected as the preferred option.

Where no impacts have been presented in money terms, it is not possible to select an option based on numeric ratios, so judgments have to be made. All such judgments should be justified and a record of the justification should be included with the preferred option.

Table B3.2	**AST for RESTORATION WORKS**					
Site under consideration:	Example site					
Objectives for the site:	To restore the site to a fully functioning saltmarsh from a degraded, overgrazed marsh					
Option/action:	Option 1: cease grazing on the site Option 2: cease grazing and replant saltmarsh plants Option 3: cease grazing, re-establish creeks and seed with saltmarsh plants					
Function	**Summary of Impacts**			**Ranking**		
	Option 1	**Option 2**	**Option 3**	**Option 1**	**Option 2**	**Option 3**
Appreciation						
Better living surroundings	Saltmarsh would improve over time	Saltmarsh would improve over time, with plants established very quickly	Saltmarsh would improve over time. In short-term considerable intervention is required	3	1	2
Resource for recreation	May attract additional visitors over time	May attract additional visitors shortly	May attract additional visitors once construction work is complete	3	1	2
Distant appreciation	No change	Restoration may attract some publicity	Restoration may attract some publicity	3	1=	1=
Cultural, spiritual and historic meanings	Unlikely to change	Unlikely to change	Unlikely to change	All options same		
Artistic inspiration	Unlikely to change	Unlikely to change	Unlikely to change	All options same		
Social development	No change	Knowledge of response of saltmarshes may improve	Knowledge of response of saltmarshes may improve	3	1=	1=
Knowledge						
Scientific discovery	Unlikely to change	Unlikely to change	Unlikely to change	All options same		
Historical analysis	Unlikely to change	Unlikely to change	Unlikely to change	All options same		
Environmental monitoring	Monitoring not included as part of project	Monitoring to be undertaken on plants only	Monitoring to be undertaken on change in species	3	2	1
Educational resource	Will provide potential educational resource over time	Will provide potential educational resource, including plant	Will provide potential educational resource, including succession	3	2	1

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Function	**Summary of Impacts**			**Ranking**		
	Option 1	**Option 2**	**Option 3**	**Option 1**	**Option 2**	**Option 3**
		establishment	on saltmarsh as it recovers			
Natural science research	Limited information potential	Potential for studies on plants and recovery	Potential for studies on plants and other species recovery	3	2	1
Products						
Food and drink	Loss of organic lamb produced from grazing on saltmarsh	Loss of organic lamb produced from grazing on saltmarsh	Loss of organic lamb produced from grazing on saltmarsh	All options same		
Fuel, fibre and construction	Unlikely to supply such materials in short term	Unlikely to supply such materials in short term	Unlikely to supply such materials in short term	All options same		
Medicinal and cosmetic products	Unlikely to supply such materials in short term	Unlikely to supply such materials in short term	Unlikely to supply such materials in short term	All options same		
Ornamental and other products	Unlikely to supply such materials in short term	Unlikely to supply such materials in short term	Unlikely to supply such materials in short term	All options same		
Ecosystem services						
Global life-support services	Improvement, but small area only	Improvement may be more rapid (but unsure)	Improvement may be more rapid (but unsure)	3	1=	1=
Flood and erosion control	Improvement over time	Increase in roughness provided by plants	Improved drainage should help encourage rapid colonisation	3	1	2
Water quality and quantity	Improvement over time	Improvement over time	Improvement over time	All options same		
Pollution control	Improvement over time	Improvement over time	Improvement over time	All options same		
Soil provision	May be slight increase in	Plants should reduce soil	Development of creeks	2	1	3

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Function	**Summary of Impacts**			**Ranking**		
	Option 1	**Option 2**	**Option 3**	**Option 1**	**Option 2**	**Option 3**
	erosion in short term	erosion and encourage accretion	may increase soil erosion locally			
Landscape formation	No significant changes expected	No significant changes expected	No significant changes expected	All options same		
Waste decomposition and disposal	No significant changes expected	No significant changes expected	No significant changes expected	All options same		
Pollination	Likely to improve over time as saltmarsh regenerates	Improvement over time, in short term plants may encourage pollinators	Likely to improve over time as saltmarsh regenerates	3	1	2
Biological control	No significant changes expected	No significant changes expected	No significant changes expected	All options same		
Habitat provision	Will improve over time	Small additional benefits from plants	Small additional benefits from creeks	3	1	2
Source: based on English Nature (2002)						

B3.4 Some impacts expressed in money terms

Where some impacts have been expressed in money terms, it is necessary to follow a three-stage process:

1. Discounting and aggregation of impacts expressed in money terms.
2. Comparison of non-monetised impacts (using pairwise comparison or ranking).
3. Consideration of whether any differences in the non-monetised impacts are sufficient to change the selection of the preferred option.

