FCDPAG1

Flood and Coastal Defence Project Appraisal Guidance

Overview (including general guidance)

Ministry of Agriculture,
Fisheries and Food

Flood and Coastal Defence Project Appraisal Guidance

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FCDPAG1
A PROCEDURAL GUIDE FOR OPERATING AUTHORITIES

Foreword

This is one of a series of guidance documents designed to provide advice on best practice for the appraisal of flood and coastal defence projects.

The content of this Overview is largely new and compiled internally by MAFF but extensively revised as a result of a consultation carried out in autumn 2000. The Ministry is grateful to all those who have contributed, through the consultation and through other discussions, to the drafting of this volume.

The final text is guidance issued by the Ministry, specifically to introduce the use of the other five volumes in the series.

Ministry of Agriculture, Fisheries and Food

Flood and Coastal Defence with Emergencies Division

May 2001

Contents

1 Background to project appraisal for flood and coastal defence

1.1 Introduction

During the year 2000, flood defence and coast protection authorities in England and Wales spent approximately £400 million on works along our rivers, estuaries and coastline. The bulk of this expenditure is ultimately met by taxpayers, many of whom may derive little personal benefit from the money spent on their behalf. Good project appraisal is an essential part of ensuring that taxpayers receive value for money.

Best use of public money

Comprehensive project appraisal ensures:

- best use of public money;
- transparent, balanced and better decision making.

This is achieved by taking an integrated appraisal of economic, environmental and technical issues with proper consideration of risk within a consultative framework taking account of local issues and needs.

1.2 Contents and purpose of the FCDPAG volumes

The Flood and Coastal Defence Project Appraisal Guidance (FCDPAG) series aims to provide best practice advice to practitioners involved in the preparation of strategies and schemes. Use of the guidance is intended to encourage a consistently high quality of decision-making supported by a rigorous appraisal of options so that the most appropriate scheme or strategy is proposed.

The FCDPAG series is made up of six volumes:

FCDPAG1	Overview (including general guidance)
FCDPAG2	Strategic planning and appraisal
FCDPAG3	Economic appraisal
FCDPAG4	Approaches to risk
FCDPAG5	Environmental appraisal
FCDPAG6	Post project evaluation.

It is recommended to users that they read this volume (FCDPAG1) in full, before making use of other volumes in the series.

FCDPAG1 provides guidance on combining the different aspects covered in volumes 2–6 and recommends how to use the document series. This volume also considers technical issues, climate change and sustainability and how they may be incorporated into the project appraisal process. A final section, on 'pitfalls' and 'common mistakes', is included to enable users to learn from past mistakes.

FCDPAG2 sets out a framework for strategic consideration of appropriate flood or erosion risk areas related to river catchments or lengths of coast. This should lead to appropriate problem definition and identification of a broad range of options for solution.

FCDPAG3 identifies methods for valuing costs and impacts in monetary terms and also sets out a recommended decision process, based on economic values.

FCDPAG4 encourages the proper consideration of risk issues in the derivation of appropriate economic values and decision making, as set out in FCDPAG3.

FCDPAG5 encourages the proper consideration of environmental aspects of flood and coastal defence works in the decision making and derivation of appropriate economic values, as set out in FDCPAG3.

FCDPAG6 provides updated guidance on undertaking post project evaluation.

2 Introduction to project appraisal

2.1 What is project appraisal?

Project appraisal

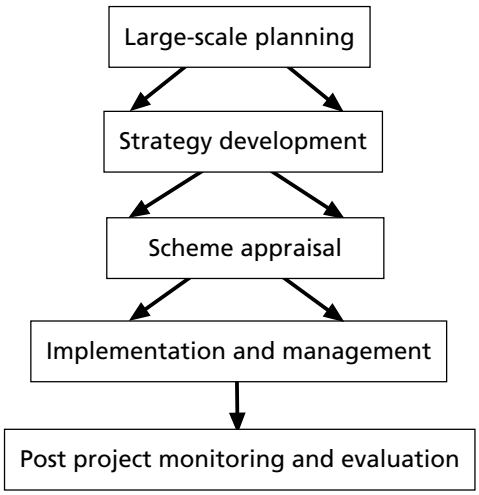
Project appraisal is the process of identifying and then evaluating options in order to select the one that most closely satisfies the defined project objectives. In the context of flood and coastal defence strategy and scheme appraisal these objectives include:

- reducing the risks to people and to the developed and natural environment from flooding and coastal erosion;
- identifying a solution that is technically sound and most fit for its purpose;
- being environmentally acceptable and sustainable; and
- ensuring best value for money from a national perspective.

2.2 Role of appraisal in project planning

Project planning

Project appraisal is an iterative process where ideas go through a cycle of being developed, reviewed and refined. The use of project appraisal techniques is desirable at all stages of the river and coastal project planning and development process as indicated below.

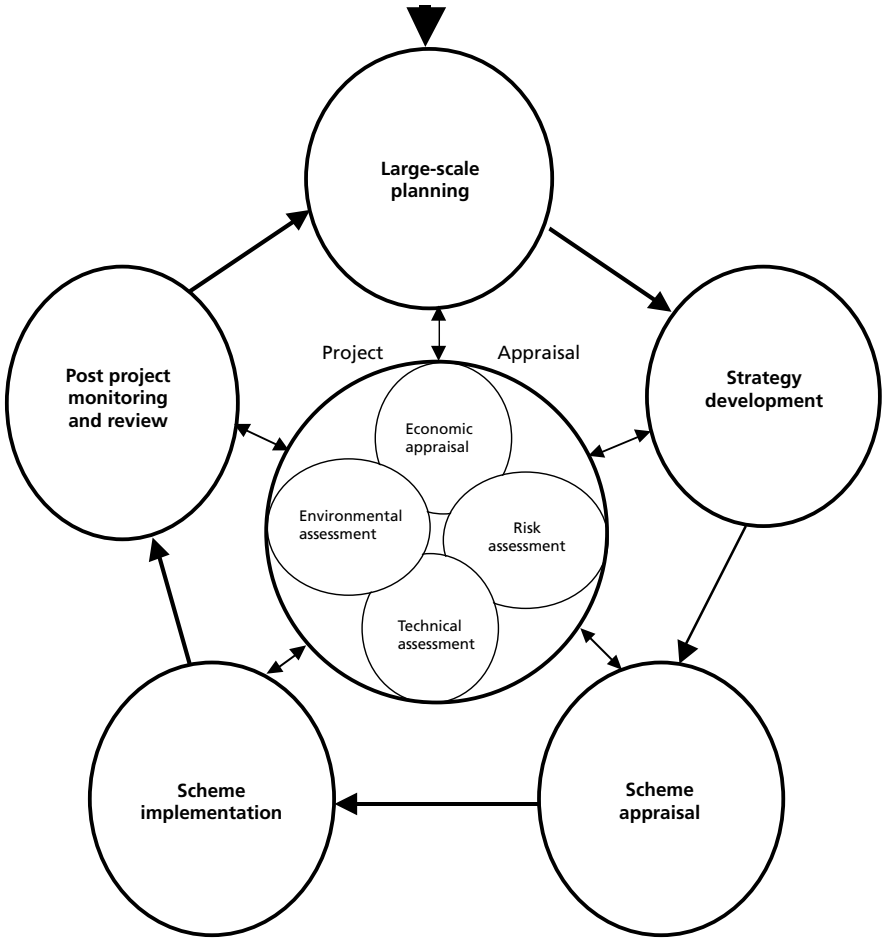


Strategic framework

For the purposes of large-scale planning, project appraisal can be used, over a wide area and taking a broad approach, sufficient to build a guiding framework within which layers of smaller-scale strategies or schemes can be developed. Similarly for individual scheme development, the appraisal process can ensure that the most suitable option is selected and progressed. At each level, all the potential impacts and options are considered to an appropriate level of detail and geographical scale to ensure good decision making and option selection. In the FCDPAG series, the ideal planning structure is frequently referred to as a strategic framework, indicating that each stage of planning has a context in a wider defined picture.

