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MESSINA project - Component 3

Socio-economic methods for evaluating decisions in coastal erosion management – State-of-the-art

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Foreword

The Messina project (Managing European Shoreline and Sharing Information on Nearshore Areas) is a European consortium made up by 11 organisations from different countries in Europe. It is founded by the European Regional Development Fund, INTERREG III C, and by the participation organisation.

Component 3 within the Messina project aims to make an inventory and analyse existing economic methodologies relevant for coastal matters. One part of this work is to write a state-of-the-art report of different methods suitable for economic analyses and decision-making on initiatives or investments in coastal zones. The report has mainly been prepared by the National Institute of Coastal and Marine Management in the Netherlands with support from Lund University in Sweden. The participating organisations within component 3 have given their comments to the report. A practical guide for economic valuation of shorelines will be the final outcome of the Messina project.

Linköping, Sweden, September 2005

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SUMMARY

It is obvious that across Europe several, different approaches are applied for coastal and particularly erosion management, with economic assessment playing only a minor role. The Defra approach (including the point system) but also the OEEI guidelines (2000) could be a good starting point to introduce and develop more systematic and rigorous procedures to support the decision process.

Balanced choices and accepted decisions can best be taken if all economic, ecological and social project impacts are taken into account. Integrated impact assessment and stakeholder participation will lead to more sustainable and satisfactory solutions. The choice of the extent of integrated assessment will depend on the information needs, the complexity of the decision and the available resources.

The public carries costs of erosion basically, which may not be sustainable in the long term. Authorities and decision makers, entrepreneurs and initiators must be aware of the erosion (and flooding) risks. Then it will be possible to take the right priorities, procedures and distribution for funding and to internalise the erosion (flooding) costs appropriately.

It is essential to monitor the economic impacts of completed projects during its lifetime and to review systematically the approaches and methods used for the valuation of economic, ecological and social impacts.

Future climate change and sea level rise will increase the risk of erosion (and flooding) in Europe and appropriate measures for protection and defence have to be decided now. A more comprehensive and harmonised EU approach to Integrated Coastal Zone Management (ICZM) from centralised data collection (but understanding of the local natural processes), strategy and policy setting (holding the line vs. realignment, soft and hard engineering) to project planning, assessment and monitoring would be useful. This could start with a more efficient and coordinated exchange of data and experiences and the introduction of agreed procedures and instruments to support the making of sustainable decisions.

The assessment methods presented in this report, Cost-Benefit analysis, Cost-Effectiveness analysis and Multi-Criteria analysis, constitute the main tools to evaluate and validate the spending of public funds on coastal erosion projects. The usefulness of these methods is demonstrated by the many examples included in this report.

1 INTRODUCTION

1.1 Messina

The Messina project studies the exposure of the European coast to coastal hazards, shares information and best practise and ultimately, aims to maximise the benefits of future investments in the coastal zone (Lombardo 2003, Messina project 2004).
One issue that requires more attention is the better integration of "erosion" into the decision making process and particularly into the strategy for sustainable coastal management.

Component 3 of the Messina project aims at establishing a guideline for the integration of costs and benefits in decision-making on initiatives or investments in coastal zones as part of the Coastal Management Toolkit, which is the final result from the Messina project. Tools for integrating costs and benefits are necessary in order for authorities to be able to make priorities between (1) areas which need attention due to threatened shorelines, and (2) which actions would be most efficient and effective to apply. Management of erosion and flood protection must be long term and take into account all possible factors and impacts of projects, both socio-economic (such as e.g. income sources from tourism, possibility for industrial use, such as fishing, transportation etc.) and environmental, accordingly.

1.2 The State-of-the-art report

The objective of this report is to give insight in valuation methods, in some cases extended with insights from social science, which can be used to materialise the recommendations of the Eurosion study (Eurosion reports 2004 - Part 1):

- **Internalize coastal erosion costs and risks in planning and investment decisions**
  ”The impact, cost and risk of human induced coastal erosion should be controlled through a better internalisation of coastal erosion concerns in planning and investment decisions. Public responsibility for coastal erosion risk should be limited and an appropriate part of the risk should be transferred to direct beneficiaries and investors. Environmental Assessment instruments should be applied to achieve this. Risk should be monitored and mapped, evaluated and incorporated into planning and investment policies."
- **Make responses to coastal erosion accountable**
  ”Coastal erosion management should move away from piecemeal solutions to a planned approach based upon accountability principles by optimising investment costs against values at risk, increasing social acceptability of actions and keeping options open for the future. This move should be driven by the need to restore the coastal resilience and meet the conditions of favourable sediment status as developed in previous recommendations. It should be supported by the elaboration and implementation of Coastal Sediment Management Plans (CSMP)"

Erosion directly or indirectly affects societal values such as a safe place to live or recreation possibilities. Therefore, public authorities take the responsibility to combat or alleviate negative impacts. As the public authorities represent all groups in the (local) society, they have the responsibility to base decisions on an integrated assessment of the consequences of alternative coastal protection schemes. Accountability of investments has to do with transparency of decision-making based on clear criteria. This paper discusses valuation methods that can enhance accountability of decision-making by making costs and effects of measures explicit. As such these economic methods are supportive to decision-making.

This paper gives a short introduction into the causes, impacts and assessment of coastal erosion (chapter 1 and 2) and summarises the steps to appraise coastal projects. It outlines economic assessment methods (chapter 3-5) that can support and enhance the transparency of the decision-making process and it discusses approaches to base decisions on an integrated assessment of economic, ecological and social consequences of alternative coastal protection schemes. Chapter 6 summarises the main conclusions and gives some recommendations.

1.3 Coastal erosion

Coastal areas perform several important economical, ecological and social functions. Over the past 50 years, the population living in European coastal municipalities has more than doubled to 70 million people (16% of the EU population). Coastal habitats are valuable for fauna and flora biodiversity. Dunes and wetlands provide flood control, drinking water and waste assimilation, and beaches are an essential asset for tourism and recreation. The estimated total value of economic assets is as high as €500 to €1000 billion (EU Commission 2004). A more extensive description of coastal erosion in Europe is given in Annex 1.

Coastal erosion is usually the result of a combination of factors - both natural and human induced - that operate on different scales. Eurosion (Eurosion reports 2004, Part 1) defines coastal erosion as the encroachment of land by the sea after averaging over a period that is sufficiently long to eliminate the impacts of weather, storm events and local sediment dynamics (such as “sand waves”).

Coastal erosion results in three different types of impacts (or risks):

- loss of land with economic value or with ecological value; a specific mechanism is the collapse of properties located on the top of cliffs and dunes,
- destruction of natural sea defences (usually a dune system) as a result of storm events, which may result in flooding of the hinterland and
- undermining of artificial sea defences as a result of chronic sediment

There is also close relation between coastal erosion and the latter follows the risk of coastal flooding as in many of the areas the former.

1.4 Coastal erosion in temporal and spatial scale

As the process of coastal erosion takes a long period and is related with long ranging sediment transport processes (European Commission 2004, Eurosion 2004). The temporal and spatial scale is an important factor in coastal protection and defence projects. Impacts also go beyond legal and regional or national boundaries. Erosion problems should therefore be analysed at the level of the sediment cell. Box 1-1 provides a definition of the sediment cell.

Box 1-1 Definition of sediment cell (Eurosion 2004 - part 1, p 19)

A coastal sediment cell can be defined as a length of coastline and associated near-shore areas where movement of sediments is largely self contained. Sediment cells are separated from each other by rivers and sometimes by large promontories where the direction of longshore drift is changing; the length of sediment cells may be very small (less than a kilometre) or very large (100 km). In practice, this means that measures within a specific sediment cell may have impact on other sections of the same sediment cell but will not significantly impact adjacent cells.

Normally it is not only one, but a mixture of various factors, natural or human driven, that causes erosion. Individually, these effects can be small but can have significant impact if cumulated.

Also the time span necessary to acknowledge coastal evolutionary change is often underestimated. Not the typical 5-20 year planning periods but a 50-100 year horizon is necessary for sustainable coastal management. This is increasingly important taken the global climate change into account. Therefore solving coastal erosion problems requires a long term, comprehensive approach to plans and programs.

1.4.1 Coastal erosion in Environmental Impact Assessment

European legislation requires for major public and private projects an Environmental Impact Assessment (EIA). However, the Eurosion project demonstrated (Eurosion 2004), that the impact of projects and activities on erosion is not properly addressed in EIA procedures. One of the reasons is that many projects have been carried out before the existence of EIA and are still “active” in disturbing the sediment flow and affecting the environment. The knowledge of erosion processes is still fragmented and erosion results from the cumulative impact of many factors, each of which too small to justify integration into an EIA. Furthermore there are no clear national legislation how to establish an EIA and which parties should be involved in the assessment. Table 1.1 shows that little attention is being paid to the Environmental Impact Assessment (EIA) of coastal zone projects.

The EU directives (EIA 97/11/EC and SEA 01/42/EC), as well as the Eurosion and EU Commission papers (Eurosion 5.4, 2004, European Commission 2000b) provide guidance how to address the potential ecological impact of public and private projects on coastal erosion.

Table 1.1 - Environmental impact assessment (EIA) of erosion

Type of project	**Impact on Erosion**	**Covered by EIA**
Harbour infrastructure and activities (including navigational dredging)	High	Yes
River water regulation works (mainly dams)	High	No
Seafront construction	Moderate	No
Land reclamation near-shore or offshore (e.g. wind farm)	Moderate	Partially
Aggregate extraction (dredging) for construction and nourishment purposes	Moderate	Yes
Gas mining (relative sea level rise induced by land subsidence)	Low to Moderate	No
Maritime navigation (ship-induced waves)	Low	No

Source: Eurosion 2004

1.4.2 Strategic Environmental Assessment

Although similar in terms of procedures and steps to EIA, Strategic Environmental Assessment (SEA) covers a wider scope and time horizon than EIA. And as coastal erosion often results from the cumulative, longer-term effects of many individual projects, a SEA may be an even more appropriate tool to consider and assess erosion impacts.

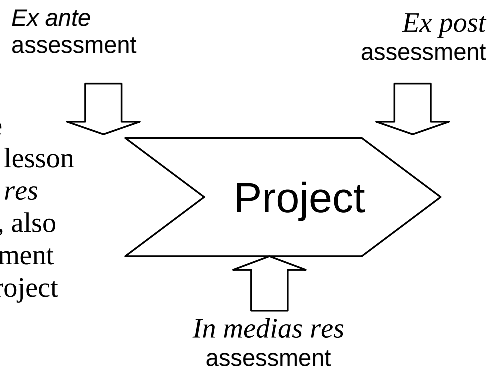
A recent consultation report provides guidance how coastal erosion concerns can be incorporated in SEA processes (EU Commission 2004b). It proposes the promotion of ICZM and stakeholder engagement.

2 ANALYSIS OF COASTAL EROSION PROJECTS

This chapter gives a general introduction on how to evaluate coastal erosion projects and what to consider. The major steps of a project assessment, valuation and how to distinguish the pros and cons of different alternatives are presented and discussed. At the end of the chapter three methods of evaluation are introduced. Cost-Benefit Analysis (CBA), Cost-Effectiveness Analysis (CEA) and Multi-Criteria Analysis (MCA).

In the report we discuss economic analysis methods for coastal protection measures. These methods are equally valid for projects aimed at coastal development, and in fact it is highly recommended for that purpose.

There are two major types of project assessment. *Ex ante* assessment is conducted before decision-making and primarily aims at selecting the best alternative, whereas *ex post* assessment is done after a project is completed and mostly aims at lesson learning. There are also examples of *in medias res* assessment (evaluation of a project in progress, also referred to as mid-term review). Similar assessment methods can be used for all of these types of project assessment.



Project assessment can be used at different levels and purposes. Normal uses are for instance

- at project level - to assess a specific stretch of coastline to find the best alternative strategy to handle the erosion problems - and
- at project selection level - to select between a number of project proposals at different locations to find which project that gives most value for money spent.

Coastal projects are long-term initiatives and it is essential that a long term economic monitoring of costs and benefits is part of the project to confirm the predictions and assumptions and to learn and build up experience for the future.

2.1 Different levels of responses to combat coastal erosion

Three levels of responses to combat coastal erosion and its negative impacts to society can be distinguished where project assessment is required

- **The planning or policy level**, which includes the different policy options "Hold the line", "Move seaward", "Managed realignment", and "No active intervention", including the understanding of natural coastal processes and the acknowledgement of strategic sediment reservoirs (Eurosion 2004)
- **The engineering or implementation level**, which cover a range of hard and soft mitigation measures. Hard techniques include breakwaters, gabions, geo textiles, groin fields, revetments and sea walls. Soft techniques include beach nourishment

and re-profiling, dune and marsh regeneration and vegetation planting, beach and cliff drainage.

- **The financial level** that include measures and incentives, for example to control excess coastal urbanisation and tourism (development and land-use taxes, user charges), to promote restoration and cultivation (e.g. through subsidies), to accommodate the resettlement of coastal population at risk (financial compensation) and to internalise costs of risk and events (insurance fees, property rights).

Economic analysis can be applied to evaluate alternative responses on a policy or project level. This report doesn't explicitly discuss financial measures and incentives to control potential damage as a result of erosion. In any project appraisal applying an economic analysis the project effects, the advantages and disadvantages, the costs and the benefits, have to be identified, measured and evaluated. Human activities and interventions combine with natural variability in coastal zone processes and produce an array of direct and indirect effects, only some of which can be directly valued in monetary terms.

When a project assessment is started the initiating organisation has to see to that adequate resources are made available for the assessment and that a work is organised with a reasonable vision of the expected outcome. It is important to make clear what kind of decisions will be made as a result of the project assessment and to select a valuation method that meets this end. Almost all literature on project assessment stresses the value and importance of stakeholder involvement in all steps.

2.2 Main steps of a project assessment

In the following the main steps of a project assessment are briefly summarised (Reference: OEEI 2000, Defra 2000). Figure 2.1 shows the normal sequence of steps in an economic analysis. The steps are explained in this chapter. The three methods for comparing alternatives (CBA, MCA, CEA) will be explained in the subsequent chapters. Hazard and risk analysis are supportive to problem analysis and analysis of effects.

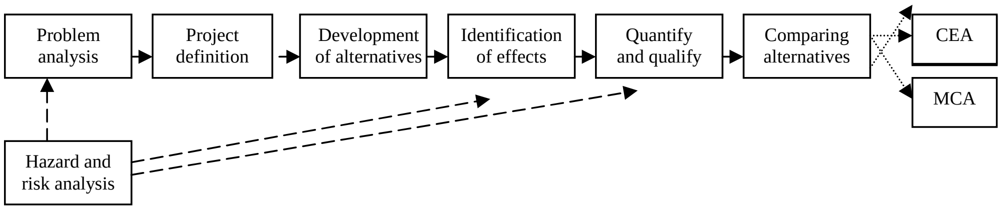


Figure 2.1 Steps in project assessment.

2.2.1 Problem analysis

A first step in appraising coastal projects consists of a thorough analysis of the problem of erosion at the specific location. The analysis involves modelling of the natural coastal processes and human influencing factors acting in the whole sediment cell. Hazard and risk analysis (explained in paragraph 2.3) can be a useful approach to map and quantify erosion. Questions as ‘what are the causes of erosion’ and ‘what problems should be solved by the project’ should be addressed. Such problem analysis is the basis for a good definition and structure of the project.
As part of the problem analysis, a stakeholder analysis should be conducted. Such an analysis pictures all groups in society that are affected by the problem: industry, interest groups (such as environmental lobbies), other societal organisations and the public,

The most obvious problem resulting from erosion is loss of land, either privately owned (housing, agricultural land) or publicly owned (nature reserves, infrastructure). The benefit from coastal protection measures is a temporary but lengthy extension use of this land.

2.2.2 Project definition and development of alternatives

Based on the analysis of the problems to be solved, the goals of the foreseen intervention should be agreed. This should of course align with applicable policies and plans on higher level. Another crucial input is knowledge about the coastal erosion process, present situation and prognosis of future development.

The project definition should describe these goals, the activities to reach them as well as the boundaries in space and time of the project. The basis for the project evaluation is the degree how these targets are achieved without and with the project respectively. This is also the proper time to consider which discipline needs to be involved for an integrated assessment and who assesses which impacts.

An integrated part of the project definition is to design alternative solutions or measures to encounter the problem(s) noted in the problem analysis. Critical is the correct definition of the “do nothing”-option, normally called the “do nothing” alternative. The “do nothing”-option stipulates future erosion and problems without intervention to prevent erosion. Erosion contours for 10, 20, 30 etc. up to 100 years are estimated. This gives an indication of what year different land areas are at risk.

The alternatives developed can follow any of the five generic policy options as defined by the Eurosion project (Eurosion 2004b) shown in Figure 2.2. These were originally defined by the UK Department for Environment, Food and Rural Affairs (Defra).

- *Do nothing*
  There is no investment in coastal defence assets or operations, i.e. no shoreline management activity.