B3.4.1 Discounting and aggregation of impacts expressed in money terms

Discounting is undertaken in the same way in this case as that described for situations where all impacts can be expressed in money terms. The approach is discussed in detail in Section B3.2.1.

B3.4.2 Comparison of non-monetised impacts

The comparison of non-monetised impacts should be undertaken using pairwise comparison or ranking, as described in Sections B3.3.1 and B3.3.2.

B3.4.3 Comparing non-monetised and monetised impacts

Once the impacts expressed in money terms have been discounted and aggregated and the non-monetised impacts compared in pairs and/or ranked, it is necessary to compare them to determine which option should be preferred.

The easiest way to do this is to first rank the options overall in terms of their Benefit-Cost ratio. The option with the highest Benefit-Cost ratio should be ranked '1', the second ranked '2' and so on.

The next step is to try and rank the options in terms of their non-monetised benefits. This is likely to require some understanding of which impact categories are considered most important. An alternative could be to first rank them in terms of each of categories (appreciation, knowledge, products and ecosystem services) before considering the relative importance of the overall categories. For the example considered in Table B3.2, the options may be ranked in the way shown in Table B3.3.

Table B3.3 ranks the three options in terms of their non-monetised impacts (and it is assumed that 'appreciation' has been valued in money terms). In this case the ranking is quite straightforward, since the options always fall in the same rank order. The only exception is in ecosystem services, where soil provision sees Option 1 ranked above Option 3. Consideration of the other impacts, however, suggests that Option 3 should be preferred over Option 2 (i.e. the combination of the other ecosystem services categories is considered more important than soil provision).

It is clear from Table B3.3 that Option 1 is not the preferred option, as it performs worst on three of the overall categories and equal on one. Therefore, it never outranks Options 2 and 3. The decision as to whether Option 2 or Option 3 is preferred depends upon the relative importance of knowledge and ecosystem services.

Table B3.3	RANKING OF OPTIONS BY NON-MONETISED IMPACTS		
Site under consideration:	Example site		
Objectives for the site:	To restore the site to a fully functioning saltmarsh from a degraded, overgrazed marsh		
Option/action:	Option 1: cease grazing on the site Option 2: cease grazing and replant saltmarsh plants Option 3: cease grazing, re-establish creeks and seed with saltmarsh plants		
Function	**Summary of Impacts**		
	Option 1	**Option 2**	**Option 3**
Appreciation	Valued as money impacts		
Knowledge	3	2	1
Products	1=	1=	1=
Ecosystem services	3	1	2

The benefit-cost ratios of the two options are:

- Option 2: benefit-cost ratio of 2.1 and NPV of £1.65 million; and
- Option 3: benefit-cost ratio of 1.4 and NPV of £0.4 million.

Therefore, Option 2 is preferred on the monetary impacts alone. Ranking the options in terms of non-money impacts is also important because Option 2 will be preferred if it is ranked higher than Option 3, however, Option 3 could still be preferred if it is ranked higher than Option 2 and if the additional non-money benefits it offers are worth at least £0.7 million (this would increase its benefit-cost ratio to 2.1, equal with that of Option 2). To decide if this is the case (or not), it is necessary to look back at the ASTs completed for the two options. The level of money benefits generated under 'appreciation' can be used to give an indication of whether an additional £0.7 million of benefits is likely. If so, Option 3 could be selected as the preferred option. If not, Option 2 would be preferred.

B3.5 Risk and uncertainty

However the assessment is undertaken and a preferred option selected, there will always be some risk that the 'correct' option has not been selected, that there will be residual impacts and that uncertainty may not have been fully addressed.

The first risk (that the wrong option was chosen) is dependent on the amount of data that was available, how (and if) stakeholders have been involved in the decision, and whether changes occur that were not expected. There may also have been some appraiser bias in terms of how the options were assessed. This is common where one option is preferred at the outset and an appraiser (often unintentionally) records that option as having greater benefits or fewer impacts. In most cases, it will not be known that the 'wrong' option has been selected unless monitoring is undertaken which allows the predicted impacts to be compared with the actual impacts.

The second risk relates to residual impacts that occur because there is not one option that always outperformed the others (i.e. is risk free). In such cases, it is important that residual risks are reported and mitigation measures proposed, as far as possible.

Uncertainty can affect the selection of the preferred option, particularly where impacts have been estimated in money terms. It is important, therefore, that sensitivity analysis is undertaken to determine the robustness of the decision. If the preferred option remains the same even when large changes are made to the assumptions and, hence, to the estimated benefits, it can usually be assumed that the preferred option is robust. It is more difficult to take account of uncertainty when using qualitative and/or quantitative descriptions of impacts. In this case it is important that uncertainties in the base data or in the predicted impacts are recorded. In this way, a decision maker will be fully informed with respect to uncertainty and can take it into account when selecting the preferred option.