Figure 2.1 illustrates the holistic nature of project planning and development and emphasises the central role of economic, technical, risk and environmental evaluation within the project appraisal process at each stage.

Figure 2.1 Stages of project planning and development



2.3 The appraisal process

2.3.1 Appraisal – an iterative process

Appraisal process

The iterative nature of project appraisal is shown in Figure 2.1. Ideally the problem identification and objective definition will be done within a strategic framework in order to encourage the widest possible impact assessment and option development. The process consists of:

- defining;
- developing;
- comparing; and
- selecting options.

It uses economic, risk, environmental and technical considerations at each stage to build up a comprehensive evaluation that pulls together all the relevant information, leading to logical decision making and best option selection.

2.3.2 Decision making

Good decision making

The purpose of the project appraisal process described above is to improve decision making. Good decisions are most likely to result from considering all economic, environmental and technical issues for a full range of options, together with a proper consideration of risk and uncertainty. By balancing these issues – even where it is difficult to put a monetary value on such effects – the most viable scheme should be identified. Good decision making will always include a role for:

- informed consultation and negotiation;
- appeals and formal adjudication.

Credible evidence

Effective project appraisal will aid these processes with credible supporting technical and economic evidence. A poor project appraisal, failing to properly consider potentially viable options, can open the door to extensive consultative problems if confidence is lost in the validity of the appraisal.

2.4 The Appraisal Report

Documenting the process

The purpose of the Appraisal Report is to provide a clear and comprehensive record of the appraisal process and a well argued justification for the selection of the preferred option for any strategy, scheme or other programme of works.

A good Appraisal Report will provide sufficient information to meet the needs of all interested parties in the particular scheme including:

- the internal approval of the organisation promoting the scheme;
- the approval process for any external funding authority or organisation;
- other organisations or individuals who have an interest in the scheme and its impact.

Section 2.3 above stresses the importance of good project appraisal in the consultative process. The Appraisal Report is equally important in providing the promoting authority with the best opportunity to demonstrate the quality of its appraisal and decision making, leading to the preferred solution. An abbreviated standard form of an Appraisal Report is shown in annex A.

3 Use of the guidance series

3.1 How to use the series

The FCDPAG series

The six volumes of this series provide an integrated suite of guidance on aspects of project appraisal. The series replaces the MAFF *Project Appraisal Guidance Notes (PAGN) – 1993* and recognises the importance of a more broadly based approach. Each volume concentrates on specific aspects of the project appraisal process in detail but also includes references to other volumes where they interrelate.

It is recommended that a new user to the series initially reviews all volumes to fully appreciate the comprehensive nature of the guidance (and the iterative way that economic, risk, environmental and technical assessments are undertaken for effective project appraisal). The contents pages and introduction of each volume present a useful overview of their scope. More detailed reading of the volumes is required prior to embarking on a project appraisal.

Different projects will inevitably place a different emphasis on the relative importance of strategic, economic, environmental and risk considerations covered within the project appraisal process.

Assisting knowledgeable practitioners

The FCDPAG documents are intended to assist knowledgeable practitioners; they are not comprehensive manuals or textbooks and they do not define government policy. However, compliance with the guidance series is likely to produce projects that are acceptable for central government support.

There is no volume on technical appraisal. This in no way implies that technical appraisal is considered less important than other aspects. However it is assumed that competent and suitably qualified technical experts will be undertaking this work to the highest standards of their profession. Section 4 of this document (FCDPAG1) provides some guidance on technical soundness with particular reference to specific areas of difficulty in flood and coastal defence, such as designing for rare events.

Figure 3.1 illustrates the role of each FCDPAG volume in the appraisal process. The following sections 3.2 to 3.6 summarise the contents of these volumes.

3.2 Strategic considerations – FCDPAG2

The purpose of FCDPAG2 – Strategic Planning and Appraisal

Strategic Planning and Appraisal

Volume 2 of the FCDPAG series sets out the general principles to be considered for the strategic planning of flood and coastal defences. The document focuses on the appraisal and development of strategy plans but the principles are equally applicable to large-scale planning or the design and appraisal stages of individual schemes.

Benefits of a strategic approach

The management of flood and coastal defence within a strategic framework encourages practices that avoid disruption to natural processes and which are sustainable in the long term (including adapting to climate change). A strategic framework also provides essential information for effective public consultation and other non-flood defence activities such as local and county planning.

The strategic approach concentrates on:

- the long-term view;
- foresight in identifying problems;
- innovation in seeking and developing solutions;
- a comprehensive regard to impacts;
- assessment and reduction of risks; and
- balanced decision making when selecting the outcome.

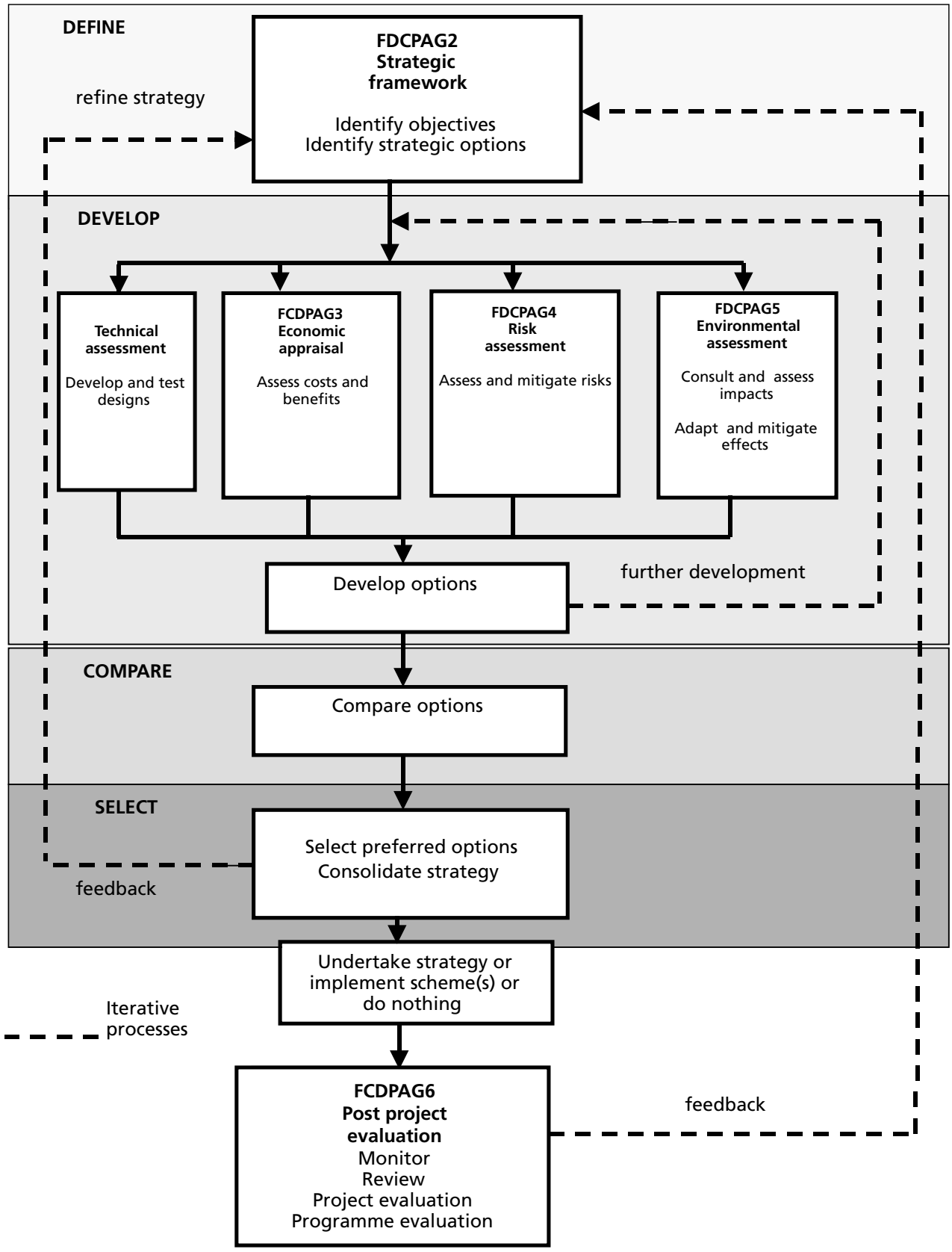
When and where is a strategic approach desirable?