- *Managed realignment*
  Identifying a new line of defence and, where appropriate, constructing new defences landward of the original defences.

- *Hold the line*
  Hold the existing defence line by maintaining or changing the standard of protection. This policy covers those situations where works are undertaken in front of the existing defences to improve or maintain the standard of protection provided by the existing defence line. Policies that involve operations to the rear of existing defences should be included under this policy where they form an integral part of maintaining the current coastal defence systems.

- *Move seaward*
  Advance the existing defence line by constructing new defences seaward of the original defences. This use of policy is limited to those management units where significant land reclamation is considered.

- *Managed realignment*
  Identifying a new line of defence and, where appropriate, constructing new defences landward of the original defences.

- *Limited intervention*
  Working with natural processes to reduce risks while allowing natural coastal change. This may range from measures that attempt to slow down rather than stop coastal erosion and cliff recessions (e.g. nourishments), to measures that address public safety issues (e.g. flood warning systems, dune and forest maintenance, building restriction in coastal strip).

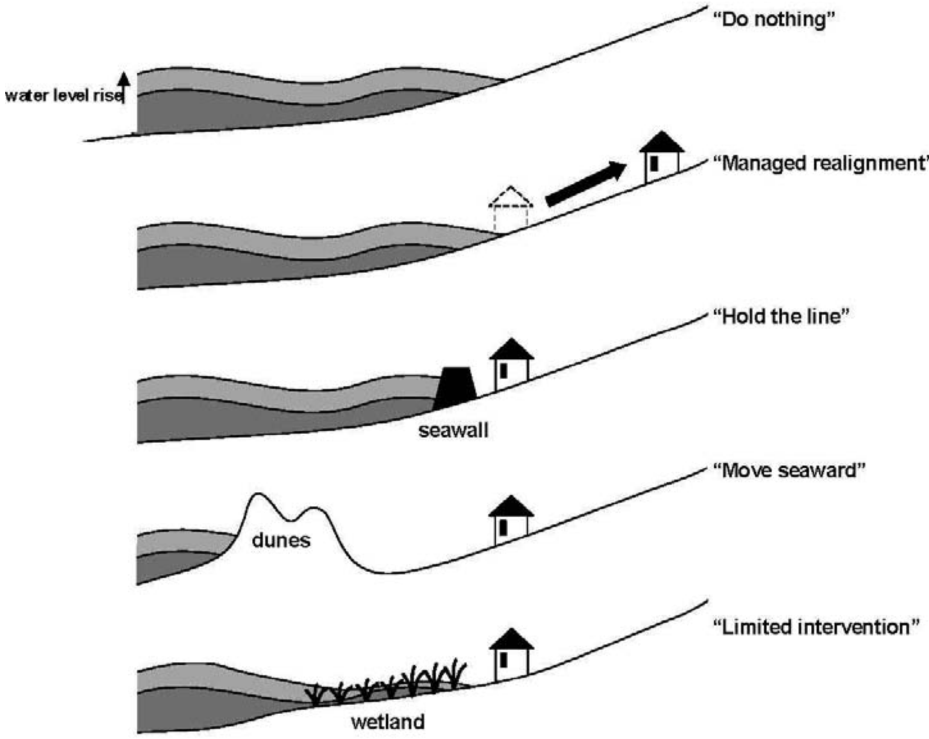


Figure 2.2 The five generic policy options (Eurosion 2004b*)*

The “do nothing” alternative describes the situation in the case that the coastal protection project will not proceed. Defra (2000) distinguishes between the

- “no action” option: where no protection scheme exists, no further action is taken to intervene with natural processes, and the
- “walk away” option: where a scheme is existent the option will be to walk away and abandon all maintenance to existent structures. Simply to continue with maintenance and repair of existent structures would be one of the “do-something” options to be considered.

If “doing nothing” is no option, (e.g. the potential damage considered to be huge) it may be more suitable to determine net effects of project alternatives on the basis of a minimal intervention scheme, such as maintenance of the existing defence structures.

To identify the “do something” options, it is recommended to choose a wide range of possible alternatives covering different standards, different probabilities of failure, different time horizons etc. It is not feasible to analyse all possible alternatives, selection of alternatives can be done in a brainstorming manner where a reasonable number of alternatives is selected for analysis. When later on the best alternative has been selected, fine-tuning of this can be done.

2.2.3 Identification of effects

The effects of all project alternatives including the “do nothing” alternative need to be identified, quantified and qualified. The effects can be desirable or undesirable, intended or unintended. Considering as many as possible effects of an intervention can help to alleviate expected negative impacts already in an early phase of project development, through adjustments in design or compensation schemes.

It is normally of great help to involve stakeholder groups or representatives in this exercise (through workshops or questionnaires). Inclusion of stakeholders in this assessment is also desirable from the perspective of acceptance of the outcome of the analysis. After having listed effects in a brainstorm session or otherwise, this gross list will require a critical review and some structuring. Some effects may overlap, appear twice, or some may still be missing.

A good way of presenting the effects is in an Effects table where the effects are sorted under different categories, such effects on the local economy and effects on nature. They can also be preliminary ordered in order of significance to indicate to the analysing team with which significant effects to start the evaluation (see table 2.1).

Three types of effects should be considered in the process of effect identification.

- *Direct effects* arise directly from a project and have a direct influence on its initiators or users. Examples are safeguarding of property and land or the construction costs of a project.
- *Indirect effects* arise from events that are only triggered or caused by the project and which do not directly affect the initiator or the users but other groups in society. Examples are the improvement of infrastructure or improvement of an amenity, which upgrade the attractiveness of a region.

- *External effects* finally are direct or indirect effects, which cannot be measured by market prices. Many impacts on the environment fall into this category.

An example of an effect table is shown in Table 2.1.

The different identified effects are categorised and sorted under different headings. Then all alternative options are evaluated and given values regarding the effects.

Combination of effects/losses can occur when the erosion of higher grounds leads to increasing risk of flooding of areas behind or when erosion threatens or destroys the defence structure. The probabilities of flood and erosion damage should be combined. Property affected by severe and frequent flooding may be uninhabitable before it is lost through erosion.

Table 2.1. Example of an Effects table: Flooding study Maas (adapted from Brouwer 2003).

	Alternatives					
	Units	Do nothing	1	2	3	4
Direct effects						
Investment costs	million €	0	8353	5350	3262	6487
Maintenance costs	million €	0	250	305	358	293
Direct/indirect effects						
Acc. Safety legislation	yes/no	No	yes	yes	yes	yes
Damage to property and infrastructure	million €	3947	0	0	0	0
Agriculture	million €	396	0	0	0	0
Recreation	million €	1754	0	0	0	0
Other damages	million €	2657	0	0	0	0
Effects on current usage						
Purchase properties	number	0	2290	320	70	1540
Purchase land	ha	0	15835	2980	2210	10705
Sand mining	million m3	0	74	26	21	25
Effects on future usage						
Extra nature areas	ha	0	16354	4229	3102	9869
Chances landscape	++/- -	0	0	+ +	+ +	+

2.2.4 Quantifying and qualifying effects

Quantifying

After having identified the relevant effects, these should be described and quantified as far as possible for all alternatives, including the “do nothing” alternative. For example, if coastal erosion endangers a living area, the hectares, number of houses, their average market value and number of citizens need to be defined. As this is one of the basic steps of the project assessment it is of high relevance to have a good information/research on effects, and as much as possible quantified. Co-operation with other disciplines is essential in order to agree on what effects should be analysed, which criteria are used to express the effects (hectares biotope lost, numbers of species lost, number of houses damaged, number of tourists affected etc.). Identification and quantification of effects is the main task of EIA/SEA and hazard analysis, and close co-operation with those processes is essential.

Qualifying
Qualifying means setting a qualitative value to each effect. The values can be monetary or non-monetary. Monetary values represent, among others, investment costs, production losses and costs of restoring damage. Non-monetary values include classification and ranking scales that describe the effects of alternatives.

The costs of a project relate to the investment, operation, management and maintenance of the technical works for coastal protection. Investment costs are caused by initial expenditures, purchases to construct, build and perform a project. Operational and management costs are future cost that occur every year and is connected with the project (e.g. energy use, safety inspections). Maintenance costs are future costs to upgrade the facilities to “original” standard after “wear and tear” and with a periodicity of more than one year. The costs of all alternatives should be estimated within a framework of risk management to enable the definition of financial contingencies (Defra 2000).
Note that the costs of “doing nothing” is always zero (except in the case of minimal maintenance).

The most obvious method to value monetary effects is to use market prices. In a perfectly competitive market, this is the simplest possibility and the recommended way to start, for example the value of lost property, costs of investment or operational and maintenance costs as a percentage of total investments. Prices used in estimates are always constant prices, i.e. they are corrected for inflation.

The cost of investments includes cost of design/planning and construction. This comprises cost of labour, material, subcontractors, consultants, fees and taxes etc., insurance, financing and all overhead costs. The same principle applies for operation and maintenance costs. Cost estimating is dependant of the level of detail of available data regarding the project and general cost data. Some basic remarks regarding cost estimating are collected in Box 2-1.

However, perfect markets are very unusual and in an economic cost-benefit analysis market prices have often to be corrected for distorting effects like taxes and subsidies and so called “shadow prices” are used instead. The shadow price is an adjusted value to better reflect the social value of an effect. Examples of shadow pricing is putting a value on human life and determining values on recreational areas. In chapter 3.1.1 more is explained about pricing of effects. Chapter 3.1.2 explains other methods of valuation of effects.

An alternative to pricing is to work with non-monetary ranking scale or ordinal scales for different aspects of the potential problems of the alternatives under assessment. This is by many argued to be better way to include valuation of for example a human life and a scenic view. The non-monetary valuation deals with the same cause and effects but can group them differently. Non-monetary values also have to take into account future changes. The valuation criteria’s and reasons may change over time and this has to be included in the project assessment in some way.

To conduct a totally assessment including all factors affecting the project under assessment will demand enormous resources. It is recommended that the effects are preliminary evaluated and ordered after importance. This should be done with the project initiator, experts and key stakeholders involvement to ensure a relevant outcome.

Box 2-1
Basic remarks regarding estimating investment, operations and maintenance costs

Different ways of estimating
Engineering build up
Sometimes referred to as “bottom-up” estimating. This methodology rolls up individual estimates for each element into the overall estimate. The engineers performing the work usually provide these lower level estimates. This costing methodology involves the computation of the cost element by estimating at the lowest level of detail wherein the resources to accomplish the work effort are readily distinguishable and discernible. Often the labour requirements are estimated separately from material requirements. Overhead factors, General and Administrative are generally applied to the labour and materials costs to complete the estimate.

Supplier Quotes
Often a project will involve the use of goods, facilities, or services for which the costs are readily available from suppliers. An example of a supplier quote would be the cost of delivering a fixed number of m3 of sand filling. The use of a supplier quote can apply to any item at any level in the estimate if the cost of the item plus its integration costs into a coastal protection project is well known and based on experience with the supplier and the product/service.

Analogous System Estimates
Analogous estimates are performed on the basis of comparison and extrapolation to equivalent items or efforts. Cost data from one past project that is technically representative of the project to be estimated serves as the basis of estimate. These cost data are then subjectively adjusted upward or downward, depending upon whether the subject alternative is felt to be more or less complex than the analogous project. Clearly subjective adjustments compromise completely the validity and defensibility of the estimate and should be avoided. Fit best, linear extrapolations from the analogue are acceptable “adjustments.”

Parametric Estimating
Parametric estimates are most often used when there are only a few key characteristic pieces of data that are known. Parametric estimates are based on historical data and mathematical expressions relating cost as the dependent variable to selected, independent, cost-driving variables through regression analysis. The implicit assumption of this approach is that the same forces that affected cost in the past will affect cost in the future.

Data collection
Data collection is typically one of the most difficult, time-consuming, and costly activities in cost estimating. Data sources can be hard to identify and often you do not find what is exactly needed and typically there is a story behind the data that is important to understand. Therefore data of three categories need to be collected, Cost data, Technical data and Project data

Cost data
Type- Historical costs, Actual costs (Labour and material costs etc.).
Source -Basic accounting records, Cost reports, Historical databases, Contracts, Cost proposals.

Technical data
Type – Physical and performance characteristics, Technology descriptors and design, Environment
Source - Technical databases, Engineering specifications and drawings, Performance/functional specifications, End user and operators

Project Data
Type - Project schedules, Implementation time horizon, Anomalies
Source - Project database, Project organisations, Project management plan, Major subcontractors

Collecting Data Methods
The following are potential mechanisms available to the cost estimator for identifying quantitative cost data: Surveys and/or questionnaires, Target research, Statistics, and Specific cost, technical, and project data from primary and secondary sources. To collect qualitative data, use: Interviews, Focus groups, Reviews, Meetings, and Targeted research

2.2.5 Comparing alternatives – selection of valuation method

Several methods can be used for the assessment and valuation. The most commonly used are Cost-Benefit Analysis (CBA), Cost-Effectiveness Analysis (CEA) and Multi-Criteria Analysis (MCA). CBA and CEA are economic valuation methods whereas MCA is not pure economic, but is presented in this report as a serious alternative to CBA. The methods are summarized in Table 2.2 and described more detailed in the following chapters.

In a social CBA the decision criterion is the best ratio between benefits and cost. If benefits exceed costs (=welfare increase) the project is worth doing from a societal point of view. For a CEA the least cost alternative is calculated for an effect. For example a cost per protected m of shoreline. In a MCA all effects are assigned scores and the effects are given different importance (weights). The option with the best total score is selected. CBA and MCA include valuation of Investment costs, Economic, Ecological and Social-cultural effects, whereas CEA does not include valuation of all effects.

The main difference in a MCA is that it can incorporate more subjective qualitative data as it uses valuation through ranking score and assigning weights to effects/factors. CBA and CEA on the other hand evaluates with monetary prices. With ranking score is meant that an alternatives is given a rank number e.g. between 1 and 10 for one effect. Valuation means putting a discrete monetary value on the effect. If it is possible to valuate an alternative monetarily the use of a ranking scale bring about a loss of information and accuracy.

In a CBA it is not always possible to monetize ecological and social-cultural effects. In fact, a CBA in theory strives after full monetization but it is not always done (e.g. due to data limitations, cost, but also methodological problems). Employment effects are redistributional and not affecting nation’s welfare. CEA and CBA do not take into account employment effects, but MCA can do. When an effect is not monetized or given a score the description, quantifying and qualifying (as mentioned in chapter 2.2.4) is used as part of the total assessment.

Table 2.2. Comparison between the different valuation methods
(* there may be limitations to what extent the valuation be performed)

	Decision criteria	**Investment costs**	**Economic effects**	**Ecological effects**	**Social-cultural effects**
CBA	Economic efficiency/ welfare increase	Monetary	Monetary	Monetary*	Monetary*
CEA	Least cost	Monetary	Monetary		
MCA	Multiple	Score	Score	Score	Score

2.3 Hazard and risk analysis

Results from the Eurosion project results suggest that underestimation of hazards and lack of risk awareness in spatial planning leads to inefficient spending of public money. Developers have often a too short time horizon and in most countries can rely on (and receive) public assistance in case of damage as a result of erosion or flooding.

Erosion hazards are related to long-term coastal dynamics and to flooding threats of areas lying close to or below sea level. Hazard analysis refers to the assessment of the (annual) erosion rate and flood incidence in a specific coastal area and to understand the scale and characteristics of the hazard. The probability can sometimes be assessed based on past records, like probabilities of high waves and floods or extrapolation of studies, like erosion contours.

Predicted rates of coastal erosion without further coastal protection form the link between the physical process and the economic benefit of protection. Based on local historical and technical information and an understanding of the local processes, a set of predicted erosions contours are generated over a time horizon of 50-100 years. Sensitivity analysis is undertaken to cover the issue of uncertainty. Similarly, maps of flood prone areas and flood probabilities can be used as a basis for flood alleviation projects. These predictions are sometimes erratic and difficult to make and may be subject to uncertainty (Hall 2000); however, they are a necessary basis for analysis of the probability of loss of land, property, habitats etc. One example of predicted erosion rate is shown in Figure 2.3.

Depicting contours of erosion and flood prone areas on a map, and combining these with land use and property data and population figures give insight in potential impact or damage of erosion and flooding. The Eurosion project calls for risk mapping and recommends using such approach in spatial planning. Hazard maps would indicate high-risk areas vulnerable for erosion and/or flooding and where protection measures are imminent. These maps could also be a lead for the selection of locations for commercial investments (hotel or industry). Vulnerable areas should be avoided for (commercial) development, as they require costly protection measures on a longer term.

Risk assessment estimates the risk that an event, for example erosion or flooding, causes damage to property, health, ecosystems etc. It involves identifying possible risks and estimating their frequency or probability and analysing their likely impact. A risk score can be estimated as:

$$\text{Risk Score} = \text{probability (of occurrence)} * \text{impact (potential damage)}$$

The risks identified are listed in a Risk Register. An evaluation is made on the probability of occurrence and consequence of each risk. This can be done for different scenarios (worst, best, normal). When the risks are delineated they can be ranked according to risk score and preventive measures can be planned and implemented. There are four ways of responding to identified risks: acceptance, avoidance, transfer or mitigation (PMBOK, 2004).