When is a strategy required

Very few schemes for management or construction on rivers and coasts have a totally local short-term impact and few flood and coastal defence schemes can therefore be regarded as truly 'stand alone'. Every major scheme requires the evaluation of all costs, benefits, physical and environmental impacts over the affected area for the whole life of the scheme. This will often be most easily achieved within a strategic framework. The Ministry is encouraging the development of a large-scale strategic framework for flood and coastal defence management based on Shoreline Management Plans (SMPs) and Catchment Flood Management Plans (CFMPs). The overall approach is set out in the MAFF Strategy for Flood and Coastal Defence in England and Wales (reference 1). The first generation of SMPs has been completed covering the entire length of the English and Welsh coastline. The development of a comprehensive framework of CFMPs will be a gradual process but one that is seen as equally important for effective and sustainable long-term management.

Fitting within the large-scale strategic framework (e.g. SMPs), more detailed strategy plans are likely to be required for managing self-contained coastal management units or river sub-catchments. Development of a strategy plan would be expected to be consistent with the recommendations of the large-scale plan. Such strategies are likely to be initiated by the operating authority perceiving a need for works to be undertaken. Ideally an increasingly proactive approach will be taken in identifying potential problem areas well in advance of either flooding or defence failure. This should not, however, be taken to imply a blanket requirement for the production of strategy plans. FCDPAG2 gives further guidance on the circumstances for which strategy plan development is the preferred approach.

Figure 3.1 The role of FCDPAG volumes in the appraisal process



3.3 Economic appraisal – FCDPAG3

The purpose of FCDPAG3 – Economic Appraisal

Economic appraisal

Volume 3 of the FCDPAG series sets out the principles that should be used in undertaking economic appraisals for nationally-funded projects for river and coastal flood alleviation, coastal protection and other related purposes. Specifically, it provides an interpretation of how the requirements set out in the Treasury's Green Book (reference 2) can be achieved. It sets out good practice but is not intended to be followed mechanically or to cover every eventuality.

The main principle of economic appraisal is an assessment of the gains and losses in national resources, often considered in terms of the economic benefits deriving from a project and the costs necessarily incurred to complete it. FCDPAG3 provides guidance on how such national gains and losses should be evaluated and when changes that do not affect national resources (often referred to as 'transfer payments') should be ignored.

Projects are only economically viable if the benefits exceed the costs (i.e. the ratio of benefits to costs is greater than 1.0). In order to achieve the best return on any programme of investment, the general objective is to maximise the ratio of benefits to costs for each scheme or project by considering different options or solutions. For each project potential options should always be compared with the 'do-nothing' scenario, i.e. no investment at all. This acts as a consistent baseline against which other options are tested and different projects can be compared. It also reduces the risk of presuming that works are inevitable.

In order to make valid comparisons using economic appraisal, all monetary values need to be referred to a common point in time – usually called the 'present' value. A standard 'discount rate' is applied so that costs and benefits of projects with varying time scales can be compared. This is particularly important when dealing with assets such as flood defences with expected design lives of 50 years or more.

Clearly, the actual timing of flood or erosion events cannot be predicted, and so the principle of 'expected annual value' of losses is adopted. This means that the probability of loss in any one year is multiplied by the value of that loss to determine the 'expected annual value'. This approach ensures that across the whole programme of long-term activity there is a sound basis for achievement of the calculated economic return.

Benefits of economic appraisal

A significant factor in option selection

Economic appraisal enables the comparison of widely differing options in order to identify those which provide overall best value for money. It also provides a basis on which long-term management decisions can be made, such as balancing capital costs with maintenance costs. If sensitivity analysis is incorporated into the economic appraisal, the relative risks associated with certain options can be evaluated and also taken into account. Good decision making depends on the provision of high quality economic information derived from the application of thorough economic appraisal techniques. Benefit – cost analysis will normally be a significant factor on which schemes and scheme options will be selected.

Limitations on the use of economic appraisal

Exceptions

There are some situations where economic appraisal is not appropriate as the principal criterion for deciding either between schemes or whether to proceed with any project. These include:

- where there is a need to meet specific legal requirements (it will still be useful to evaluate benefits and costs to establish the least costly method for satisfying legal requirements); or
- where there are significant unquantifiable costs or benefits that are difficult to reflect adequately in the appraisal (e.g. some environmental or social costs). Even where no direct valuation is made, a decision to proceed with a particular option implies a valuation of benefits, at least equivalent to the extra costs incurred, and this should be explicitly considered in the decision-making process.

See also section 5.2 for more discussion on decision making.

3.4 Approaches to risk – FCDPAG4

The purpose of FCDPAG4 – Approaches to risk

Approaches to risk

Volume 4 of the FCDPAG series seeks to encourage the incorporation of risk assessment and risk management methods into all phases of scheme development, including the key concept of risk as a combination of probability and severity of outcome.

Role of risk assessment

Informed decision making

Risk assessment contributes to informed analysis and decision making at all stages of project appraisal. It not only assesses the likelihood of design conditions being exceeded but also the likelihood of defence failure and the degree of harm resulting to people, property or other assets behind the defences. It provides a framework within which risk can be documented and communicated to relevant stakeholders. Risk assessment reduces the chance of 'surprise' and enables consequences to be managed and planned for in advance.

Risk assessment can also provide a sound basis for 'educated' sensitivity testing by quantifying the relative likelihood of deviations from the expected.

Climate change brings additional uncertainty over future storm and flood design conditions. The use of probabilistic or risk-related methods in the design and management of coastal and flood defence schemes with a clear understanding of how these will perform under a range of extreme conditions will help in the determination of appropriate standards.

Role of risk management

Managing risks

Risk management builds recognition of uncertainty into the decision making process and takes the form of:

- mitigation (e.g. incorporation of procedures or design features to limit the consequences if risks occur);
- control (e.g. actions to avoid risks occurring such as the institution of appropriate training procedures); and
- acceptance (e.g. provision of an appropriate allowance in scheme costs in case the risk arises).

Risk mitigation and control enable unwanted outcomes to be managed. Risk acceptance is a form of management (also applying to residual risks) that implies the risks are either unlikely, of low impact or beyond control. Risk acceptance is not an option that short-circuits assessment. If risks are determined as 'acceptable' it must be on the basis of an informed judgement, not ignorance. Risk management may add costs to a project but it also provides the supporting information for justification.

3.5 Environmental appraisal – FCDPAG5

The purpose of FCDPAG5 – Environmental appraisal

Environmental appraisal

Volume 5 of the FCDPAG series provides guidance on assessing the impacts of projects on the natural environment and heritage sites. Its purpose is to assist flood and coastal defence operating authorities to improve decision making with regard to environmental impacts and to set out and aid compliance with relevant environmental legislation. It stresses the need for assessment throughout the life of a project from conception through construction to the long-term effects. Critical to this is the assessment of the relative importance of impacts (e.g. through their valuation). The volume also seeks to offer good practice in the design of schemes to take account of environmental objectives such as contributing to biodiversity targets and sustainability.

Environmental valuations as input to economic decision making

Close links are maintained with FCDPAG3, which sets out a basis for environmental evaluation. Further techniques for monetary and non-monetary environmental valuation are suggested in FCDPAG5. The iterative nature of economic and environmental appraisal in identifying the preferred option is shown in Figure 3.1. The cost of mitigation measures, habitat replacement, protection of archaeological features or environmental enhancement opportunities will also feed back into the economic appraisal at each stage.

Identification of non-monetary concerns and input to decision process

Non-monetary evaluation

Some impacts are difficult or impossible to value on a monetary basis. There are several acceptable methods of presenting valuations of environmental impact, which are not based on monetary value. These include descriptive methods, quantitative measures such as changes in species populations, or scoring and ranking approaches. Impacts which have been measured using non-monetary measures will need to be considered in parallel with economic measures at the decision-making stage. If the environmental impacts of a scheme preferred on economic grounds alone are judged unacceptable, an authority may be justified in

proceeding with the next best economic option with acceptable environmental impacts. (See also section 5.2 on the decision-making process.)

3.6 Post project evaluation – FCDPAG6

The purpose of FCDPAG6 – Post project evaluation

Post project evaluation

Volume 6 of the FCDPAG series presents guidance on post project evaluation. The purpose is to promote good practice in reviewing schemes (or strategies) in order to assess the success or otherwise of the work undertaken and to demonstrate that value for money has been achieved. Lessons learnt from post project evaluation need to be fed back into future project development.

Monitoring objectives

Success is measured by comparing achievements with defined objectives. A one-off audit process at some point in time can achieve this. To measure scheme performance, however, it is preferable to set objectives for monitoring so that the required information is collected over a period of time to facilitate post project evaluation. Monitoring objectives can be set for individual schemes or may relate to sampling a larger programme of work.

A particular problem in evaluating the performance of schemes is that most will not have been subjected to the extreme events that they have been designed to resist. The nature of flood defence schemes is that they are designed to be subjected to their full design load very infrequently. This highlights the need for setting valid monitoring objectives that can reasonably be expected to produce useful information in the shorter term. Monitoring objectives can be set for factors other than just testing to the design limit such as:

- design performance;
- construction performance;
- structural (physical) performance;
- operational performance;
- environmental performance;
- public acceptance/response;
- economic performance.

Monitoring objectives must be realistic if they are to be effectively implemented and result in the collation of useful information for post project evaluation at reasonable cost.

National targets

The MAFF *Strategy for Flood and Coastal Defence* (reference 1) states a requirement for operating authorities to carry out post project evaluation:

> *'to ensure that grant funds are spent to good effect in schemes which meet their design criteria and achieve value for money, and as an aid to the evaluation of the effectiveness of policies and procedures.'*

It is necessary to maintain a balance between demonstrating achievement and the cost of data collection and collation. This will often be achieved by sampling. However, more comprehensive but less detailed monitoring is appropriate in assessing all schemes against some targets such as their performance in extreme (design) events or final costs.

High-level targets taking effect from April 2000 set up the framework for the development of a National Flood and Coastal Defence database which will provide a basis for monitoring flood and coastal defence provision.

The value of post project evaluation will only be delivered by regular programmes of data analysis and the publication and distribution of the findings (see reference 3).

Programme delivery

Post project evaluation of the performance of individual schemes is important for the ongoing management of those schemes and for the lessons that others can learn from them. However, a co-ordinated national programme of post project evaluation is also important to demonstrate delivery of strategic and policy objectives and the efficiency of national investments. This is likely to be achieved by a combination of broad-brush monitoring of the whole programme, together with a more detailed sampling of selected evaluations. Clearly there is a need to carefully balance costs and potential benefits when setting the requirements for such large-scale monitoring and evaluation exercises.

4 Technical soundness

Technical aspects of project appraisal are not dealt with in depth elsewhere in the FCDPAG series on the assumption that all options considered for appraisal will have been developed to a technically sound standard expected of the engineering profession. In addition, there is an expectation that those designing flood defence schemes adopt improvements in technical knowledge resulting from the ongoing programmes of research and development. Some issues in the design of flood and coastal defence works, however, retain a considerable degree of uncertainty where few codes of practice or standard methods apply. Some examples are included to highlight those areas where failure to properly assess such aspects in event frequency, hydraulic and design issues can result in technically unsound appraisals.

4.1 Event frequency considerations

Estimating design flows

There are general difficulties in working with rare hydrological events in the 'tail of the frequency distribution'. This situation can apply even when relatively good data sets are available for analysis. Records of river flow seldom exceed 50 years at present and yet typical design standards of 100 and 200 years are required. The *Flood Estimation Handbook* (reference 4) presents new methods for estimating design flows and is highly recommended for its realistic approach to flood estimation. Whatever method is used, the confidence limits should be determined and incorporated into a risk assessment so that the potential impact of uncertainty in the overall design can be considered. (See also section 6.)

Misleading trends

Inappropriate analysis and interpretation of data from historical events can result in misleading conclusions, especially in the light of climate change. There are well known cycles in tidal data, which may wrongly appear to signify a trend if only short-period records are considered. The possibility that extreme events may result from significantly different circumstances or combinations than those occurring more frequently should also be considered. Simple extrapolation techniques for frequency relationships are seldom valid and, for fluvial cases, methods recommended in the *Flood Estimation Handbook* should be considered.

Joint probability methods

In coastal design studies, the determination of extreme sea levels and combinations of surge and wave conditions require expert analysis usually involving the use of joint probability methods. Incorrect application of such methods (or inappropriate use of simplified methods) can easily result in overestimation of the risk, and therefore the benefits of a scheme. Conversely, a failure to take account of all potential failure mechanisms can result in significant under-design. Good documentation of the full range of identified critical design combinations of tide, wind and surge is essential as it provides useful information for post scheme maintenance checking, flood warning criteria and post project evaluation.

Defining analysis requirements

In all types of frequency analysis for scheme appraisal it is important to define carefully the requirements of the analysis. Usually it will be appropriate to consider this in terms of probability of occurrence of major impacts. For example, to reduce the annual likelihood of property flooding to less than 1% per annum it may be acceptable that the river flood wall overtops with a 2% probability if the

drainage system behind the wall can cope with the overtopping flow and the areas flooded do not represent a risk to life and property.

Use of terminology in consultations

The use of return periods can often be misunderstood and should be avoided where possible, particularly in public consultation and discussions with other bodies. Use of probabilistic comparisons with randomly distributed events, which relate to common experience and simple explanations, based on encounter probabilities given in section 2.3.2 of FCDPAG4, are likely to provide a better insight than simple return periods. They also provide a better way of understanding recurrence of the '50-year' flood. The complexity of joint probability problems can also cause difficulty during consultation where good local knowledge and experience of sea or river conditions exists. In such cases there may be a degree of scepticism on the proposed standard of defences. It can be useful if complex studies are supported by case studies of notable events to demonstrate that these lie within the range of conditions that have been considered.