The risks register is continuously updated and evaluated during the project assessment. Risk and impact assessments provide essential information to take the right decision on the best use of investment capital against value at risk and the right approach to ensure shoreline stability.

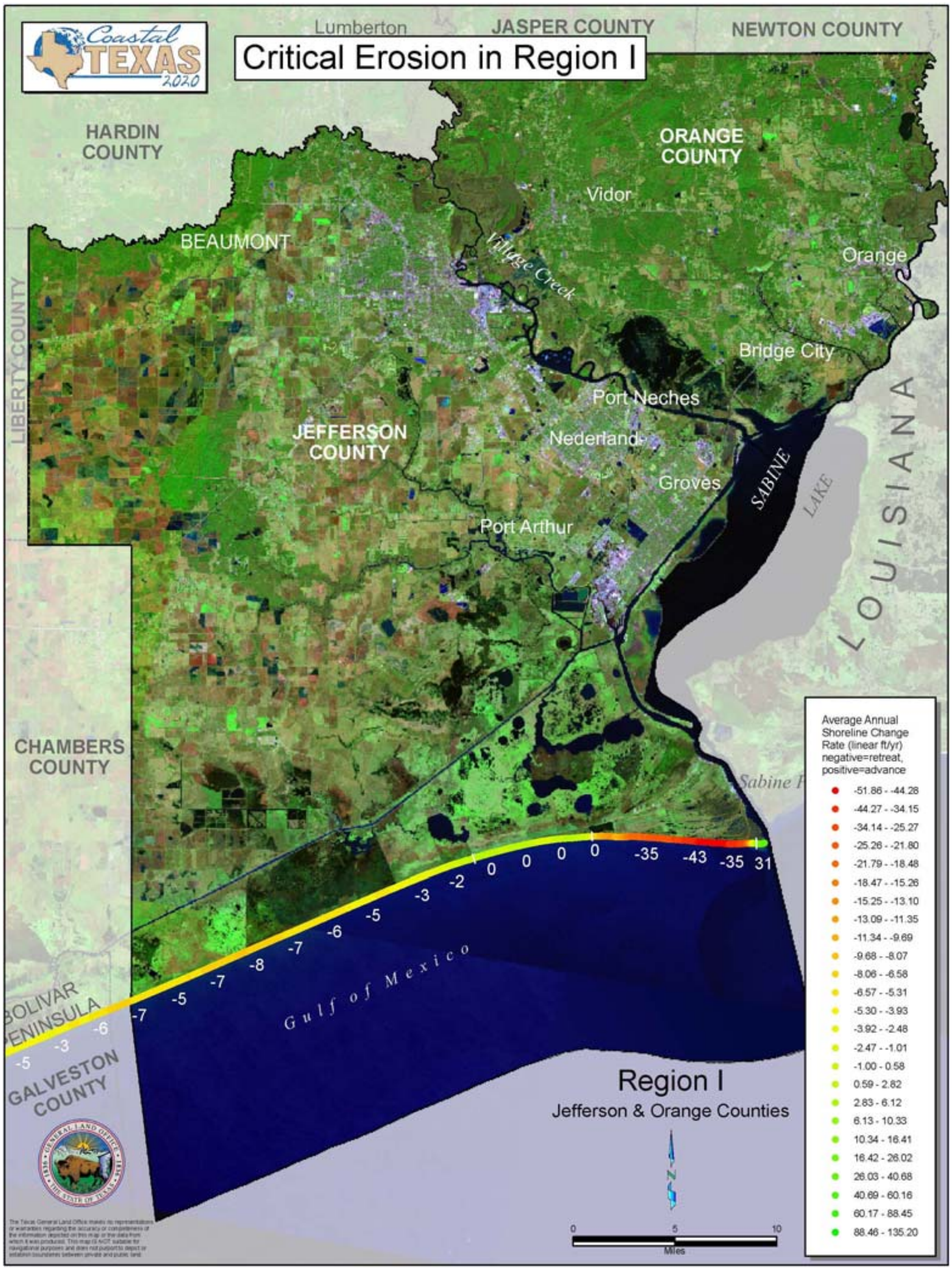


Figure 2.3. Example of erosion rate prediction (Coastal Erosion Planning & Response Act - Report to the 79th Texas Legislature April 2005).

2.3.1 Examples – risk analysis of erosion hazards

Practice: Evaluation of erosion hazards at U.S. coastlines

A study carried out by the Heinz Center, US, (see Box 2-2) investigated means to reduce erosion losses. Erosion hazards in the US were assessed and several different policy options evaluated, among others to make citizens aware of erosion hazards and associated impacts.

Box 2-2

Evaluation of erosion hazards at U.S. coastlines (The Heinz Center (2000). Evaluation of erosion hazards www.fema.gov/pdf/library/erosion.pdf)

1. Objective

Current and prospective property owners at the coast are not informed of erosion risks and insurance rates do not reflect the magnitude of risks. The US Congress debated erosion management legislation during the early 1990s and requested 1994 an analysis of possible policy changes to address erosion hazards within federal programs. The goal of the study, carried out by the Heinz Center, was

- to improve the understanding of erosion impacts on coastal communities and how erosion is managed
- to analyse the economic impacts of erosion and to evaluate policy options to reduce erosion losses

2. Methodology

The study was conducted in 3 phases: in phase 1, the Federal Emergency Management Agency and State agencies produced maps for 27 counties along the US coast including projections of how far inland the coast line may erode over the next 60 years.

The Heinz Center conducted phases 2 and 3, which included a representative field survey of over 10 000 structures within the 60-year projected erosion hazard zones in 18 of the 27 counties throughout the entire length of the mapped coastline and an analysis of the erosion related damage. Current management procedures and policy options were studied to address that damage.

3. The economic impact

The study concluded, that over the next 60 years, 25% of the 340 000 houses within 500 feet of the shoreline may be lost due to erosion. The impact may be even worse if coastal development continues unabated and if sea level rises as predicted.

Coastal property values within the 60 year erosion hazard zone are reduced by $3,3 – 4,8 billion.

Over the next decades, approximately 1500 homes with the connected land will be lost to erosion each year, costing the coastal property owners some $530 million per year, the communities $ 410 million and the Flood insurance programme some $ 80 million annual payout.

As coastal erosion makes coastal protection and defence as well as ecosystems more vulnerable to storms and sea level rise, i.e. the risk is expected to increase in the future.

4. Recommendations

The study recommended the Congress to direct the Federal Emergency Agency to develop erosion and flooding hazard maps to make property owners and investors aware of potential erosion risks. It was also recommended to internalize the costs of expected erosion losses into the insurance rates.

The study presented also several additional federal policy options such as requiring building zone set backs, setting more severe building standards and providing relocation help or buy outs.

5. Lessons learned

The dynamic nature of the shoreline makes it difficult to assess accurately risk and vulnerability of a community. As a respond to erosion hazards, shoreline protection projects are built and financed by the public sector. The study shows the importance of proper information and communication between all stakeholders:

- The costs of mapping for 12 500 miles of the U.S. coastlines was estimated as 44 million $. The awareness of the hazards will influence the future coastal development and reduce future losses, particularly if the future external costs are internalised for example into mandatory insurance rates.
- This could also put some critical light on alternative federal investment expenditure and their cost-effectiveness. The spending of an equivalent amount on coast nourishment would protect roughly 10 mile of shoreline (assuming a 10 year life of the maps).

The study recommended to introduce erosion hazard mapping and to internalise the risk and costs of erosion as a cost efficient mean to influence investment decisions and to reduce erosion losses.

Practice: UK Foresight studies

In the UK, so called Foresight studies are done to provide challenging visions of the future and to guide effective strategy development. A Flood and Coastal defence study (OST, 2004) analysed future risks of flooding and erosion for the next 80 years for four different scenarios including central versus localised governance and high versus sustainable economy growth. Table 2.3 summarises estimates of expected annual damage due to flooding and coastal erosion in England for the 2080's (billion pounds per annum) of different economic growth and policy scenarios. The results indicating that both climate and socio-economic changes will influence damage impacts and budget demands significantly over the medium and longer term:

Table 2.3. Expected annual damage due to flooding and coastal erosion (OST, 2004)

	Damage today (billion £ per year)	**Damage 2080s (Different economic scenarios) (billion £ per year)**
Flooding	1,4	2 – 27
Erosion	0,014	0,046 – 0,126

In economic terms, the impacts of coastal erosion were considered to be small in relation to the national economy. However, by the 2080's, the associated losses, expressed as absolute costs, could increase to three to nine times the current values. Several options to response to the increasing risks were discussed in the report, under which catchments wide storage, land use planning and realigned coastal defences. Approximately 20 – 80 billion £ additional defence and protection costs are to be expected, which are on an average annual basis 0,7 to 1,1 billion £ (compared to 0,5 billion £ today).

3 EVALUATION METHODS

3.1 Cost-Benefit Analysis (CBA)

3.1.1 Introduction

The broad purpose of Cost-Benefit Analysis (CBA) is to assist society in decision-making and to facilitate more efficient allocation of society's resources. In a CBA all the costs and benefits to society as a whole are considered. By measuring social costs and benefits, information on optimal use of scarce resources to meet the agreed objectives is obtained and the efficiency of the investment can be judged. However given a governmental/political rationale, CBA is used to demonstrate the superior efficiency if a particular intervention relative to alternatives, including the status quo.

Economic (or social) CBA should not be confused with financial CBA. The objective of a social CBA is to determine whether a project is socially desirable, i.e. whether the net social benefits (NSB) are positive. A social CBA, which is carried out from a society perspective is referred to as an economic CBA (increase/decrease in individuals utility). A CBA carried out from an individual investor viewpoint is referred to as a financial CBA (maximising profit). Box 3-1 indicates the main differences between the two.

For simplicity this report uses the abbreviation CBA for Economic or Social Cost-Benefit Analysis.

Box 3-1
Main differences between economic and financial analysis (Penning-Rowsell 1992, Brouwer 2003)

Economic analysis	**Financial analysis**
Perspective: Society	Perspective: Initiator
Concerned with the total net change in resources, all costs and benefits, across the nation	Concerned only with those changes which affect the organization for which the analysis is being done
Uses money as a yardstick to compare changes in the stocks and flows of goods, whether or not these goods are priced	Only concerned with changes which have monetary consequences for the organization
Including external (non-priced) effects	Excluding external effects
Based on the concept of opportunity costs (explain). These may be reflected in market prices, but usually are not (shadow prices). Changes in taxes and subsidies are excluded	Based upon market prices. Taxes, subsidies and similar monetary transfers are included
Result irrespective of way of Financing	Financing method may affect result liquidity analysis

3.1.2 Economic valuation of effects

In a Cost-Benefit analysis project effects are first described in quantity and quality and ultimately expressed in monetary terms. Project effects can be distinguished in two major categories: *Priced effects* and *Non-priced effects* (OEEI 2000, Bower 1997) and there are different difficulties in assigning the monetary value to the effects.

Priced effects

Section 2.2.4 gives clues how to estimate investment cost and recurrent cost of a coastal protection scheme. This section deals with pricing of other market effects divided into Direct and Indirect effects. *Direct effects* are effects such as Impact on property, Infrastructure, Agriculture, Tourism, Land use, Production functions, Project and operational costs. *Indirect effects* are effects such as Improved economic value of the region and mitigation and replacement costs.

Land with private houses and commercial buildings are examples of *properties*. The loss or protection of property can be valued by market price of the property, or relocation costs.

Infrastructure such as roads, railways, harbours, water and sewage pipes, electrical and telephone communication cables are generally valued with replacement costs.

Loss of *agricultural land* or production should be valued by market value of the land or the current value of foregone agricultural production. Also for agricultural land shadow prices have to be used (Defra 2000, Penning-Rowsell 1992).

Recreation at coastal sites is in most cases free. The tourists do not have to pay an entrance fee; in some cases a parking fee is charged. Recreation and tourism give an economic impulse to the (local) economy. The expenditures of the tourists (such as overnight stays, restaurant visits, purchase of goods and souvenirs) constitute a first estimate of the economic value of recreation.

Non-priced effects

For the valuation of non-priced or external effects no market prices exist, because goods and services are provided freely or are freely available as public goods. In coastal erosion and flooding, this is the case for most environmental and recreational assets but also of goods/direct effects such as Quality of life, Health, Habitats, Erosion and flood protection, Water nutrient regulation and indirect effects such as Social and employment impacts. Various direct or indirect methods can be used for a monetary valuation. Table 3.1 shows some examples of most commonly used methods to value effects.

In the absence of market prices, certain techniques can be used to evaluate effects of such non-market goods (Ruijgrok 1999, Brouwer 2003). They can be divided into:

- Methods, which investigate the *”willingness to pay”* of people for environmental changes or impacts. These include the Travel Cost Method (TCM), the Hedonic Price Method (HPM) and the Contingent Valuation Method (CVM)
- Methods, which estimate the costs of an *environmental impact* or the costs to restore environmental damage. These include the Production Factor Method (PFM), the Prevention Cost Method (PCM) and the Shadow Project Method (SPM).

The **Benefit transfer method** is a low cost approach worth mentioning. It provides rough estimates and is particularly useful in the feasibility stage. It uses the costs of goods or services from earlier made studies with similar characteristics from another location but with similar demographics as the current location.

The different methods are briefly summarised in Table 3.1 and Annex 2.

Table 3.1. Methods for economic valuation (Brouwer 2003, Ruijgrok 1999, Defra 2000)

Effects		**Method**							
		Market price	TCM	HPM	CVM	SPM	PFM	PCM	
Property	loss	X							
	change in prices			X					
Infrastructure		X				X		X	
Agriculture	reduced salination						X		
	loss of production	X*							
	loss of land	X*				X		X	
Tourism	No of visitors	X**	X						
	change in quality		X		X				
Environment	biodiversity					X			
	nature				X	X			
Social	reduced risk level				X				
	quality of life				X				
	cultural sites				X			X	

*corrected for subsidies and taxes
** e.g. entrance fee, and/or estimated expenditure by visitors

Environmental economists have identified different categories of environmental values, i.e. goods and services which are delivered by “nature” and which make up the total economic value (TEV) of the environment.

The TEV of a natural resource can be divided into (Table 3.2):
- **Use values:** they arise from the actual use and production. Normally, they can be measured by market prices and related means and are well accounted in decision making processes. They can be further divided into direct use values, indirect use values and option values.
- **Non-use values:** for these values no market prices exist because they are not traded. They are usually divided into and existence and values bequest values (for future generations) they can be a significant part of TEV.

Table 3.2. Valuation of Non-market goods Source: Nunes 2000 (see also Bower, 1998)

Total Economic Value	Use Value	Direct use value	Recreation, fishing, drinking water, timber Method: TCM, CVM, market price, benefit transfer
		Indirect use value	Climate regulation, flood protection, other regulational functions that support a healthy and productive environment Method: PFM, HPM
		Option Value	Insurance for having the asset on stand-by in the future resource, habitats, drugs Method: CVM
	Non-use Value	Bequest Value	Legacy benefits Habitat conversation for future generations Method: CVM
		Existence Value	Existence benefits Knowledge of existence of habitat, diversity Method: TCM, CVM

*the evaluation methods are described in Annex 2

In Annex 3 more detailed guidance to valuation of losses and benefits of erosion is presented.

3.1.3 Characteristics

Decision criteria

The objective is to obtain "best value for money" within the constraints of budgets and uncertainties. The aim is to maximise the benefit cost ratio (B/C), Net Present Value (NPV) or Internal Rate of Return (IRR) seeking to achieve a certain standard of protection, as set by the national authorities or evaluation initiator. B/C, NPV and IRR use the same basic data but the results are presented differently.

Both NPV and B/C tests require that costs and benefits be presented in terms of their value as of the time of the decision-making. This involves a two-step process. First, all costs and benefits must be expressed in constant monetary value (which effectively controls for future inflation). Then, a discount factor is used to reduce the values of future costs and benefits to represent their present values. The calculation is presented in section 3.1.4. The B/C is then calculated as a B/C-ratio, benefits divided by costs. The higher B/C-ratio the better. NPV is calculated as the difference between Benefits and costs. The higher positive NPV the better. By definition, any project with a positive NPV will also have a B/C ratio exceeding 1. However, a large project with lower B/C ratio (e.g., 1.5) may still have a higher NPV than a small project with a higher B/C (e.g., 1.7). For organisations with constrained funding resources, the B/C test is thus the preferred basis for decision-making among alternatives (such as the choice of project size, location or configuration). While in theory, any project with a B/C ratio exceeding 1 is worthwhile, most organisations have recognised that there is some uncertainty associated with both the benefit and the cost estimates. Accordingly, it is not uncommon for agencies to desire a threshold of B/C exceeding 1.5 for large new projects, and 1.3for incremental projects (in which uncertainty is less.)