4.2 Hydraulic considerations

Safety factor in design

Certain design features naturally provide a factor of safety against uncertainty. Where possible these should be exploited to reduce associated risks. For example, river levels in wide flood corridors with greater surface area are less sensitive to changes in water volume or estimates of peak flow than narrow corridors. If restrictive embankments or bridge abutments are built along rivers, the effects of any errors in flow estimation are magnified. Hence wide river corridors are generally preferable and schemes that significantly reduce the available width for flood flow should be avoided.

Assessing the impact of changes

When introducing changes which affect the natural regime of a river system, great care must be taken in their correct identification and the analysis of before and after effects. For example, if storage is introduced into a river system, either deliberately with detention reservoirs or through changes in hydraulic conditions in the river channel, the effects on the duration of critical design storms must be taken into account. In general it is important to re-analyse all systems with proposed changes in place so that effects such as new critical flow conditions (i.e. those liable to cause flooding) or changed timing of combined downstream effects of the natural and changed catchment areas are fully considered.

Checking model results

There can be a danger of over-reliance on computer modelling. Models can only represent the processes that they are designed for and for which appropriate parameters are entered. Over-simplification of processes should also be avoided, e.g. the use of global coefficients and factors in process models. This should be obvious, but there is a strong tendency to attach greater credibility to output from a computer than from a set of manual calculations, particularly when the output is displayed using sophisticated graphics. Clearly there is a need to ensure that the underlying processes are well understood. 'Order of magnitude' checks should be carried out and models calibrated with a range of event data and then validated with independent data, if gross errors are to be avoided.

Visual inspection

Knowledge of the site and the use of visual inspection of areas to be modelled should always be used to back up survey data. It is important that staff with sufficient experience to be able to recognise physical features relevant to hydraulic analysis should do this work. Visual inspection is particularly important for the

correct identification of 'controls' in rivers where the effects of physical features, particularly in 'out of bank' conditions, can be critical to effective hydraulic analysis. Similar considerations apply in coastal situations when, for example, considering structures to control coastal sediment transport.

4.3 Design considerations

A full range of options

The need to develop a full set of technically and operationally viable options (covering an appropriate range of standards) is vital if a comprehensive and meaningful appraisal is to be undertaken. For example: protection only to certain areas of development or other forms of differential protection within flood risk areas may sometimes be appropriate, even the possibility of individual protection to existing properties should not be ruled out in suitable cases.

Identifying failure mechanisms

As a general rule, the more complex a defence system is, the more ways it can fail. For coastal defence systems that consist of many inter-related elements (e.g. beaches, control structures, sea walls and cliff drainage), or equivalent river situations (e.g. sluices, pumping stations, channels and raised defences), there is a need to consider a wide envelope of design conditions including (joint) probabilities and partial defence failure. The possibility of 'failure' from non-extreme but repeated events should also be considered in the range of design conditions.

Exceeding design conditions

Consideration should always be given to what happens when the design standard event is exceeded. The presence of defences can cause worse effects in severe floods compared to the 'no defence' case. Such effects should be recognised and mitigation measures incorporated into the scheme, such as preferential flooding of recreation areas, the creation of safe flow paths or water evacuation routes and the provision of flood warning systems, where appropriate and justified. It is also important that the results from such analysis of 'above design standard' events should be taken into account in flood warning and emergency planning.

Freeboard allowance

Freeboard is generally understood as being the difference in level between the built crest of a flood defence and the design flood level. This is incorporated to allow for uncertainties in the design, construction and operation procedures. An Environment Agency R&D Guidance Note has recently been produced which provides a consistent technical approach to the calculation of freeboard allowances using risk analysis (reference 13). The use of this approach is recommended. The method involves determining an allowance for uncertainty in the design flood level (e.g. due to hydraulic modelling and frequency analysis) plus an allowance for physical processes such as settlement. A further allowance relating to the consequences of overtopping can also be made. However, care is still needed in the application of freeboard allowances as, for example, their differential application to different structure types can have a significant impact on the residual damage in 'above design standard' events.

5 Decision making

5.1 Economics as a basis for decision making

Economics and design making

The critical role of project appraisal techniques in promoting good decision making is stressed throughout this FCDPAG series, indeed it is the main driving force behind the series. Each element of project appraisal, from developing a strategic framework to economic and environmental assessments, technical soundness and a full consideration of risks is drawn together in the final decision making stage to achieve the selection of the best overall option. Good decision making should not rely on chance but on a full and informed consideration of all the relevant factors influencing the outcome.

FCDPAG4 provides guidance on the role of risk assessment in decision making and option selection. It includes evaluating the economic impact of risk and, where necessary, methods for non-monetary assessment.

A significant section is also included in FCDPAG3 (section 6) titled 'Choosing the option' which gives guidance on economic-based decision making.

If **all significant factors** in the project appraisal can be satisfactorily expressed in monetary terms, then benefit – cost considerations are the most appropriate basis for decision making. The benefit of such decision making is that it is founded on logic and is transparent. However, if this is not the case, economic considerations should be viewed in the context of other factors if the most appropriate decision is to be made.

5.2 Other considerations in decision making

Other factors

If all significant factors in the project appraisal cannot be satisfactorily expressed in monetary terms, an alternative basis for decision making must be determined. Options that might be considered include the following.

Legal obligations

- There may be clear legal obligations to undertake some course of action, which override a benefit/cost basis for decision-making. Selecting the **least cost** option, that still meets the legal criteria, is an acceptable solution in this case. However there is still a need to consider the wider implications of such decisions (e.g. if health and safety requirements for operating a pumping station are going to cost more than the whole-life benefits derived from the station then there is always an option to abandon and demolish).

Multi-criteria analysis

- Multi-criteria analysis is a non-monetary based technique, which compares attributes of different options by assigning a scoring and weighting system. The method is described in FCDPAG4 – risk assessment. It can aid the process of screening options or build a consensus between project participants with possibly divergent objectives. Such analysis can cover issues that are economic in nature, e.g. concerned with efficiency of resource use or maximising welfare, but are difficult to express in monetary terms. Although it is not necessary to assign monetary values it is still clear that a significant amount of data is required to construct a meaningful and robust decision process based on multi-criteria techniques.

Sustainability

- Where there is a choice of implementing an option that is judged to be more sustainable (see section 7), or one that offers a greater degree of environmental enhancement, a decision will have to be made as to whether any additional cost is worthwhile. Such decisions can only be taken on a case by case basis, taking account of all factors including the responses to consultation.

Prioritising expenditure

5.3 Prioritisation

Since 1997, MAFF has operated a formal prioritisation system in England, which identifies at an early stage in project development whether schemes of sufficient priority may be considered for grant support in the national investment programme. The scoring system is designed to ensure that public money for flood and coastal defence is invested in the areas of highest priority.

To avoid unnecessary work, the scoring system is designed to be applicable on the basis of information available at the pre-scheme feasibility stage. These priority scores are often used by the operating authorities as a major factor in deciding whether to proceed with a detailed scheme development. If the priority score is insufficient to attract grant aid an operating authority is likely to have difficulty justifying to other funders the need for urgent investment.

The original prioritisation system was introduced as a pilot and an undertaking was provided to review the operation of the system after three years. A review is being undertaken in 2000/2001 and any new scheme of prioritisation will take account of that review and extensive consultation.

6 Climate change

6.1 Background

Human influence on climate

In 1996, the Intergovernmental Panel on Climate Change (IPCC) reported for the first time that the balance of evidence suggests there is a 'discernible human influence on global climate'.

In January 2001, this was updated to 'there is new and stronger evidence that most of the warming observed over the last 50 years is attributable to human activities'.

The level of 'greenhouse gases', principally carbon dioxide, in the atmosphere has increased by about 30% since pre-industrial times. Increased levels of greenhouse gases are known to have the potential for warming of the global climate. The world is about 0.6°C warmer than a hundred years ago. The latest indications are that a further 2–3°C increase in average global temperature is expected by 2100. Global warming results in changes to atmospheric circulation and ocean currents that drive the world's climate patterns.

Mitigation of factors that cause climate change is being approached through international agreements such as the Kyoto targets for emission control and reduction. However, even if targets are achieved, it is likely to take several hundred years to stabilise the effects. Some climate change is therefore inevitable and adaptation to these changes will be essential. Scientists and policy makers still do not have a full assessment of the implications of climate change and how it is going to affect the way we live and work. The challenge for policy makers, operating authorities and individuals is to understand:

- the nature and scale of climate change risks; and
- the steps needed to adapt to unacceptable risks or to capitalise on opportunities.

Responding to climate change

Changes in flood risk and the implications for flood defence have been identified as one of the top five national concerns arising from climate change predictions (reference 8). However, the response to uncertainty cannot be to build ever-higher defences. This would probably have significant adverse implications for river and coastal processes and lead to extra risks in the event of defence failure. Also, if funds are invested in the short term in achieving particularly high standards in a few locations, this will mean that other defence improvements are not funded and the overall risk may well increase.

6.2 National research framework

6.2.1 General climate change research

DETR research

Government-funded research into climate change is co-ordinated by the Department of the Environment, Transport and the Regions (DETR). In 1997, DETR established the UK Climate Impacts Programme (UKCIP) with the specific objective to:

'co-ordinate and integrate a stakeholder-led assessment of the impacts of climate change at a regional and national level and to help organisations plan for climate change.'

Climate change scenarios

A key approach taken by the programme has been to develop a set of four alternative climate change scenarios. The scenarios represent different rates of global warming to 2080 classed as low, low-medium, medium-high and high (see references 5 and 6). Outcomes are derived from modelling experiments undertaken by the Hadley Centre for Climate Prediction and Research at the Meteorological Office and concentrate on effects in the UK. Current and future research is using these scenarios to evaluate impacts on the natural, commercial and social life in the UK and possible adaptive measures in areas such as water resources, flooding, buildings and infrastructure, nature conservation, agriculture and planning (see reference 7 and 8). New UKCIP scenarios will be developed by 2002, which will provide greater spatial detail and more information on extremes.

Climate change indicators

Other initiatives include the identification and reporting of a set of 34 climate, ecological and socio-economic indicators to monitor how climate change is affecting the UK (reference 9). It is, however, recognised that the early detection of changes in extremes, such as flood frequency, is very difficult and predictions of such changes are very uncertain. Clearly it is those extremes that interest all designers of flood and coastal defence schemes, although only future generations will know if such predictions were correct. In the interim, pragmatic approaches to dealing with such changes need to be adopted.

6.2.2 MAFF-funded work on flood and coastal defence

MAFF research

In recognition of the particular potential impacts of climate change on flood and coastal defence, MAFF also has an ongoing programme of related research (co-funded with the Environment Agency) that will be used to keep current guidance under review. This programme includes:

- long-term monitoring of selected sites on the national tide gauge network in an absolute reference frame through both precision Global Positioning Systems (GPSs) and relative gravity measurements;
- over a further five- to ten-year period, these will provide the basis for re-estimating the long-term land level movements that need to be taken into account when assessing relative sea level rise;
- estimation of the potential economic impact of climate change due to sea level rise and changes in river flood regime and the development of methods for a comprehensive assessment of regional impacts due to these changes; and
- investigation into the potential impact of changes in extremes of waves, tides, surges and river flows on river and coastal flood and erosion risk areas.

6.3 Impacts of climate change

6.3.1 Introduction

Uncertainty

Global warming is predicted to cause changes to the world's climate and ocean processes but uncertainties remain as to the nature and degree of these changes, particularly at a regional level and with respect to the occurrence of extreme events. There can no longer be confidence that the climatic statistics of the recent past will provide an adequate description of the climate of the future. To address this, adjustments and allowances (e.g. for sea level rise or design flows) are recommended in the design process. As understanding of climate change improves guidance will be updated.

Natural variability

The climate change scenarios described in section 6.2 provide basic information on sea level rise and meteorological aspects affecting the long-term sustainability of flood and coastal defence. Existing natural variability in climate is thought likely to dominate until 2020, and then the effects of human-induced climate change may start to become more noticeable, with climate change effects superimposed on natural variability.

It must be recognised that such climate changes will not take place in isolation. At the same time, ongoing socio-economic and geographical changes in land use and planning policy will continue to affect the impact and occurrence of flooding. The following sections provide a summary of likely impacts of climate change on sea level rise, ocean circulation patterns, precipitation and wind-based on current understanding. Recommended allowances or approaches in dealing with these impacts are included where available.

6.3.2 Sea level rise

Rising sea levels

Global warming has already been causing sea levels to rise at a rate of some 1.5 mm per annum during the last century to the year 2000. There is reasonable agreement that this rate of rise is likely to increase over the coming decades. The rise is principally due to thermal expansion of the oceans (liquids expand when heated) and to a lesser extent from melting of the ice caps and glaciers (see Figure 6.1 that shows median predictions from the Hadley Centre in 1998).

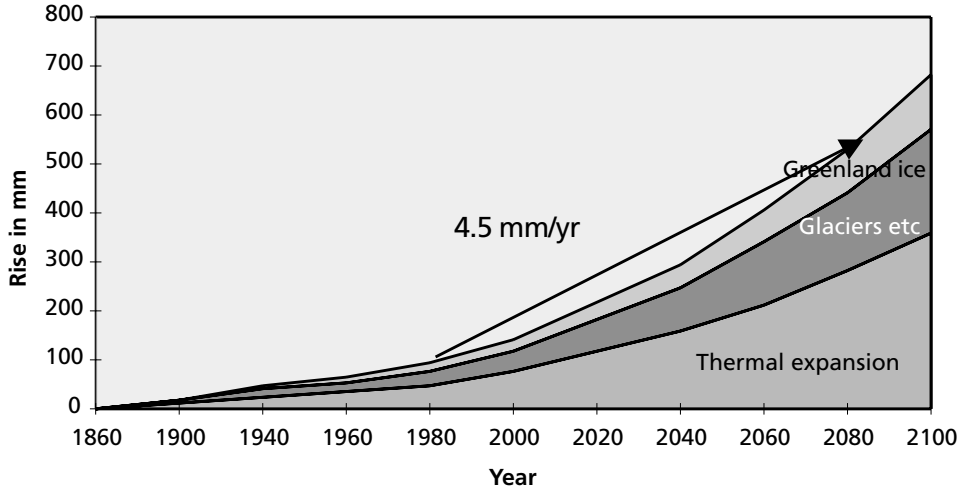
Land movements

MAFF has been providing guidance for incorporating sea level rise into the design of sea defences since 1989 based on an assumed linear rate of global rise of 4.5 mm per year. As can be seen from Figure 6.1, if the latest median predictions are correct and can be assumed to be reflected in changes to extremes, then the current allowances should be sufficient to take account of sea level rise until well into the latter half of the 21st century. The UK is also subject to post-glacial geological land movement. The effect of this is a small rise in land levels, more so in the north and west and to a lesser extent in the south and east. The MAFF guidance combines these land movements with the sea level rise estimates to give a net figure for sea level rise. FCDPAG3 provides guidance on the current recommended regional allowances for sea level rise that should be used.