Internal Rate of Return (IRR) is a version of Net Present Value (NPV) and is based on the same principles and the same calculation. NPV shows the value of a stream of future cash flows discounted back to the present by a discount rate that represents the minimum desired rate of return, often an organisations cost of capital. IRR, on the other hand, computes a break-even rate of return. It shows the discount rate below which an investment results in a positive NPV (and should be made) and above which an investment results in a negative NPV (and should be avoided). The break-even discount rate is the rate at which the value of cash outflows equals the value of cash inflows.

One additional thing to consider in the assessment of a project is the identification of who will gain from a project and who will suffer a negative impact. Only if we know "the winners, losers and payers", costs and benefits can be assigned or eventual compensation claims be granted to economic actors who suffer damage from the project, or the environment. From the public point of view, the basic idea is that all effects to everyone in society are summarised and that the alternative with the best total value wins. In some cases this may not be acceptable because some individuals, groups in society or environment suffer severely from the erosion effects. This may influence the decision-making process.

Data needed

As mentioned in Box 2-1 data collection is often the most time-consuming part of estimating cost and benefit. Data is needed for all of the effects and methods mentioned in Table 3.1 and 3.2. Additional example of data needed is shown in table 3.3

Table 3.3. Example of data needed.

	Quantification of effects	**Valuation of effects**
Economic effects		
• Damage to property	Number of houses (size) damaged, description of damage, when are houses abandoned and can they be restored/relocated?	Costs of restoration, relocation or market price in case the house will be abandoned. Change in market price
• Loss infrastructure	Number, length, area of roads, bridges, railways, cables, pipes etc. relocated or lost	Investment cost. If property lost the infrastructure may be obsolete.
• Loss of agricultural land	Hectare of land lost, lost annual production, for how long production is lost?	Sales price of production (corrected for subsidies and taxes)
Tourism		
• Change in tourism behaviour	Number of visitors and their activities Alternative activities	Willingness to pay. Expenditure in region from tourism
Ecological effects		
• Loss in biodiversity	Hectares of nature lost, specified for biotope, number of species etc.	Survey of willingness to pay and shadow project pricing
• Loss nature areas	Hectare of land lost	Survey of willingness to pay and shadow project pricing
Social effects		
• Reduced risk level	Risk analysis indicating reduced risk level for coastal zone hazards.	Survey of willingness to pay via Contingency valuation method
• Quality of life	Activities related to quality of life	Survey of willingness to pay via Contingency valuation method
• Culture sites	Size and description of site lost	Survey of willingness to pay via Contingency valuation method

The resource required to carry out the project assessment must be in balance with the seriousness of the problem and the size of the project. A feasibility study could be useful to judge the importance and required details for the full assessment. The relative cost of economic valuation of non-priced effects is shown in box 3-2.

Box 3-2
Magnitude of evaluation costs of assessing some streams of Benefits and Costs (Defra, 2000)

Benefit or Cost stream	**Relative cost of assessment***
Flood alleviation scheme	
- protecting residential & small commercial/industrial properties	x
- protecting agricultural land	xxx
- protecting large commercial/industrial properties	xx
Coastal defence scheme	
- protecting residential & small commercial/industrial properties	xx
- infrastructure	xx
Traffic disruption	xx
Recreation benefits	xxxx
Environmental assets: replacement cost method	xx
Environmental assets: evaluation of non-use value	xxxxx

*the more x, the greater the relative cost

Applicability and restrictions

CBA is applicable for assessment of all sorts of coastal erosion projects. It is the method of choice for a number of governmental agencies as it gives a monetary value to the projects. A monetary value is pretty easy to explain: “If we invest this amount of money we will gain this much!”

One weakness is that CBA is difficult to apply if effects are difficult to express in monetary terms. Applicability is restricted for projects whose justification is specifically improvement of ecological conditions, and projects that have large effects on ecological and socio-cultural circumstances. Although methods exist for valuing non-priced effects, their applicability is restricted due to methodological en practical drawbacks (see paragraph 3.1.3).

CBA disregards redistributional effects on welfare. A high NPV or B/C ratio may imply an undesirable situation in welfare redistribution. For example, where industry enjoy large production increases at the expense of the environment. Or where the population of the large and rich village A is protected from erosion at the expense of increased erosion in small and poor village B.

A common critic on the use of CBA is that decision-makers trust blindly on the numeric outcome of the analysis, whereas important social effects (such as environment, employment, and redistribution of welfare) are not or insufficiently captured in the NPV. The OEEI guideline on Cost-Benefit Analysis for infrastructural projects of the Dutch government therefore stresses the importance of a clear presentation of the outcome of a CBA. A comprehensive effect table in which the effects of all alternatives considered are quantified and, if possible, valued (see Chapter 2) should be part of the CBA report.

Criticism against CBA is sometimes raised regarding questions as if everything really can be monetized (attached a monetary value) and if it is reasonable to make trade-offs e.g. between the losses of one person and the gains of another. However it can also be argued that with a clear presentation of the assumptions behind and outcome of a CBA all factors are available and can be scrutinised and discussed (also with MCA). Other evaluation methods hide this kind of arbitration in verbal descriptions and different scales of measurement.

3.1.4 Method

While the CBA encompasses more than just the consideration of the economic returns of a project, most of project data on costs and benefits is provided by economic analysis. This analysis provides essential information on inputs and outputs, their prices and the overall timing structure of revenues and expenditures, benefits and costs. The economic analysis should be presented in a series of tables that collect the flows of investment, operating and maintenance costs and revenue and cash flow analysis of all effects for the time horizon selected (normally 100 years). These Economic tables are established for the different alternative options analysed (Inforegio, 2002).

The economic sustainability can be examined in the economic analysis tables. Similar B/C ratios and NPV's may show very different distributions of net annual benefits. In such a case an outline appraisal over a longer period is appropriate to take longer-term gains and losses into account (Defra, 2000).

In order to test the economic efficiency of the different options on a comparable basis, it is necessary to consider the influence of general inflation and change in prices and to discount all costs and benefits of the scheme to their present value.

In project analysis, it is customary to use constant prices, that is to say prices adjusted for inflation and fixed at a base-year. However, in the analysis of economic flows, current prices may be more appropriate; these are nominal prices effectively observed year by year. The effect of inflation, or rather the general increase in the price index, or oscillations in relative prices, may impact on the calculation. Therefore, the use of current prices is in general recommended. On the contrary, if constant prices are used, corrections must be entered for changes in the relative prices when these changes are significant. (Inforegio, 2002).

To discount economic flows to the present and to calculate Net Present Value (NPV) the suitable discount rate must be defined. The discount rate is the rate at which future values are discounted to the present. Usually considered roughly equal to the opportunity cost of capital. An example of calculation is shown in Box 3-3.

Box 3-3 **Calculation of Net Present Value**
1 Euro invested at an annual discount rate of 4% will be: 1+ 4%=1.04 after one year 1 · (1,04) (1,04)=1,0816 after two years 1 · (1,04) (1,04) (1,04)=1,124864 after three years, etc. The discounted economic value of 1 Euro that will be spent or earned is in two years is 1/1.0816= 0.924556 in three years 1/1,124864=0,886022

The key concept is that of the opportunity cost of capital i.e. the rate of return that could be obtained if investment was made for another purpose e.g. money in bank account. The discount rate should not be set to high since it reduces the impact of future costs and benefits. Authorities normally define the discount rate to be used.

The formula for calculating the present value (PV) if you know the future value (FV) with an discount rate (r) in year (n) is:

$$PV = FV / (1 + r)^n$$

The interest "discount rate" is sometimes also known as the "internal rate of return", the "equivalent rate of return", or "compound annual growth rate".

To compare the “do nothing” with the “do something” options, market values of properties are converted to their equivalent present values (PV), using the approximation:

$$PV = MV \cdot df$$

where *df* is the discount factor and *MV* is the market value (Defra 2000).

If without a scheme an asset would have been lost in year p, but the scheme delays the loss by s years, than the benefit of carrying out the scheme is the difference between the two PV figures (see Box 3-4, Defra approach), which represent the gain from s years of equivalent annual profit. It is also illustrated by an example, where a series of assets, each worth 100 would be lost between year 1 and 45, and a proposed scheme would delay each of these losses by 20 years.

Box 3-4
Calculating asset loss and benefit of the erosion protection scheme with illustrated example (Source: adapted from Defra 2000 - fcdpag3, Penning-Rowsell 1992)

Defra approach

PV(without scheme) $= MV\,(1 - 1/(1+r)^{p})$

PV(with scheme) $= MV\,(1 - 1/(1+r)^{p+s})$

Penning-Rowsell proposes direct calculations of benefits using an extension of life factor (ELF)

PV benefits $= MV\,(1/(1+r)^{p} - 1/(1+r)^{p+s})$
$= MV \cdot ELF$

Definitions
PV = present value
MV = market value
r = discount rate
p = year of loss without scheme
s = years of loss delay by scheme
ELF = Extension of life factors

This will provide the same result. However, Defra warns, because benefits are derived directly without explicit comparisons of “do something” and “do nothing” values. This can be confusing if several options are compared or flooding and coastal protection impacts are considered together.

Calculation example:

Formaterat

Asset losses and effects of proposed scheme (Extension of life: 20 years)

Market value	Year of loss		Without scheme		With scheme		PV benefit of scheme
	No scheme	With scheme	PV asset value	PV asset loss	PV asset value	PV asset loss	
100	1	21	5,7	94,3	70,6	29,4	64,9
100	5	25	25,3	74,7	76,7	23,3	51,4
100	10	30	44,2	55,85	82,6	17,4	38,4
100	20	40	68,8	31,2	90,3	9,7	21,5
100	35	55	87,0	13,0	95,9	4,1	8,9
100	45	65	92,7	7,3	97,7	2,3	5,0

3.1.5 More information

Theory

Guidelines for applying CBA are among others, available in Eijgenraam (2000), OEEI (2000), Defra (2000, 2003), Brouwer (2003), Inforegio (2002), Boardman (2001).

Documentation and guidelines are also available over the Internet (see References).

Practice: Hondsbossche Sea Dike

The Dutch authorities (Rijkswaterstaat) set up a project “Baten van water” (benefits of water) with the aim to consider in the decision process all social values of (water related) projects: all economic-financial values but also the ecological and the social-cultural values need to be identified and quantified.

As part of this projects the Vrije Universiteit van Amsterdam and the Resource Analysis, Delft carried out two case studies, one of them the evaluation of different approaches of ICZM at the Hondsbossche sea dike (IVM 2001).

In Annex 4 a summary of this study is provided as an example of an integrated assessment, including the following steps:

- definition of the project objectives taking into account the policy guidelines;
- data collection and choice of the alternatives;
- identification and valuation of economic, ecological and social-cultural effects;
- CBA (NPV, B/C ratio) and sensitivity testing;
- integrative assessment (MCA).

Practice: Preserving Texas coastal assets: Economic and Natural resources evaluation of erosion control projects

Background

Erosion along the Texas coast is a significant, long-term problem. Public resources to tackle this challenge are limited. Erosion control efforts must therefore seek to preserve the maximum value of coastal properties and natural assets for a given commitment of public resources (Oden et al. 2003).

To address the threat to valuable coastal areas, affected by natural and man-made damage, Texas State allocated $15 million for erosion control covering 2000/2001 and created local partnerships and participation in the funding of erosion projects under the Coastal Erosion Planning and Response Act (CEPRA http://www.glo.state.tx.us/coastal/erosion/cepra.html). The aim of this evaluation was to assess the efficiency of the initiatives undertaken in this period, i.e. to analyse the costs and economic and natural resource benefits of 23 projects.

Estimating costs and benefits

Estimating of costs was straightforward: investment and maintenance cost were used as provided by the Texas General Land Office. Design life horizon assumed was 20 years for projects with structural elements and 10 years for one-time measures like beach renourishment.

Two major classes of benefits generated from the projects were analysed:

(i) the economic benefits associated with mitigation or reversion of erosion and degradation of developed areas like beaches, shorelines and park lands (13 projects).
These include benefits such as public and private property protection (land and infrastructure), enhanced valuation of proximate residential properties and revenue benefits from recreational visitations.

(ii) the natural resource benefits that accrue when projects protect, restore or create wetland areas and other habitats (10 projects).
Here, the losses avoided are much harder to specify and many resource protection and environmental functions are difficult to translate into precise economic benefits due to severe data limitation and major variations between wetland sites and zones. The literature on wetland valuation offers a wide array of estimating methodologies that yield highly diverse estimates (Barbier et al. 1997).
In this study a full cost-benefit analysis was not carried out because no data were available on the indirect values and non-use values of the sites. It was decided to use a qualitative assessment method to evaluate the 10 projects: the "Army Corps of Engineers" Wetland Evaluation Technique WET (Adamus et al., 1987). The qualitative evaluation of the projects focuses on three elements: cost of the project, wetland acreage restored, protected or created and the environmental values and functions of each site like groundwater recharge, biodiversity, sediment stabilisation, heritage etc.

A summary of the study is presented in Annex 5.

3.2 Cost-effectiveness Analysis (CEA)

3.2.1 Introduction

Cost-Effectiveness Analysis (CEA) is a technique for selecting among competitive wants wherever resources are limited. There are many similarities between CEA and CBA therefore much of what is mention in chapter 3.1 also applies for CEA. Cost-effectiveness analysis is often seen as an alternative to Cost-Benefit Analysis. CEA is most useful when constraints prevent a full CBA to be conducted. The most common constraint is the inability or unwillingness to monetize benefits.

3.2.2 Characteristics

Decision criteria

CEA measures costs in common monetary value and effectiveness in physical units. Since the effectiveness measurements are difficult to add or subtract to an aggregated measurement one can determine the:

- Least cost to achieve a present goal,
- CE ratio as C/E (e.g. amount of € spent per meter of protected shoreline) or
- EC ratio as E/C (e.g. meter of protected shoreline per expenditure in €).

CEA does not say whether a given option is intrinsically worthwhile merely whether the option is better than some other option.

There is also a possibility to reach halfway between CBA and CEA by computing an *adjusted CE ratio* = (social costs - other social benefits)/effectiveness. This approach includes benefits of effects that would otherwise have been omitted. By using this approach benefits that are relatively large and/or easy to value can be incorporated in the analysis, thus increasing the creditability of the valuation.

Data needed

Valuation of effectiveness involves deciding on a way of measuring the effectiveness. Examples of effectiveness measurement are saved lives, saved lives of specific specie, protected length of shoreline. It is important to distinguish between the outputs of a project and effectiveness of a project. Effectiveness should compare the output of a project against the objectives specified for the project.

Applicability and restrictions

CEA is appropriate in cases where the main, benefits cannot be quantified in monetary terms and where the project is less complex and where the number of alternatives is limited. Examples where CEA is applied include the comparison of different methods to improve environmental quality or medical and health service projects.

One restriction with CEA is that it only measures on one effectiveness measure whereas there might exist side/secondary omitted impacts e.g. the effectiveness measure is number of saved lives but a side-effect is a decreased number of injured as well. Then this "side-effect" is not included in the analysis.

3.2.3 Method

The stages of project definition, identification and valuation of cost and discounted cash flow analysis are similar to a CBA. An appropriate measure of effectiveness must be identified, close as possible to the objective of the project. As in CBA, a sensitivity analysis will be required.

3.2.4 More information

Theory

Boardman (2001), Levin (2000).
Documentation and guidelines are also available on the Internet (see References).

Practice

Most examples of Cost-Effectiveness Analysis are from the health-sector.

3.3 Multi-Criteria Analysis (MCA)

3.3.1 Introduction

Comparison of alternatives is an essential part of the decision making process. However, in the case of large, infrastructural projects, the information is mostly heterogeneous, many impacts cannot be measured in monetary terms and many actors (stakeholders) have competing and conflicting objectives. Multi-criteria analysis (MCA) is an approach for choosing from a set of alternatives in such complex, multiple objective situations and to incorporate all social, economical and ecological costs and benefits, measured on different measurement scales, monetary and not monetary, quantitative and not quantitative

Whereas CBA and CEA use economic efficiency criteria (NPV, BCR) in the assessment of projects, MCA adds other types of criteria like equity and ecological and distributional aspects.

Increased public participation in the decision making process has created the need to communicate large amounts of information in a transparent and understandable way. By integration of the opinion of stakeholders and by incorporation all the economic, social and ecological aspects of a policy or project, MCA can make the decision process more transparent and the information more manageable for all stakeholders. MCA is also a well-established decision tool in Environmental Impact Assessment, to compare alternatives (Janssen, 2001).

3.3.2 Characteristics

Decision criteria

MCA uses weighted sums of the standardised economical, ecological and social criteria to structure and visualise the ranking of project alternatives.

The result of a multi-criteria analysis is presented in a effect table (sometimes called *performance matrix* or *consequence table)* as shown in table 2.1, in which each row describes an option and each column describes the performance of the options against each criterion. The individual performance assessments are often numerical, but may also be expressed as icons, or colour coding. The criteria can be measured in cardinal numbers (price, number of drawbacks), some in binary terms (a tick indicates presence of a particular feature), and one in qualitative terms.

In a basic form of MCA this effects table may be the final product of the analysis. Then the decision makers are left with the task of assessing the extent to which their objectives are met by the entries in the matrix. Such an intuitive processing of the data can be speedy and effective, but it may also lead to the use of unjustified subjective assumptions, causing incorrect ranking of options. In analytically more sophisticated MCA techniques the information in the basic matrix is converted into consistent numerical values and graphs using different computer software.

Qualifying effects

MCA requires a thorough mapping of effects as outlined in Chapter 2.2. For the valuation the techniques commonly apply numerical analysis to an effect table in two stages:

1. **Scoring**: the expected consequences of each option are assigned a numerical score on a strength of preference scale for each option for each criterion. More preferred options score higher on the scale, and less preferred options score lower. In practice, scales extending from 0 to 100 are often used, where 0 represents a real or hypothetical least preferred option, and 100 is associated with a real or hypothetical most preferred option. All options considered in the MCA would then fall between 0 and 100.

2. **Weighting**: numerical weights are assigned to define, for each criterion, the relative valuations of a shift between the top and bottom of the chosen scale.

Mathematical routines, which may be implemented into computer software, then combine these components to give an overall assessment of each option being appraised. The software's used can use approaches for *compensatory MCA techniques, mutual independence of preferences* and *outranking methods.*

Applicability and restrictions

All choice processes have a subjective character. Thus, the MCA cannot objectively define a best alternative, and it, cannot replace but support judgement.

An MCA created for a project is based on the specific conditions of that project. This makes the scores obtained for one project not comparable with another project. This makes MCA difficult to use for selection among projects.

A MCA does not give a value that says if a project is worth doing or not as a CBA does. Instead it compares alternatives of a project in the same way as a CEA does.

Some of the arguments mentioned for MCA also apply to CBA and CEA. It is of great importance how the whole assessment process is carried out. CBA and CEA can often be seen as very technical as you need to do extensive economic valuation to reach to the exact and correct value (you also need to be an expert to do this) whereas with MCA almost anyone can participate and have a point of view about what is the appropriate ranking and weighting.

3.3.3 Method

Problem definition (described in Chapter 2) involves the collection of all relevant information, the generation of a complete list of alternatives and the selection and definition of the criteria to evaluate the alternatives, i.e. the effects or indicators which are relevant for the decision and which represent and reflect the requests and conflicting objectives from all interested parties. The criteria to evaluate the alternatives may be measured on different measurement scales and are normally grouped into three main objectives: to maximise economic benefits, to maximise environmental benefits, and to maximise social benefits.

Scores can be assessed in many ways such as tests and simulation models, direct measurements and expert judgement. The impact of the criteria can be measured on a quantitative scale (ratio, interval or monetary) or on a qualitative scale such as ordinal, +++/--- (useful for expert judgement) or binary.

GIS information systems play an increasingly important role and can be included into MCA as well (Herwijnen, 1999).

The result of the problem definition step is the "effect table", i.e. a matrix of the alternatives and the scored criteria, an example is shown in paragraph 2.2.3.

Analysis work

The purpose of MCA is to derive at a ranking of the alternatives. To do this the scores must be standardised to make them comparable and they must be weighted to determine the relative importance.
There are several ways to standardise the impacts of the different criteria to a common dimension or dimensionless unit:

- Maximum standardisation: scaling the performance according the relative distance between zero and the maximum performance (between 0 and 1).
- Interval standardisation: scaling according the relative position on the interval between the lowest and highest performance.
- Goal standardisation: specify a goal value and a worst value and scale the scores between these two values.

The standardisation relations can be linear or non-linear (value functions).

Weights for each of the criteria can be attributed by experts based on accepted knowledge or by politicians on the basis of policy priorities. Weights can be set by direct assessment or by the use of pair wise comparison or to provide an ordinal ranking of importance. This weighting step is criticised as subjective, to be prone to manipulation and to pretend a false sense of accuracy. However, this is only true if the choices are not made explicit and if not all interested parties are properly involved. Proponents claim that MCA provides a systematic and transparent approach that increases objectivity, includes all relevant aspects and generates results that can be reproduced (Janssen, 2001).

There are many methods available to transform the performance scores and the weights to a ranking of the alternatives. The most popular is “weighted summation”: the weights and the standardised scores are multiplied and a linear function is used to calculate the weighted average of the standardised scores. Other methods are Evamix, Electre2, the Analytical Hierarchy Process (AHP) and the Regime Method (for a description see Janssen and Munda, 1999).

Sensitivity Analysis

The next vital step of MCA is to assess the robustness of the ranking to uncertainties of scores and weights. This is done by varying weights and scores individually or by using a more extensive Monte Carlo Analysis and investigating how the ranking of the alternatives change.

Reporting

Finally, the results have to be reported to all relevant stakeholders. The stakeholders have different expertise and different interests and it is recommended to present the extended and complex information in graphical form. MCA support the discussions since MCA can couple the available information on the political priorities or individual interests and translate them into the ranking of alternatives.

3.3.4 More information

Theory

More information is given by for instance Bonte (1997), Herwijnen (2003), Herwijnen (2004) and Janssen (2001)

Software for MCA

A number of software tools are available to conduct MCA and to support effectively decision making with multiple objectives but also discussions and negotiations between stakeholders.

MCA software tools can be divided into 4 groups of problems:

1. To structure discrete choice problems, i.e. where the cause-effect relationship is unknown, the evaluation criteria are not specified and the alternative are not well defined.
2. To evaluate structured discrete choice problems with one single set of information.
3. To synthesise evaluation input of more than one user and to support discussions in stakeholder sessions.
4. To integrate GIS information.

A list of MCA software is shown in Box 3-5.

Box 3-5
MCA Software (Herwijnen, 2003)

1. Problem structuring for discrete choice problems	
- Decision Explorer 3.2	Qualitative data analysis, linking concepts www.banxia.com
- MindManager 4.0	To structure complex situations, graphical visualisation www.mind-map.com
2. Discrete choice problems	
- Criterium DecisionPlus 3.0	Value function model based on trade-off analysis www.infoharvest.com
- Definite 3.1	Multi-attribute value functions, including options for imprecise preference information cost-benefit analysis www.bosda-definite.nl
- HIPRE	www.hipre.hut.fi
- Hiview	www.enterprise-lse.co.uk
- Logical Decisions 5.1	www.logicaldecisions.com
- VISA	www.simul8.com/visa.htm
3. Discrete group choice problems	
- Team Expert Choice	Pair wise comparisons www.expertchoice.com
- VISA	
- HIPRE	
4. Discrete spatial choice problems	
- Idrisi 3.1	A GIS that includes several decision support procedures www.clarklabs.org
- EMDS	Decision support, combining ArcGIS, NetWeaver and Criterium DecisionPlus www.fsl.orst.edu/emds
5. Multi-Criteria Methods	
- Maut	multiattribute utility theory
- Electre	www.lamsade.dauphine.fr/english/ software.html
- Regime	
- Naiade	http://alba.jrc.it/ulysses/voyage-home/naiade/naisoft.htm
- AHP	Analytic Hierarchy Process

Note: examples of software that can be used for MCA
Other listings of MCA software can be found in Belton (2002) and at www.lionhrtpub.com/orms/surveys/das/das.html

Practice: Hondsbossche Sea Dike

As mentioned in Chapter 3.1.5, the potential problems at Hondsbossche Sea Dike were recently evaluated. Three options were investigated – Hold the line, Move seaward and Move landward. An effect table was established and the project was evaluated both with a CBA and a MCA. The results of both the CBA and the MCA indicate that the option to Move landward is the most favourable. A good overview of the effects and their valuation is available from the presented effect and evaluation tables. For further reading see Annex 4.

Practice: Flooding study Maas

The flooding study of the Maas river was evaluated with MCA. The effect table established is shown in Paragraph 2.2.3 Table 2.1. This effect table outlines direct and indirect effects as well as effects on current and future usage. In multi-criteria analyses effect scores can be standardised, that is converted into a score between 0 and 1. Different standardisation methods exits. The following table 3.4 gives an example for this.

Table 3.4. Example of an Effect table: Flooding study Maas (adapted from Brouwer 2003)

	Doing nothing	Dike improve-ment	Concentration without retention (1)	Concentration with retention	Network with widening of river forebed	Network with 'green rivers'(2)	Mozaïek
Cost	1.00	0.95	0.00	0.01	0.36	0.61	0.22
Nature	0.00	0.00	1.00	0.86	0.26	0.19	0.60
Landscape	0.50	0.50	0.00	0.00	1.00	1.00	0.00
Houses	1.00	1.00	0.00	0.00	0.86	0.97	0.33
Agriculture	1.00	1.00	0.00	0.01	0.81	0.93	0.33
Recreation	1.00	1.00	0.13	0.38	0.86	0.88	0.00
Enterprises	1.00	1.00	0.00	0.02	0.71	0.90	0.26
Sand extraction	0.00	0.00	1.00	0.99	0.35	0.28	0.34

1) Concentration without retention (=large area where water can be retained in case of high water level)
2) Network with 'green rivers' (= creation of river that only inundates in case of high water level)
Standardised effect score from effect table

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ANNEX 1 COASTAL EROSION

The value of the coastal zone

Coastal areas perform several important economical, ecological and social functions. Over the past 50 years, the population living in European coastal municipalities has more than doubled to 70 million people (16% of the EU population). Coastal habitats are valuable for fauna and flora biodiversity. Dunes and wetlands provide flood control, drinking water and waste assimilation, and beaches are an essential asset for tourism and recreation. The estimated total value of economic assets is as high as €500 to €1000 billion (EU Commission 2004).

A study, carried out by Firn Crichton Roberts and the University of Strathclyde (2000), assessed the socio-economic benefits generated through the adoption of Integrated Coastal Zone Management (ICZM) of 21 demonstration projects in Europe (Box A1-1). The total annual value of the benefits of these zones exceeds 18 billion €, making coastal zones the most valuable areas within the European Union.

Box A1-1

The value of coastal zones (Firn Crichton Roberts, 2000)

Looking at 21 locally defined ICZM initiatives (covering 5,8% of the entire European coastal zone) and using the environmental valuation approach (Constanza et.al. 1997), the market and non-market values of these areas can be calculated and extrapolated to the total European coastal zone.

- The costs investigated included: R&D costs, management and promotion costs and capital investment.
- Benefits were defined as: Habitat protection, Infrastructure, Business and Tourism benefits.
- The annual estimated cost/benefit values (million €) of Europe's coastal were:

	Costs (million €/year)	Benefits (million €/year)		
		Ind.&Tourism	Habitat	Total
Low level estimate	10,2	47,8	89,5	137,3
High level estimate	87,1	478,5	268,5	746,9

The study concluded:

- the value of benefits outweigh the costs, by 13,6:1 and 8,6:1 respectively.
- some countries benefit more from "habitat" (Scandinavia), the main industrial countries more from "tourism/business" activities. Even without the non-market values of the environment, the initiatives are profitable.

The study gives indications for direction of management.

It would be interesting to carry out a similar exercise for specific erosion initiatives to motivate decision makers to consider erosion not as an ad hoc problem but as a general issue.

Causes of coastal erosion
The coastline is a complex series of interlinked physical systems, comprising both offshore and onshore processes. Coastal erosion is one of these physical processes, wearing away and redistributing shoreline body and sediment, normally by an instance of natural forces like waves, tidal and littoral currents or deflation. These sediments together with the sediments from inland erosion delivered by rivers are redistributed along the coast and provide the material for dunes, beaches, marshes and reefs.

Waves and currents move sediment around the coast in two directions: long-shore and cross-shore. The result is the balance of gradual destruction of land by sea in one location and possible accretion in another site (Eurosion, 2004).

Erosion is influenced by both natural factors and human activities with different time and space patterns and also different in nature: continuous or incidental, reversible or irreversible.

Natural factors contributing to erosion include sediment transport, changes in sea level, geological characteristics, land subsidence and sand sharing systems of beaches and dunes as well as effects of currents, slope processes, wind, waves and tides. According to the scenarios from the International Panel of Climate Change (IPCC), sea levels in Europe will rise by 20-100 cm over the next 80 years and storm frequencies will increase, both intensifying erosion and flooding impacts.

Not only human influence, particularly urbanisation and economic activities in the coastal zone but also measures to protect assets against erosion and flooding have a significant effect on natural coastal systems. Coastal erosion induced by human activities have now surpassed in Europe erosion driven by natural factors (Eurosion, 2004).

Human activities which can alter natural processes include sand and gas mining (subsidence), dredging of tidal entrances, port constructions and marine traffic, construction of jetties and groins, vegetation clearing and land reclamation, hardening of shore line and river damming, beach nourishment and sand mining. Engineering structures build to protect the shoreline in one location may cause down drift erosion impacts or can be undermined by ongoing erosion. **(**Heinz Center 2000, Eurosion 2004).

Impacts of coastal erosion
Through the loss of land – in Europe estimated as 15 km^2 per year (Eurosion, 2004) **-** erosion directly or indirectly affects important functions of the coastal zone. Furthermore, erosion may lead to increased risk on flooding, inundation and the intrusion of saltwater that in turn also lead to damage of land use.

Impacts arising from erosion can be distinguished in three main groups: economic impacts, environmental impacts and social-cultural impacts. (Table A1.1):

Table A1.1 - Impacts of coastal erosion (Source: EU Commission 2004, IVM 2001, Eurosion 2004, Penning-Rowsell 1992)

Economical impacts	Ecological impacts	Social-cultural impacts
Loss of property, value - residential, commercial, industrial Loss of infrastructure - integral to the coast - roads, power, water lines, bridges etc. - transport, services interruptions - water, energy generation Loss of land or land value - agricultural - aquaculture - open space land Loss of income from recreation and tourism Loss of artificial and natural sea defence, protection Damage to ports, marine transport, ship building	Loss or damage of ecological functions: - natural storm buffering, protection against erosion, surges/flooding, salt water intrusion - habitat for plant and animal species - waste treatment, nutrient cycling, water filtration - climate control - loss of geological, hydrological important sites	Risk to human life, health (flooding) Loss of safety feeling, psychological stress Loss of cultural heritage, historical landscape and sites of scientific importance (SSI, SCI) Unemployment and loss of social structures

Flooding impacts are similar, and the damage scale can even be much greater. However, the nature of the damage is different. Flooding is a temporary phenomenon and damaged property or agricultural production may be re-established within a few months. In case of erosion, there is speaking of irreplaceable loss. Another main difference is the scale. Whereas erosion tends to affect a limited piece of land in a long time period, flooding inundates large areas within short notice leading in addition to loss of life and health impacts.

Coastal erosion in the EU

Natural processes of coastal erosion and accretion have shaped the European coastline throughout history. However, as the Eurosion study (Eurosion 2004) has indicated, the current scale of erosion in Europe is mostly induced by human coastal activities that have turned the natural phenomena into a problem of growing intensity. Given the predictions for climate change, we can assume that erosion and flood risks will increase. Europe's 132 000 km² of coastal land are under growing threat from erosion (Table A1.2): approximately 20-25% of the 100 000 km coastline is severely affected despite protective measures, with coastlines retreating by between 0,5 to 2 meters per year, in some cases even by up to 15 meters.

Table A1.2 - Coastal erosion trends in Europe (Source: EU Commission, 2004)

EU coast line: 100925 km:	
Naturally stable (without protection)	39 %
Artificially stabilised	5 %
Eroding and unprotected	12 %
Eroding in spite of protection	3 %
Accreting	14 %
No information or not applicable (e.g. harbours, estuaries)	27 %

The effects of coastal erosion differ across Europe depending on the geological and hydrological conditions, as Figure A.1 shows. High percentages of eroding coastline around 25% can be seen in countries with sandy beaches.

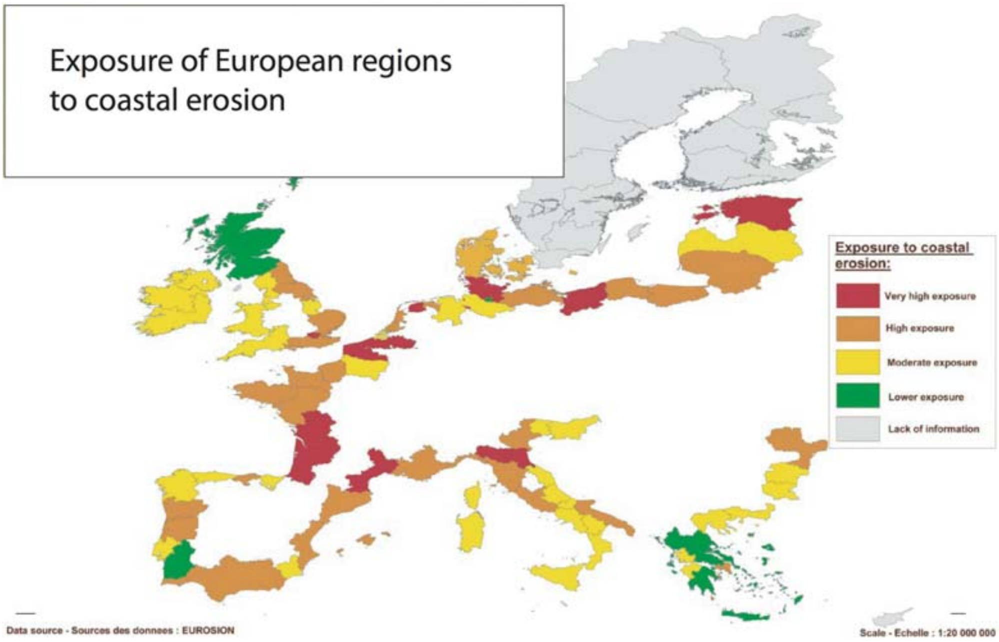

Figure A.1: Exposure of EU regions to coastal erosion (EU Commission 2004)

Natural causes coupled with rapid urbanisation and hard coastal protection constructions accelerate erosion processes, particularly in the Mediterranean countries and Belgium, (Eurosion, 2004).