Flexibility in design

It is intended that these predicted changes should be incorporated into the design process and economic appraisal. This should be achieved by recalculating impacts such as wave run-up and overtopping volumes for each period in the future. FCDPAG3 recommends that such evaluations be made at ten-year intervals, although some interpolation can often be used. Clearly there are significant areas of uncertainty. For long-term schemes, such as new sea walls, the possibility of raising levels in the future without major reconstruction should be incorporated in the design.

Figure 6.1 Predicted global mean sea level rise showing its components and rate used for current allowances



6.3.2 Ocean circulation changes

Gulf Stream changes

There is some speculation that climate change could have a significant effect on certain important ocean circulation patterns, including those in the North Atlantic. Potentially, this could have considerable local impact on the climate of the British Isles that depends on the warming effect of the Gulf Stream for its mild maritime climate. Although currently considered unlikely, a weakening or 'switch off' of the Gulf Stream could lower UK temperatures by 3–4°C. However, global warming scenarios would still be likely to dominate such local effects in the long term. In addition, parameters of global ocean temperature and ice melt should not alter and the need to plan for sea level rise in the lifetime of current schemes remains.

6.3.3 Precipitation effects

Wetter winters

Current research indicates that average precipitation in the UK will increase, with wetter winters and drier summers (except in the north, where summer rainfall may also increase). Climate change scenarios (see section 6.1) suggest increases in winter precipitation of between 3–15% in the north and 1–6% in the southeast are possible by the 2080s. Some research is indicating that the distribution and intensity of precipitation may also vary, with more rain potentially falling in heavier bursts; a factor that is critical in determining the severity of flooding.

An increase in higher daily totals during the winter months and lower daily totals in the summer months has been detected over the period 1961–95. However, analysis of national records of flood occurrence has not detected any significant long-term trend to date. Natural variability in precipitation is considerable and attributing trends to climate change has many uncertainties. A phenomenon known as the North Atlantic Oscillation is one potential cause of natural variability in the UK. It relates to the difference in barometric pressure between Greenland and the Azores and influences the position of pressure systems in the North Atlantic. An upward trend in the winter North Atlantic Oscillation from the 1960s to the early 1990s is associated with stronger and more frequent westerly and southwesterly flows over the UK in winter, causing more frequent heavy rainfall.

Precipitation patterns

The effects that changes in precipitation patterns might have on different catchment types can only be speculative at present. For example, persistently wetter autumns could affect the frequency of flooding in chalk catchments and more frequent intense storms could increase flooding in small rapid response catchments or urban areas.

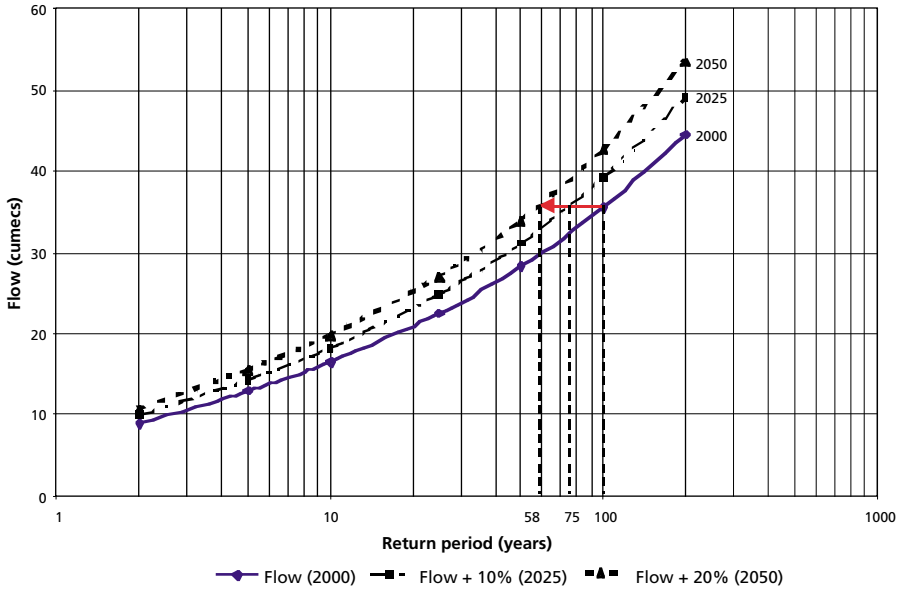
Flexibility in design

In view of the current uncertainty, it is recommended in FCDPAG4 that consideration of possible increases in peak flow is included in the sensitivity analysis of river flood alleviation schemes. In particular, it recommends that the sensitivity analysis of river flood alleviation schemes should take account of potential increases of up to 20% in peak flows over the next 50 years. In view of the uncertainties it will often be preferable to consider design options which allow the possibility of future incremental adaptation.

Sensitivity testing

Figure 6.2 provides an example of how it is intended that the 20% adjustment should be applied to the design flow frequency. In the figure, a typical flow-probability relationship is shown, with the flows increased by 10% to reflect the revised relationship in 2025 and by 20% to reflect the prediction for 2050. In this case, the 1% (1 in 100-year) flow event becomes the 1.33% (1 in 75-year) event by 2025 and the 1.7% (1 in 58-years) by 2050. This approach should be used as the basis for appropriate sensitivity testing of options and their benefits.

Figure 6.2 Flow frequency adjustment for climate change sensitivity



6.3.4 Wind effects

Uncertain impacts on winds

Average autumn and winter wind speeds may increase by 1–7% by the 2080s with a possibility that extreme events, storminess and wave impact may become more frequent (although this is still an area of significant uncertainty and further research). This has obvious implications for the design and maintenance of sea defences. Previous research has shown that even relatively modest changes in mean wind direction can have a marked impact on sediment transport, in some cases even reversing the direction of drift. Clearly such extreme sensitivities should be investigated during routine modelling and design. It is not, however, possible at present to give general guidance on the magnitude of potential change that should be considered.

6.3.5 Surge effects

Inconclusive research results

Investigations into the effect of climate change on the frequency and severity of storm surges are at an early stage. Initial results modelling up to the year 2100 have produced inconsistent results depending on which models are used. Some models indicate as much as a 20% increase in extreme surge heights whilst others indicate a potential reduction. In view of this high degree of uncertainty, it is not possible at present to give guidance on whether allowances for changes in storm surge due to climate change should be used. Guidance will be issued when further research provides more consistent indicators of likely changes.

6.4 Adapting to climate change

Adaptation responses

Whilst reducing greenhouse gases emissions remains the primary goal, the UK Government also recognises the need to adapt to the unavoidable impacts of climate change if the worst effects are to be avoided. It accepts the need to take a precautionary approach to risks and seeks to identify short-term 'no regrets' actions and longer-term 'adaptation responses' as a first step to living with climate change (see references 7 and 8).

Precautionary approach

For flood and coastal defence, the challenge of dealing with climate change impacts will be a long and sustained process based on building adaptive measures into the maintenance and provision of new defences. A strategic approach to the management of flood and coastal defence will be crucial to this process if appropriate short-term measures and long-term policies are to be identified and implemented successfully. Examples of how the precautionary approach might be applied to flood and coastal defence are included below.

Examples of the precautionary approach:

- Oversized culverts/bridges on a relief channel scheme;
- Designs for defence walls with provision for future raising;
- Consideration of overflow routes to minimise risks to life and property in the case of 'above design' events or culvert blockage;
- Avoid creation of new defended areas (e.g. leave recreational and other margins in urban areas outside defences to provide additional storage/flow capacity and reduce the chance of increasing hazard through future development).