Measures to combat coastal erosion

To fight erosion, public expenditures are constantly increasing: in 2001 they amounted to an estimated €3.1 billion, compared to €2.5 billion in 1986, and given the current trend, may reach €5.4 billion in 2020 (European Commission 2004a).

It seems that there is still ample room to improve the battle against erosion: Table A1.3 summarises the results of a study analysing the efficiency of different protection measures at over 60 European pilot sites (Eurosion 2004):

- The results are disappointing. In previous years, many hard structures were built along European coasts, and still 70% of erosion measures are hard defence. Such a "hard coast" has not the room to let natural processes react and mitigate erosion and has no or only a limited natural adaptation capacity.
- Thus, most of these measures had not the expected effect to stop erosion, but merely displaced the problem: Seawalls and revetments protect the local site where they are built but also induce backwash effects which transfer the erosion problem up drift. Similarly, groins and breakwaters influence the long shore sediment flow and relocate the erosion problem down drift.

Table A1.3 - Assessment of coastal protection measures Europe

Pilot site (country)	Technical measure	Impacts	Costs
Poland	Hard	Inefficient	High
Netherlands	Soft (Hard)	Appropriate, effective Unpredictable	High
United Kingdom	Hard Soft	Appropriate, effective	High to Medium
France	Hard Soft	Erosion down drift, partially effective	Medium
Portugal	Hard	Erosion drown drift Artificial coast	High
Spain	Hard Some soft	Inefficient	High
Italy	Hard Soft	Erosion drown drift, artificial coast, ineffective	High
Cyprus	Hard	Inefficient	High
Romania	Hard	Erosion drown drift	Low

Source: Eurosion 2004

Costs and effects of hard measures are now studied more thoroughly and applied more critically and results tend to favour soft measures like beach nourishment. Also a change in policy, for example towards "managed realignment" options can be observed.

The Eurosion study proposes a number of approaches for sustainable measures for erosion protection and coastal zone management:

- To reduce the effect of sediment blocking by removing the obstacles, i.e. jetties, seawalls, breakwaters and to fill up the lack of sediment by nourishment
- To combine soft measure of under water nourishment and beach nourishment
- To review the policy (do nothing, hold the line, managed realignment), risks and land use plans in view of the available budget and a move away from "protect at all costs".
- To promote natural processes and to rehabilitation of the coastal zone like Dutch plans of breaches in fore dunes and drifting dunes for more natural fluctuations.
- To investigate improved hard protection measures like semi-buried or submerged breakwaters, geo textile revetment and the combination of structure with low environmental impact (like semi-buried breakwaters) and periodic nourishment.

The need for more efficient management of coastal protection is also demonstrated by the Defra study in the UK (Box A1-2). The seize of the estimated annual damage costs of 14-20 million pounds due to erosion and of 100 million pounds due to flooding, the expected increase of damage due to climate change by the factor 3-9 in the next 50 to 80 years (see Box A1-3) and the required annual protection and defence costs of 300-400 million pounds ask for effective targeting of the investment and maintenance capital. This requires also a review of the current decision and coastal management procedures, for example a promotion of participatory processes to increase transparency and social acceptability and the internalising of erosion costs and risks into the planning and investment decisions.

Box A1-2

Overall protection and defence needs in the UK (Defra 2004, NADNAC, www.defra.gov.uk)

To assess future funding requirements, Defra estimated (on a high scale level) the costs and benefits associated with investment in flood and coastal defence infrastructure in England. As alternatives, a "Do nothing" option, several maintenance options and an "Improvement" option were considered.

Around 1,940 billion of residential and commercial properties and 1,46 hectare of agricultural land are at risk of flooding and erosion. 4-5 million people are affected. The capital values of assets at risk are about 244 billion UK pounds, 7,5 of which due to erosion.

Market price related values of residential and commercial property was considered as well as of agricultural land. "Flat rates" were included for human related impacts like health and stress (200 UK pounds per household and year) and recreational, environmental and other benefits connected with coast protection (200 UK pounds per household and year). Impacts on transport and infrastructure were considered to be low and are not included. Protection for the Natura 2000 statute sites was taken into account as well as eventual replacement costs of compensatory habitat. The following tables summarize the key data:

Flood defence costs and damages (billion pounds, Present value, 100 years)

	Do Nothing	Maintain	Improve
Flood Defence Cost	0	3,1	7,9
Damage Cost	82,7	35,2	22,1
Total Cost	82,7	38,3	30,0

Erosion protection costs and damages (billion pounds, Present value, 100 years)

Do Nothing	Maintain existing	Improve, maintain >1	
Erosion Protection Cost	0	2,9	1,2
Damage Cost	2,5	0,6	0,7
Total Cost	2,5	3,5	1,9
No houses lost x1000	92	22	28

Do Nothing: stop maintenance and active intervention
Maintain: maintain, replace existing defence regardless of BCR
Improve, maintain >1: maintain, and provide new defence if BCR>1
Improve: maintain, replace defence, provide new defence to undefended areas

In order to demonstrate the robustness of the proposed investments the benefit to cost ratio has been calculated: for flood defence in an "improve to higher standard" scenario the ratio is in average 7,7:1, the comparable ratio for coastal protection is (only) 1,5:1:

	Costs (billion pounds)	Benefit (billion pounds)	B/C ratio
Flood Defence	7,9	60,6	7,7
Erosion protection	1,2	1,8	1,5

The study demonstrates the need for effective targeting and prioritisation of both investment and maintenance capital to avoid unnecessary expenditure. Also an increased demand of spending can be expected, given an increasing development pressure and the risks associated with climate change.

Indications of annual investment requirements can be obtained by dividing the 100-year PV by the sum of discount factors (29,8 for current discount rates) and are estimated as 370 million pounds. The Foresight study (see below) suggests considerable higher levels of investment in the longer term as a result of climate and socio-economic changes.

The study did not assess different solutions and therefore could not quantify all potential impacts and benefits like water quality, biodiversity and recreational benefits. These are thought unlikely to have a significant impact on overall investment requirements, but may be important at local and more detailed levels of appraisal.

Box A1-3

Evaluation of erosion hazards at U.S. coastlines (The Heinz Center (2000) Evaluation of erosion hazards www.fema.gov/pdf/library/erosion.pdf)

1. Objective

Current and prospective property owners at the coast are not informed of erosion risks and insurance rates do not reflect the magnitude of risks. The US Congress debated erosion management legislation during the early 1990s and requested 1994 an analysis of possible policy changes to address erosion hazards within federal programs. The goal of the study, carried out by the Heinz Center, was

- to improve the understanding of erosion impacts on coastal communities and how erosion is managed
- to analyze the economic impacts of erosion and to evaluate policy options to reduce erosion losses

2. Methodology

The study was conducted in 3 phases: in phase 1, the Federal Emergency Management Agency and State agencies produced maps for 27 counties along the US coast including projections of how far inland the coast line may erode over the next 60 years.
The Heinz Center conducted phases 2 and 3, which included a representative field survey of over 10 000 structures within the 60-year projected erosion hazard zones in 18 of the 27 counties throughout the entire length of the mapped coastline and an analysis of the erosion related damage. Current management procedures and policy options were studied to address that damage.

3. The economic impact

The study concluded, that over the next 60 years, 25% of the 340 000 houses within 500 feet of the shoreline may be lost due to erosion. The impact may be even worse if coastal development continues unabated and if sea level rises as predicted.
Coastal property values within the 60 year erosion hazard zone are reduced by \$3,3 – 4,8 billion.
Over the next decades, approx. 1500 homes with the connected land will be lost to erosion each year, costing the coastal property owners some \$530 million per year, the communities \$410 million and the Flood insurance programme some \$ 80 million annual payout.
As coastal erosion makes coastal protection and defence as well as ecosystems more vulnerable to storms and sea level rise, i.e. the risk is expected to increase in the future.

4. Recommendations

The study recommended the Congress to direct the Federal Emergency Agency to develop erosion and flooding hazard maps to make property owners and investors aware of potential erosion risks. It was also recommended to internalize the costs of expected erosion losses into the insurance rates.
The study presented also several additional federal policy options such as requiring building zone set backs, setting more severe building standards and providing relocation help or buy outs.

5. Lessons learned

The dynamic nature of the shoreline makes it difficult to assess accurately risk and vulnerability of a community. As a respond to erosion hazards, shoreline protection projects are built and financed by the public sector. The study shows the importance of proper information and communication between all stakeholders.
The cost of mapping for 12,500 miles of the U.S. coastlines was estimated as \$44 million. The awareness of the hazards will influence the future coastal development and reduce future losses, particularly if the future external costs are internalized for example into mandatory insurance rates. This could also put some critical light on alternative federal investment expenditure and their cost-effectiveness. The spending of an equivalent amount on coast nourishment would protect roughly 10 mile of shoreline (assuming a 10 year life of the maps).

ANNEX 2 METHODS FOR VALUATION OF EFFECTS

For more detailed descriptions and literature references see: Brouwer 2003, Defra 2000, Penning-Rowell 1992, Ruijgrok 1999.

Travel Cost Method (TCM): it is assumed that the costs in terms of time and transportation that an individual incurs in visiting a site reflect the person's value of that site. TCM is a useful method to assess recreational benefits. Travel costs are related to distance and can only capture part of the total value of nature (recreation). Whereas TCM is a frequently used method in US to estimate recreational values, this method is not considered reliable under UK conditions, with too many comparable sites and too many site unspecific reasons to visit the coast (Defra 2000, Penning-Rowell 1992).

Hedonic Price Method (HPM): values for an environmental goods or service are estimated from market prices of close substitutes like house prices or wages. Environmental impacts like air pollution and noise will influence (reduce) the house prices or the willingness to accept less paid positions. HPM can also be used to gain information about health costs and the value of human life (willingness to pay for reducing a health risk).

Contingent Valuation Method (CVM): this is the most widely used method. People are asked the maximum amount of money they are willing to pay (or willing to accept as a compensation) for a hypothetic change of a natural good or in environmental quality. Beside the representative ness of the sample, the structure of the question, the cause for the payment and the payment vehicle are important to avoid bias. Only the Contingent Valuation method can capture both use and non-use values, however, the surveys have to be carefully designed. Practical examples of the application of CVM are shown in Box A2-1 and A2-2. Without considering all tangible and intangible effects it would have been difficult to prove the economic viability of the projects.

Production Factor Method (PFM): observed market prices of environmental goods or service with an established market (like fishery, agriculture, water production) are used to value a proposed or observed environmental change, mostly referring to the change in productivity. Non-use benefits are excluded.

Prevention Cost Method (PCM): this method measures the minimum cost of preventing or rectifying the environmental damage and the cost of replacing environmental services. Generally, a cost-effectiveness analysis carried out to define the lowest costs to achieve a defined objective (abatement costs). Non-use benefits are excluded.

Shadow Project Method (SPM): defines costs to compensate environmental effects of the original project. These costs (Mitigation costs) have to be added to the original project costs.

Box A2-1

S. Erasmo, Venice (Alberini, A., Rosato, P. 2004)

In this case, CVM is applied to assess the willingness to pay (WTP) to protect the island from erosion.

S. Erasmo is the largest island in the Venice Lagoon and suffers from coastal erosion problems, degraded environmental quality and causing lack of infrastructure and services. A Contingent valuation study (CVM) was carried out between residents of the Veneto region to investigate their willingness to pay (WTP) for a public programme to improve environmental quality. The respondents were told about a hypothetical public programme that would restore beaches, implement erosion control and improve infrastructure on the island.

The Venice Lagoon System law covers high tides, storms, erosion and pollution and states that protection of the Lagoon is of "pre-eminent national interest". The statute does not require considering costs and benefits in selection of measures and the wisdom of expensive public works on scarcely populated islands is questioned.

In the case of S. Erasmo, the cost of public works is estimated € 40 million and the resident population is only 800. This underlines the importance to estimate all tangible and intangible benefits associated with such an initiative.

CVM was used as this methods captures both use and non-use values. For Hedonic pricing the number and transfer frequency of property are too small. Travel cost methods would be suitable, but only capture recreation (use values).

Use and non-use components like recreation, education and option values were identified and mean and median WTP calculated.

The study indicated that people of the Veneto region are willing to pay a mean of € 66 per household, whereas the median - a robust lower bound - was roughly € 20.

Total benefits accruing to the residents of the Veneto region (some 1,7 million) from the programme range between € 41 million and € 107 million, both exceeding the costs of the programme.

Box A2-2
Contingent valuation of beach replenishment at Caister-on-Sea Study (Bateman,I.J., Klein, R.J.T., Langford, I.H. 2001)

Caister-on-Sea is located on the Norfolk coast (UK) in an area prone to erosion. Over time, much of the sand at Caister beach was washed away to the point that the beach became entirely covered at high tide, leaving the sea wall exposed and vulnerable. Following the appraisal of a wide range of options, it was finally proposed to construct 4 rock bunds 200 yards offshore, which would reduce coastal wave power allowing sand to accrete and would create together with some beach nourishment an extended beach in front of the seawall.
To contribute to the cost benefit analysis of the project, a contingent valuation study (CV) was undertaken to assess the net benefits of the recreational attributes. In the CV, the respondents are asked for their WTP to secure a welfare gain from the project. The CV method seemed more appropriate than some other monetary valuation methods as it was intended to estimate benefits associated with the future rather than with the present condition of the beach.
The set up of the study, selection of the samples and the design of the questions are discussed in detail. A summary of the results is presented in the following table, showing the mean WTP and aggregate recreational net benefit of the beach extension scheme:

WTP: Pounds/household/year		Net Benefit: Pounds/year
Holiday makers	31,62	641 287
Residents	25,84	100 230
Total		741 517

The total recreational benefit of just under 750 000 pounds per annum of the beach extension is substantial, sufficient to change the benefit-cost ratio, when benefits are simply base upon avoided costs of flooding.

An additional simple, low cost approach should be mentioned, which provides rough estimates and is particularly useful in the feasibility stage is the **Benefit transfer method**. It uses the costs of goods or services from earlier made studies with similar characteristics from another location but with similar demographics to the current location. Box A2-3 indicates values of a number of examples.

Box A2-3
Benefit transfer, based on 30 meta-studies of aquatic and wetland systems in the US and EU (Brouwer 2003)

Benefit transfer	Average economic value €/household/year
Wetland	22
River	45
Reduction flooding risk (absorption)	55
Biodiversity and Habitat	45
Water quality (absorption nutrients)	30
Use values	40
Non-use values	20

ANNEX 3 LOSSES AND BENEFITS OF EROSION

Property
Land with private houses and commercial buildings are examples of properties.
The loss or protection of property can be valued by:

- market price of the property, or
- relocation costs.

If the property is at risk from erosion, it will either be lost or replaced. The owners are forced to find or rebuild a new house for living or premises for commercial exploitation. In case of actual loss of the property, the costs to buy new property represent the economic costs. The market value of new property may differ from the market value of the property that is actually lost. In practice, it is generally assumed that the market prices are more or less equal. In case of relocation, the relocation costs (including costs of moving) should be used, including the purchase of new land (if applicable). The costs should be used to value the property that is either lost through erosion (cost) or saved by an erosion prevention project (benefit). The impact of erosion and of protecting measures on house prices is illustrated in Box A3-1.

Trade and industry that are endangered by erosion will anticipate and move their production elsewhere. This may have significant impact for the local economy but from a national economic point of view, no economic loss will occur (except for the relocation costs, see above) unless the industry moves abroad.
Related employment effects and social effects not reflected in NPV (Net Present Value) calculations, but may be important in decision-making.

In case of flooding, the damage to property is different. The damage is temporal, instead of permanent and there is in general no need to move away. In this case, damage involves costs of repair, possible temporal commercial losses, evacuation costs etc.

Infrastructure
Generally, replacement costs are used to value destroyed infrastructure serving a wider area including harbours, roads, railways, bridges, cables, major pipelines etc. A more detailed assessment of different categories of integration of infrastructure is given in Penning-Rowsell (1992). Traffic disruptions are normally not worth to evaluate, if not occurring regularly. In the case of severe and extended disruptions, it may be realistic to use cost of reconstructing the road as the economic loss.

Agricultural
Loss of agricultural land or production should be valued by:

- market value of the land or
- current value of foregone agricultural production.

The market value of agricultural land would normally represent the expected production potential. However, agricultural prices are often distorted by subsidies and taxes and therefore do not represent the economic value. Furthermore, land values are often strongly influenced by land use control and future use (option) values. For example, agricultural land can have high market values despite low production values, due to speculating behaviour of project developers if they expect the land to be given free in the future for development.

When agricultural land is lost, a first question to ask is whether the production will be replaced? In most West-European countries this will not always be the case. The agricultural land is lost for any future use such as natural or commercial development and the most appropriate valuation method would be to use the market price. Penning-Rowsell (1992) points out, that in some cases the added value of agricultural production, adjusted for subsidies (shadow pricing) may be negative, i.e. an economic benefit would result if erosion of agricultural land takes place. If total land loss is involved, Defra (2000) recommends using adjusted agricultural land value, i.e. the market price multiplied by a factor to remove national costs of agricultural support (currently 0,45).

Recreation
In most cases, recreation at coastal sites is free. The tourists do not have to pay an entrance fee; in some cases a parking fee is charged. Recreation and tourism give an economic impulse to the (local) economy. The expenditures of the tourists (such as overnight stays, restaurant visits, purchase of goods and souvenirs) constitute a first estimate of the economic value of recreation. The benefit of avoiding a loss of recreational value (or of an increase) can be calculated by estimating the number of visits made to the site and multiplying these by the change in the value of enjoyment. Methods to estimate number of visitors include: long periods counts using automatic counters, short period counts, inferred estimates by using data from related sites (car park, museum), distance-frequency functions, estimates from informed persons (rangers), average visits to similar sites.

Contingent valuation surveys assess the value of enjoyment (see Box A2-2, A3-2 and A3-3).

Box A3-1

Impacts of erosion on property prices (Source: Kriesel, W. 2002 www.agecon.uga.edu/~kriesel)

1.Objective

This study analyzed data on some 1200 properties in 9 US states to better understand the effect of a coastal erosion threat and of erosion protection measures on the sales value of both waterfront properties and properties several rows inland. Also the economic implications of the method of protection to the initiator (community) and to the user (property owner) were considered.

2.Methodology

The effect of beach management options on property values was estimated by analyzing the primary property values (house seize, ocean view, neighbourhood etc., in total 20 variables) and than comparing typical properties with and without beach nourishment, shoreline stabilization and along natural stable and eroding shores. The statistical technique used was the Hedonic Price analysis. This method is commonly used to estimate such relationships and also to predict how certain changes (such as coast protection) may lead to other changes (such as house prices).

The hypothetical waterfront house was located 150 ft from the shoreline, the non-waterfront house 300 ft inland. The rate of erosion was set 3 ft/yr, which means that –unprotected- the waterfront house would be lost within 50 years.

3. Results

The results indicated that a soft method (beach nourishment) increases the value for both waterfront and non-waterfront properties. Thus the total benefit to the community may be far greater than estimated for waterfront properties alone, as is typically the case.

In contrast, (hard) shoreline stabilisation appears to lower property values a few rows inland, whereas waterfront properties still benefit.

However, also type and extend of protection affects sales prices: the first few waterfront owners to stabilise their shoreline achieve benefits but as more and more of their neighbours follow suit, property values drop. An explanation may be possible negative environmental or aesthetic consequences particularly of hard protection measures.

The prices of 6 waterfront and 4 non-waterfront property cases were evaluated, the following table summarises the main results.

Cases	% Value of houses compared to base cases	
	Waterfront	Non-waterfront
Base case, stable shoreline		
value	$640 000	$499 000
	= 100%	= 100%
No action, erosion 3 ft/y	75%	77%
Nourishment project	87%	100%
Property stabilised		
Only few neighbours stabilised	86%	
Property stabilised		
50% of neighbours stabilised	76%	
Property not stabilised		
50% of neighbours stabilised	66%	67%

Considering community wide impact, beach nourishment seems an attractive option, whereas it raises concern about beach stabilisation. Interesting is also that houses which are separated from the beach are affected by erosion. Stabilisation even reduces the value of inland houses below the case where the shoreline is left to erode. This illustrates how the stabilisation actions of threatened waterfront owners have an unintended effect of harming their inland neighbours, a classical case of a negative economic externality.

4. Lessons learned

Coast protection measures and the method used affect property prices of houses that are not likely to be damaged by erosion over the next 60 years. Thus the number of houses that benefit from coast protection extend to non-waterfront houses and increases the basis for justifying the costs and more expensive but preferred technologies.

Box A3-2

Recreation value of Cley Marshes Natural Reserve (CV and TC)

A large part of the North Norfolk coast is low-lying and vulnerable to flooding. In the coastal management plans, managed realignment has been recommended for undeveloped stretches. Managed realignment involves allowing the coastline to recede to a new line of defence, usually created by natural processes and accompanied by measures to encourage the development of mudflats and alt marshes as a buffer seaward of the new defence line. Considering three prerequisites it can be a favourable option for less developed cost lines in terms of:

- economic efficiency: the costs of maintaining existing structures are not justified by accruing benefit
- nature development: natural processes enhance environmental values
- resilience to stress: a natural coast line is considered to be less vulnerable to extreme events like storm surges

One of the areas affected is Cley Marshes Nature Reserve, a fresh water habitat and internationally acknowledged bird reserve.

The main argument of realignment was, that the costs of maintaining the current flood defence structures of some 30 – 40 000 pounds/annum may not justified by the benefits accrued from the site as protected.

A major concern of the Norfolk Wildlife Trust was that the draft management plan had failed to consider the recreation value to birdwatchers of the site when proposing a policy of managed realignment. The shoreline management plan did acknowledge that such a value should be taken into consideration but did not give a quantitative estimate of its value.

A study was carried out to valuate the recreation value using two methods: Contingent Valuation (CV) and Travel Cost (TC). Both methods have an established track record of application and both rely on surveys to collect information, but differ to the type of preference they analyze. CV relies on the expressed preference (WTP) for some hypothetical change of the situation under investigation. Here, respondents were asked on their WTP to preserve the site in the current non-flooded state compared to the realignment state (i.e. a hypothetical comparison).

TC investigates the preference that is revealed by actions (travel costs and time) of visitors rather than by statements.

Again the design of the studies, estimates and calculation models are described in detail (visitation estimates ranged from 25 000 to 100 000). The following table summarizes the aggregated recreation value estimated via various approaches:

Approach	**Recreation value (pounds/annum)**	
	25 000 visits/yr	100 000 visits/yr
WTP via fee	55 000	222 000
WTP via tax	189 654	758 748
TC	152 964	611 956

The WTP via fees is lower than those produced by the WTP via tax or the TC. Such results have been observed in previous studies. One can speculate that “fee or entrance values” are more concrete for the respondents than “tax values” and reflecting an extremely lower level estimate and are not ideal for project appraisal purposes.

The maintenance costs of some 30-40 000 pounds per annum are significantly below the value estimates of some 150 000 to even 750 000 pounds per annum suggesting BC ratios between 4 and 17.

However, this economic comparison may be too simplistic. Any future management plan should consider a wider spatial and temporal scale, for example:

- severe storms and the related flood risks are expected to increase as are the maintenance costs
- management for the coast as a whole has to be optimised and the impact of protection at Cley Marshes on adjacent areas has to be taken into account
- the possibility of the relocation of the habitat and costs of restoration has to be taken into consideration as required by the EU habitat Directive.

Adding these issues into the debate might have changed priorities and cost-benefit considerations and could have given the decision process another direction (for a more detailed discussion see Turner 2001). Also a more participatory form of coastal management could have influenced the decision process as a pilot scheme of stakeholder negotiations indicated (O’Riordan 2001).

Environmental and heritage effects

Economic valuation methods exist to assess the economic value of environmental assets with the objective to determine which of the options are best from the environmental perspective.

Application of these methods can be questioned from a methodological point of view because of issue of the irreversible changes in environmental quality and the question of appropriate discount rates. CBA does also not offer a guarantee for sustainable development because it allows the running down of environmental capital as long as it compensated by the gain of another utility. In addition, there are practical drawbacks because the valuation is time consuming and costly. Nevertheless, environmental benefits and costs need to be included into economic assessment and the economic valuation of nature may open eyes about its value.

The recommended approach from Defra (2000) particularly for internationally important sites and habitat is to use costs of retaining and protecting the site in situ or replacing and relocating the site to identify what can be considered as the minimum environmental value, i.e. to use the lowest of:

- cost of creating a similar site elsewhere of equivalent environmental value
- the costs of relocating to another site (historic buildings, protected species)
- the cost of local protection

How difficult it is to assess values and how values are linked to definition of policies shows the Elmer's Island case (Box A3-3), dependent on which authority is responsible, values and decisions will differ.

Box A3-3

Elmer’s Island, Louisiana US: Linking recreation to restoration (Source: Sea Grant 2004, Louisiana Wetland News)

The Louisiana case highlights the issue of land valuation: depending on the perception and standards of two local agencies and of the methods used, different results are obtained.

Louisiana coastal wetlands are judged as the most rapidly deteriorating estuarine systems in the US. More than $500 million has been spend to date to stem the loss of coastal land and ten times that amount is being sought to fund the future restoration programme.

A majority of the state’s coastal land (78%) is privately owned, restricting public access to the coast. Therefore numerous appeals for state acquisition of Elmer’s Island for recreational use emerged as the former owner died. A survey was held to measure general aspects of natural resource management and the result indicated widespread support for public acquisition as a recreational site.

Several basic forms of land value assessment were available for negotiating an offering price for Elmer’s Island:

- The replacement-cost approach in which the coastal restoration spending serves as a value proxy. However, estimates from this method of $14 000 - 58 000 per acre were much higher than prices demanded in the open market. Use of the replacement cost method in real estate is typically limited to property loss situations.
- A second method estimates the business value based on 30 years history as a commercial campground. Values of $1600 – 2400 per acre were obtained, assuming visitations of 40 000 annually.
- Thirdly, comparable sales (market) prices indicated a value range of $50 – 750 per acre. Comparable sales are only a suitable metric of value if multiple analogs exist.
- Additional economic impacts – indirect effects - must be considered when evaluating property for public purchase like in this case the economic benefit of tourism: for Elmer’s Island itself this is estimated to be $1,5 – 3 million annually, on a regional scale even $7,3-11 million/year.
- Another example of public benefits are Non-use values which can be estimated via Contingent Valuation: People were asked to estimate the maximum one-time amount they are willing to pay to ensure future access to Elmer’s Island for the following reasons: Option value: “so that I can visit in the future”, Bequest value: “so that my children, grandchildren can visit”, Existence value: “just to know it is there and will be maintained for the public”. An average $ 110 was estimated per person.

Some controversy exists over the validity of CV estimates, but it is frequently used as a decision making tool in restoration and preservation initiatives.

The following table summarises the different economic value estimates for Elmer’s Island

Replacement cost value	18,9 - 78,5 $ million	14 000 - 58 000 $/acre
Income capitalised value	2,2 - 3,2	1 600 - 2 400
Comparable sales value	0,07 - 1,0	50 - 750
Contingent valuation	4,4	3 250
Tourism impact Elmer’s Island	1,5 – 3,0	1 100 – 2 200
Tourism impact region	7,3 – 11,0	5 400 – 8 100

The state offer based on comparable sales value $750 per acre was turned down by the landowner. In turn, the acquisition of Elmer’s Island was finally declined because a spending of $2,2 million for coastal recreation ($1600 per acre) was considered to high by the agency and outside their legal competence. This contrasts with proposed spending of the agency responsible for environmental resources of $41 million ($14 600 per acre) for restoration of an adjacent site where CVM was used as the valuation tool. This disconnect of primary resource agencies is interesting to note. Separate management of coastal restoration and coastal recreation may be advantageous but can lead to inconsistency of resource valuation.

Note: (1 acre = 4047 sq. m.)

Potential issues are that different habitats are affected differently by alternative options. If the site is not replaceable, no monetary value can be identified. Also certain environmental effects are principally unacceptable to (parts of) the society and cannot be compensated (in this case a MCA may be considered). And for many environmental but also heritage sites a recreational value can be identified and has to be considered as well.
To determine replacement costs, data need to be provided for each of the following steps:

- setting objectives (features to be replaced, targets and timings, characteristics of the habitat, area required etc. Costs are mainly staff and consultation costs)
- land acquisition, normally 50-90% of costs (Present Value Economic costs)
- planning, assessment and design (surveys, hydrological assessment, feasibility of achieving etc.)
- implementation (drainage, translocation of habitat, infrastructure requirements, staff costs etc.)
- monitoring and additional costs (project management, contingency costs etc)
- the economic costs need to be discounted to PV

To calculate non-use value of benefits of protection is possible but difficult, expansive and rarely justified.
In UK, a value of pounds 175/ha/year (256 €/ha/year) has been agreed for environmental enhancement obtained for grassland from water level management (Defra 2000).
For non-use values of nature conservation assets of local importance the value of the nearest equivalent commercial land use (grazing land, forest etc) can be used.
The value of archaeological and heritage assets is assessed similarly, i.e. to use protection costs of the site from erosion or relocation costs (buildings).
There is no recommended method to assess the value of landscape. For landscape of particular importance (National Park etc) CVM may be considered. In view of the effort, this may only be worthwhile if the CBA would be significantly affected.

Social-cultural effects
Impacts on households like increased stress or health damage may be more important to householders than material damage. The inclusion of these intangible effects into economic evaluation is controversial, however, a recent Defra note (July 2004) recommends to include a lump sum of 5000 Pounds per household (7300 €).

Climate change and sea level rise
Coastal defence schemes need to include allowances for estimated sea level rise, and land movement/rise and flooding.
Also other impacts of climate change like frequency and severity of storms may affect the standards of protection. The impact of these changes is best examined as part of the sensitivity analysis.

Calculating Discounted Cash Flows and Project Criteria, Funding
To compare the alternatives the monetary C/B streams over time have to discount, i.e. “converted” to their present values. The choice of the (social or test) discount rate is

critical and controversial: the higher the discount rate, the less important are future benefits and costs. Normally, "risk free real market rate" is used (US 30-year bond rate) and a sensitivity analysis is used to test the effect of discount rates on the project selection criteria.
Performance criteria include the net present value (NPV > 0), benefit-cost ratio (BCR > 1) and the internal rate of return (IRR).

An area of potential conflict is the question of funding within the constrains of limited resources. In the US, significant resources have to be delivered by the municipalities involved. In the UK, Defra introduced a point scheme to provide grant aid support, which is summarized in Box A3-4.

Box A3-4
Defra funding point scheme (O'Riordan, T. 2001, NorthNorfolk.org, www.northnorfolk.org/coastal/doc4.html)

A difficult aspect of managing coastal protection is to reconcile conflicting priorities within the constrains of increasingly limited resources. Funding comes from county councils (25%), the bulk of capital (75%) is grant aided on a annual basis from Defra. Before 1997 there was only a cost benefit criteria to satisfy, where the benefits of any scheme had to outweigh the costs of installation and maintenance and meet the three basic criteria "technically sound", "environmentally acceptable" and "economically viable". Since 1997, Defra introduced the Priority Scoring scheme, where coastal defence and protection schemes are assessed individually and only projects exceeding a given point threshold are provided with grant aid support. Until 2003, a "priority score" was calculated, consisting of the 3 components:

- **Priority**: This reflects the governmental priority for flood and coastal defence. It is based on principle land use. A scheme is "urban", if 50% of benefits relate to industrial, commercial or domestic property or infrastructure.
- **Urgency**: This determines how quickly work is required and whether delay will create unacceptable risks. It is based on the residual life of the defence structures.
- **Economics**: This scores BC ratios from >5 to >1.

Each component is scored out of 10, giving a possible score of 30.The following table details the key scores:

Element of scoring system	Description	Score
Priority (according to stated Ministerial Priorities)	Flood warning scheme	10
	Urban warning scheme	8
	Urban/coastal defences/Internationally important environmental assets	6
	Rural coastal/tidal defence/National important environmental assets	4
	New rural flood defence	2
Urgency (derived from expected residual life or shortfall in standards of protection)	Failure has already occurred	10
	Failure expected within 2 years	8
	Failure expected within 5 years	6
	Failure NOT expected within 5 yr	0
	Studies leading to a SMP	8
Economics: Cost-Benefit ratio	Over 5	10
	Between 3 and 5	8
	Between 2 and 3	6
	Between 1,5 and 2	4
	Between 1 and 1,5	2
	Studies where B/C is not known	8

Note: The box continues on the next page

Box A3-4, continuation

Annually, Defra publishes a “threshold” score for the following year. Currently, a minimum of 20 points (2002) must be achieved to justify central grant aid.

The new Defra priority scoring scheme: 2003 onwards

Based on experience and some critics: - the system is short term (urgency <5 years) and urban biased, not taking long term pressures on overall coastal resilience and large scale geographical cause and effect relationships into account. (O’Riordan 2001) -, Defra have introduced a revised system. It divides the 44 potential points score into three categories: economics (20 points), people (12 points) and environment (12 points).

The **economic section** deals with the BC ratio similar to the above. A BCR of 1 receives 1 point and for BCR>10,5 the maximum of 20 points is allocated. All ratios between 1 and 10,5 are awarded 1-20 points on a linear scale.

The **people score** is divided into three sections:

- the number of properties at risk over the life of the scheme (50-60 years, regardless of the individual value) is multiplied by 75 and divided by the costs of the scheme (kpounds). The maximum score is 8 for defence costs less than 100 pounds per house.
- Points are given for areas at very high risk (2 points) and high risk (1point). Protecting fro erosion is not regarded as high risk.
- All regions are ranked according their social vulnerability. Points range from +2 for the most deprived to -2 to the least deprived areas.

The **environment section** accounts for any environmental benefits that may be achievable by the implementation of a scheme. This includes the protection of an existing designated area, heritage sites or listed buildings and the creation of new habitat through realignment.

The threshold score for 2004/5 is 20 (with an decreasing trend indication for the following years).

Risk and Uncertainty

The term ”risk” refers to a potential outcome, where both the magnitude of the outcome and its probability is known or can be determined. “Uncertainty” refers to a situation where the magnitude of the outcome may or may not be known and where the probability is unknown. In practical terms, however, probability is difficult to define precisely and therefore the distinction may not be clear-cut.
The degree of risk can sometimes be assessed based on past records, like probabilities of floods or by extrapolation of studies, like erosion contours. As erosion projects are long-lived with the aspect of potential irreversibility, they contain a large number of uncertainties like valuation of some cost or benefit items, natural and human impacts etc. Measure being used to handle required predictions about risks and uncertainties include sensitivity analysis (“what-if” question, single impact of parameters), break-even and risk analysis (simultaneous impact of parameters) and scenario and system analysis (future scenarios with varied parameters).

System analysis supports project management and decision making by exploring alternative futures. The future is a function of the current status, exogenous factors (climate change, policy and economic trends etc.) and actions that could be taken by managers. System analysis provides a formal procedure by which different management actions are tested and compared and delivers insight which action is more likely to yield the desired future. A software tool (STELLA) supports system thinking and analysis (Richmond 2001, Herwijnwen 2004).

In erosion projects, one critical factor is what is regarded as unacceptable sacrifice of present values or services and what can politically be justified. In such cases of insufficient information the precautionary principle should be used.

ANNEX 4 CASE: HONDSBOSSCHE SEA DIKE

The problem, objectives and policy

The Hondsbossche sea dike has been build 1880 and has a length of 5 km. Currently, several issues became apparent, which question the long-term safety of this coast protection. Increasing erosion at the near shore area causes instability of the dike. Erosion at the north and south end of the dike weakens the dune connection and increases the risk of flooding. And finally, the general risk of sea level rise requires an overall safety review of the protection design.
The objective of the government is to keep the current shoreline, to ensure the safety of people and property against flooding and erosion and to combine this as far as possible, with a preservation or restoration of the natural processes. The measures have to ensure a well-balanced solution of economical, ecological and social-cultural values. Existing national and EU legislation i.e. habitat directives are applicable.

Choice of the options

Three possible options were proposed by IVM following the principle of dynamic coast management (beach nourishment, restoration of natural processes):

- to hold the line (A): continue the current management, i.e. maintenance of the dike and strengthening its construction, combined with additional nourishment in front and at the North an d South end.
- move seaward (B): dismantle the dike and enlarge and raise the dune area via jetty promoted accretion and significant nourishment. This will provide more space for natural processes and at the same time increase resources for recreation, agriculture (reduced salination) and residential areas.
- move landward (C): dismantle the middle part of the dike and create a wetland buffer area. This option restores the original situation keeping the shoreline and maximises natural processes and ecological resources.

Identification and valuation of the economical effects

The effects of the alternatives were assessed from three different perspectives: from an economical, an ecological and a social-cultural point of view. These three dimensions were assessed separately, using specific methodologies and criteria. Finally, an integrated assessment was made, using the MCA approach.

The economic valuation

Costs - Only financial values are taken in the calculation of costs. External effects are included in the quantification (positive or negative) of the benefits**.** Costs of measures include investment costs, costs of expropriation as well as operational and maintenance costs. The costs and the main measures are summarised for each option in the following table:

Costs / Option	**Hold the line (A)**	**Seaward (B)**	**Landward (C)**
Investment (M€)	62,5	103,4	65,7
Operational (M€/50 yr)	9,4	1,8	2,0
Investments	Raise dike, nourishment of the dike base	Demolish dike, dune creation (nourishment), jetties, relocation of a village (compensation)	Demolish dike part, new dike, compensation for polder
Operation and maintenance	Yearly nourishment to strengthen dike base	Nourishment	Reduced dike maintenance

Benefits - The following table summarises the main effects and the monetary valuation method used:

Type of benefit	Effect	Valuation method
Production Agriculture	Lost production Changed productivity	Net Market price
Fishery	Creation breeding grounds	Production Function method
Recreation	Increase number visitors Change in perception	Travel Cost method
Fresh water storage, production	Change volume	Market price
Security	Change in perception	Contingent Valuation method
Biodiversity	Change in perception	Contingent Valuation method
Property	Change in house value Change in number houses	Hedonic Price method Market value
Economic activity of the region	Reduced flood damage	Replacement costs (Risk assessment)

Agriculture: Each alternative causes change in productivity and land used. Production will be lost in option C, whereas options A and B will profit from reduced salination and other agricultural activities like bulb production.

Fishery: Natural coast zone have an important task as the breeding and feeding grounds for the fish population. The production function method is information intensive but appropriate method to measure the relation between environmental change and fish production.

Recreation: Today, the sea dike area has only limited recreational value. Option B and C will increase the beach and dune area and the improved "naturalness "of option C will attract additional visitors.

Fresh water: The reduced salinisation will increase the fresh water production particularly in option B. Production will cease in option C.

Biodiversity: Natural processes can spread in option B and particularly option C, increasing the variety of flora and fauna. The perception of 200 000 people is measured by their WTP.

Property: Several studies indicate an increase of house prices in function of an improved "naturalness" in average by 7%. In this case, price increase between 1% (option A) and 5% (option B and C) were assumed.

Security: Technically, all three alternatives should guarantee the security. However, the perception of the local people can still be different for each alternative, estimated by their WTP.

Flood damage: The risk of flooding increases over time, particularly considering the estimated sea level rise, Option A showed the largest reduction of a flooding event over the 50 year period (-8%), followed by option B (-5%) and option C (-3%). This was put in relation to the maximum possible damage, calculated by the replacement method.

The monetary values of the benefits for each alternative discounted at 4% over the period 2000 to 2050 are shown in the following table. Interesting to note is the large effect on property, whereas the impact on recreation is relatively small. This is mainly caused by the fact that sufficient similar recreational alternatives exist and both options B and C do not attract significant new visitors.

Value (Million €) /Option	**Hold the line (A)**	**Seaward (B)**	**Landward (C)**
Agriculture	4,4	4,7	0
Fishery	0	0	10,2
Recreation	0	0,3	1,9
Fresh water	0,05	0,3	0
Security	8,5	6,1	0
Biodiversity	0	2,5	12,0
Property	10,9	55,0	49,5
Reduced flood damage	61,4	47,7	38,2

Cost-Benefit Analysis and Sensitivity Analysis

The following table shows the discounted (4%) costs and benefits and the calculated net present value (NPV), the benefit cost ratio (BCR) and the internal rate of return (IRR):

	Hold the line (A)	**Seaward (B)**	**Landward (C)**
Total costs	71,8	105	67,7
Total benefits	85,5	116,8	111,8
NPV	30	26	97
BCR	1,2	1,1	1,7
IRR %	5	4,5	8

The results indicate that all 3 alternatives are economically efficient at a discount rate of 4% with a NPV > 0 and a BCR > 1. The alternative C has the highest values and is the preferred option. Alternative C remains the preferred option also at higher discount rates up to 14%, whereas alternatives A and B change places at a rate of 10%. Relative small changes in the two largest scores of option A (Property and Flood damage) can lead to a reversal of NPV between the options A and B. However, the preference of option C is still robust, even given a significant increase of these two largest scores.

Integrative Assessment

Increasing scarcity of coastal zone goods and services and the public character of many of coastal values imply conflict between stakeholders, between users and actors. The public, but also the experts of the different disciplines will have different perceptions and different measuring scales to assess these values and the effects of change.

In addition to the application of CBA, it is therefore essential that decision makers comprehensively and systematically consider also the social-cultural and environmental context of activities.
Multi-Criteria Analysis (MCA) is one approach available to accomplish this.

The following examples show the benefit assessment of the ecological and the social-cultural dimensions and how they can be combined with economical benefits into an integrated assessment.

Ecological benefits
Ecological benefits are quantified according to the envisaged changes in biodiversity and function of natural processes using an expert assessment. For each category, a number of criteria are measured such as changes in different ecosystems, species, soil, hydrology or geomorphology. The table below shows a relative scoring, summarising the different effects:

Score/Option	Hold the line (A)	Seaward (B)	Landward (C)
Diversity ecosystems	0,12	0,31	0,46
Diversity species	0,21	0,21	0,22
Naturalness	0,16	0,50	0,73

Option C reaches the highest score, mainly due to the naturalness result.

Social-cultural benefits
The social-cultural assessment focuses on judgement of values by people without ecological or economical expertise. The research is more directed to questions like how people (stakeholders) are affected (or want to be affected) by the project, and how they experience and understand the project and its effects.

A first step is to review relevant literature of comparable cases and to collect relevant local information like maps, history and notes on the project, municipal internet sites etc. to get a comprehensive understanding of the local issues and views. Also an inventory of all stakeholders and their interests is made. Following steps are to consult one or more panels of stakeholders and experts for advice on necessary steps towards decision making, i.e. to decide and agree the project goals, which benefits have to be achieved and how are they realised by the alternatives. Based on this information further confirming research on sensitive topics may be considered.

The following table summarise the assessment of the project goals, where the stakeholder groups could give a score of 100 to their main project goal. Two sub-groups were chosen, because it became evident in pre-meetings that the stakeholders judged the value of the option C differently.

Project goals	Most preferable outcome	Least preferable outcome	Score Group 1	Score Group 2
Preserving safety culture	Recognisable responsibility of the government	Apparently left to nature	100	100
Increase tourism	Unique identity	Not distinct from others	60	60
Promote heritage, amenity	Keeping all polders	Removing all polders	60	30
Promote authentic nature	Recovery of sea inlet	No sea inlet	0	60
Limit congestion	No intensive traffic, constructions	Intensive traffic, constructions	20	20
Keep flexibility for future generations	Keeping option to demolish polders	No option	20	20

The following step is to assess, how each of the alternatives meets these objectives. A coding between 0 and 1 is used and an average per group calculated. The following table summarises the results:

Project goals	Hold the line (A)	Seaward (B)	Landward (C)
Safety	1	1	1
Tourism	0,5	0	1
Heritage	1	0	0
Nature	0	0	1
Congestion	1	0	0,5
Flexibility	1	0	1
Weighted score Group 1	0,88	0,38	0,73
Weighted score Group 2	0,69	0,34	0,86

The result indicates that group 1 prefers option A; group 2 prefers option B (see above, different people have different opinions, and more rounds of discussion may be required to reach agreement). A more detailed research may be carried out to refine the project goals and preferences. Or intensive information, visualisation using MCA software and discussion rounds with all stakeholders may be considered to reach common agreement.

To provide a more complete picture of the project and its alternatives, an integrated assessment of the three dimensions can be carried out. Very divergent information has to be handled and a very complex situation has to be explained to stakeholders and local population. MCA can be used as an efficient tool.
MCA uses weighted sums of the standardised economical, ecological and social criteria to structure and visualise the ranking of project alternatives:

	Hold the line (A)	Seaward (B)	Landward (C)
Economical valuation	0,31	0,26	1,0
Ecological valuation	0,16	0,29	0,4
Social-cultural valuation	0,88	0,38	0,73
Total average result	0,45	0,31	0,71

Option C seems to be the preferred one, however, the total average result is indicative and has only a limited meaning as a comparison of the values of the 3 dimensions remains difficult. A sensitivity analysis with changing weightings can provide further insight in the robustness of this ranking. Option C is certainly preferred to option B, with all scores lower in all 3 dimensions. Option A scores high in social values, based on the feelings and perceptions of the local population, whereas option B wins with regard to economy and ecology, indicating a local vs. national conflict. The initiator can use this information in further communication to stakeholders and to come to a well-balanced decision.

ANNEX 5 CASE: PRESERVING TEXAS COASTAL ASSETS - RESULTS

Costs and benefits of the 13 Economic projects

Preserving coastal assets from erosion damage generate tangible economic benefits through avoided losses of public (replacement costs) and private property, generation of enhanced property value (Hedonic price model) and tax and additional tourist spending and user fees from recreational activities. To account for the time value, annual costs and benefits were discounted using a corporate bonds rate of 7,08%.

Benefit types and %		PV of Total costs $ million	PV of Total benefits $ million	B/C ratio
- Value of public property damage avoided - Increase in property value - Additional spending from increased visitations - Additional user fees from increased visitations	1% 14% 83% 2%	8,48 (of which 4,38 paid by Texas State)	136,25	16,06

The economic benefits of the 13 projects were impressive, mainly resulting from increased tourism spending that stem from preserving the quality and seize of beaches, parks and bay shore areas. Another positive effect results from a considerable increase in property values. Avoided damage was only a minor contributor to overall benefits. The B/C ratios of all projects were above 1, ranking from 1,7 to over 350, with an average of 16, indicating strong positive returns from taxpayers' investment.

Environmental benefits of the 10 Natural resource projects

The following table summarises the impact of a project on the main functions of the natural site (H= high, M= medium, L= low positive impact) as well as the project costs and the area of the site.

The natural resource projects had a significant environmental pay off. They scored high virtually in all cases on the significance of shoreline stabilisation, biodiversity, and uniqueness/heritage. They will provide other wetland functions such as toxicant retention, nutrient removal or flood flow alteration.

It is not possible to make confident judgements about the cost-effectiveness of the projects from these data. However, a study (Whittington et al., 1994) of the marginal value of Texas wetlands based on an evaluation of recreational fishing estimates a capitalised value of $ 8500/acre. Given modest inflation since 1994, the costs per acre of all except one of the 10 projects suggest a positive net benefit of the investments. The full value of the wetland restoration is considerably higher taken all the other functions into account.

Project										
Wetland function	1	2	3	4	5	6	7	8	9	10
Groundwater Re/Discharge	L	M	M	L	L	L	L	L	M	L
Flood Flow alteration	M	M	M	M	M	M	M	M	M	M
Sediment stabilisation	H	H	H	H	H	H	H	H	H	H
Toxicant retention	L	M	M	M	M	H	M	H	H	H
Nutrient removal/Transform	M	M	M	M	M	H	M	H	H	H
Wildlife diversity	H	H	H	H	H	H	H	H	H	H
Aquatic diversity	H	H	H	H	H	H	M	H	H	H
Uniqueness/Heritage	H	H	H	H	H	H	H	H	H	H
Recreation	L	H	H	M	L	H	M	M	M	L
Project costs $ million	0,32	0,75	0,88	1,3	0,8	0,33	1,34	0,33	1,5	0,57
Acreage protected/restored	500	222	480	6,4	103	21,5	760	51,8	45000	184
Costs/acre $	650	3378	1833	482000	7767	15517	1768	6370	33	3083

Some comments

The study highlights the importance of an economic review and longer term monitoring of projects after completion. Even rough and approximate data, applying limited resources can give valuable insight on efficiencies and objectives achieved and provide useful learning for future initiatives.

The economic projects assessment concentrated very much on “real money” costs and benefits and did not take all indirect effects into account. This practical oriented US approach leads to conservative benefit estimates, but avoids also unfavourable surprises in the longer term.

There seems some room to expand the natural resources projects assessment: benefit transfer but also some CVM and stakeholder surveys could have added more quantitative and relevant estimates of the in- and non-use values.

GLOSSARY

Common acronyms

BCR	Benefit Cost Ratio
CBA	Cost-Benefit Analysis
CEA	Cost-Efficiency Analysis
CSMP	Coastal Sediment Management Plan
CVM	Contingent Valuation Method
EIA	Environmental Impact Assessment
HPM	Hedonic Price Method
ICZM	Integrated Coastal Zone Management
IRR	Internal Rate of Return
MCA	Multi Criteria Analysis
Messina	Monitoring European Shoreline and Sharing Information on Near-shore Areas
NPV	Net Present Value
NSB	Net Social Benefits
PCM	Prevention Cost Method
PFM	Production Factor Method
SEA	Strategic Environmental Assessment
SPM	Shadow Price Method
TCM	Travel Cost Method
TEV	Total Economic Value
WTP	Willingness to Pay