Very few items are true 'no regrets' actions in the sense that they do not impose cost anywhere (e.g. a loss may be incurred in developing a more expensive site outside the floodplain if permission for floodplain development is refused). However the following are probably practical examples of 'no regrets' actions in most situations.

'No regrets' actions

Examples of 'No regrets' actions:

- Retaining existing natural floodplain areas, salt marshes and mudflats;
- Enhancing wetland areas (provided this does not significantly reduce flood flow capacity or storage);
- Adopting sustainable drainage practices for new development (these techniques will reduce the impact of the development for more frequent floods even if they do not have a significant impact in more severe flood events, and costs are often not significantly greater, and may be less, than for conventional drainage systems);
- Measures to increase the awareness of flooding risks amongst floodplain residents and decision makers.

It is clear that those areas which are at risk of flooding and erosion today will, unless abandoned, also be at risk in the future and that the levels of risk will almost certainly increase. The best adaptive response is therefore to avoid significant increases in risk by avoiding inappropriate development in high-risk areas. The promotion of managed realignment as a means to provide long-term, viable flood defence requires evaluation wherever possible. For existing development, mitigation measures should be adopted in high-risk areas, in the form of improved or upgraded flood and coastal defences, where these are sustainable and justified on technical, environmental and economic grounds. In some areas, relocation may be the only viable long-term solution.

FCDPAG 4 includes guidance on dealing with climate change from the point of view of uncertainty and using sensitivity analysis to assess the impact of potential changes. Where appropriate sensitivities (e.g. design flows, sea level rise, surge, wind/wave) as identified in section 6.3 should be considered in scheme design.

7 Sustainability

7.1 Background

The aim of Government flood and coastal defence policy is:

Understanding sustainability

> *'To reduce risks to people and the developed and natural environment from flooding and coastal erosion by encouraging the provision of technically, environmentally and economically sound and* ***sustainable*** *defence measures.'*

Sustainable schemes are defined as: 'schemes which take account of the interrelationships with other defences, developments and processes within a catchment or coastal sediment cell, and which avoid as far as possible tying future generations into inflexible and expensive options for defence.' (MAFF *Strategy for Flood and Coastal Defence in England and Wales*, reference 1).

Sustainability has also been defined as:

> *'development that meets the needs of the present without compromising the ability of future generations to meet their own needs' (Bruntland Commission Report, reference 10).*

In May 1999, the Government published *A better quality of life – a Strategy for Sustainable Development for the United Kingdom* (reference 14). Following this general approach more specific sustainability strategies for areas such as construction – *Building a better quality of life – a Strategy for More Sustainable Construction* (reference 11) have been produced and led to the development of industry action plans, such as *Achieving Sustainability in Construction Procurement* (reference 12).

7.2 Sustainability in practice

In recent years, sustainability has increasingly been quoted as a desired objective but seldom implemented in practice to the extent that it could be.

Expectations

This appears to be due in some degree to uncertainty by practitioners in what is expected and the extent to which time and effort should be expended in seeking out and comparing the sustainability of various actions (clearly this implies aims for sustainability that are capable of being comparative). The implementation of action plans (reference 12) for sustainability, as referred to in section 7.1, should in future give improved direction to achieving this.

Sustainability is an issue dealt with in FCDPAG5 on environmental appraisal, where it is linked to strategic objectives of long-term planning and to environmental objectives such as the wise use of resources and achieving biodiversity targets.

Long-term benefits

Sustainability is considered in FCDPAG3 in economic appraisal. The achievement of long-term stable benefits is suggested as an alternative preferred option to one with a higher benefit – cost ratio but which has reducing protection standards over time (i.e. is less sustainable).

Design issues

Sustainability is also an issue for technical soundness when it comes to looking at construction processes (reference 11). The relative maintenance demands of technical solutions, the long-term availability of equipment or materials and even the mode of failure or ease of demolition and potential for eventual recycling of materials are aspects of sustainability that may need to be considered in the design process.

What can be concluded from the above is that sustainability is an issue which affects all aspects of project appraisal. It most often affects the 'way it is done' but can also impact on 'what is done'. If it is to be addressed in practice, some basic principles need to be established to support practitioners in the project appraisal and decision-making process so that appropriate weight is given to the development and selection of sustainable options on merit.

7.3 Some basic principles for achieving sustainability

Achieving sustainability

A strategic approach to problem identification and project appraisal is most likely to ensure that all relevant issues have been addressed. Taking proper account of these issues and establishing sustainability as one of the strategic aims when exploring a wide range of solutions that address them is likely to result in the identification and development of sustainable options.

Taking a long-term and whole-life design approach is most likely to result in options being developed which naturally meet all types of sustainability criteria including technical, environmental, social and economic. Good decision making on the basis of whole-life costs and benefits gives a truer comparison between options than simply looking at limited, short-term scheme life costs and benefits, and is more likely to favour sustainable options.

Proper consideration of the 'do nothing' option is a critical step in the process to identifying sustainable options. The assumption that 'something must be done' is a common mistake and can lead to the introduction of a non-sustainable regime of work.

Adopting the approach of working with natural processes rather than fighting against them can improve both the resilience and sustainability of defences and river and coastal habitats. The opportunity to incorporate and use natural habitats, such as salt marsh or wetlands, as a part of the flood defence solution, may in some cases reduce the extent and cost of built defences.

7.4 Sustainability check-list

Issues to consider

The check-list below is a summary of aspects which may need to be considered if sustainability issues are to be addressed fully. However, the list is not exhaustive and neither is it intended that it should be used as a procedure to incorporate sustainability in project appraisal. Individual projects will require different aspects of sustainability to be considered in more or less detail depending on the nature of the works and their impact.

Sustainability is – Preserving and enhancing the environment

- Minimising the environmental and social impact of activities, e.g. ensuring water quality is not affected, unacceptable noise levels created or heritage sites disturbed;
- Ensuring all actions are environmentally neutral or positive, and contribute to biodiversity and other environmental targets, e.g. ensuring that there is no net loss (or some gain) of inter-tidal habitat on an estuary;
- Avoiding pollution and reducing greenhouse gas emissions (largely through reduced energy use) during construction and scheme life.

Sustainability is – Using resources efficiently

- Using sustainable construction materials – renewable, recycled or in the local natural resource cycle, and gained without adverse environmental effect;
- Minimising the use of construction materials (especially where these are not renewable);
- Being energy efficient in transport and operational activities;
- Minimising or recycling waste materials.

Sustainability is – Ensuring design, operation and maintenance processes are efficient and flexible to long-term needs

- Ensuring maintenance and operation is efficient in using the least materials and energy for the greatest effect;
- Designing for long-term viability and adaptability to meet the needs of future generations;
- Designing with a whole-life approach – including adaptability to natural processes, climate change impacts and other factors as listed below:
  - Repairable design – designed with maintenance and repair needs in mind;
  - Designed for failure – designed so that any failure is not catastrophic but controlled;
  - Designed to optimise the overall scheme costs and minimise any dismantling costs;
  - Sustainable use of skills – not unique or overly complex (related also to risk);
  - Designed with a dual or multipurpose functionality – e.g. sea wall with promenade or offshore reef providing fisheries habitat or the provision of a walkway along a river floodbank (efficient use of resources).

8 Pitfalls and common mistakes in project appraisal

This section gives examples of some of the more common pitfalls and mistakes that can occur when appraisals are not carried out correctly. With use and reference to the FCDPAG series it is hoped that such problems will not occur. Pointers are given in *italics* after each of the examples to illustrate how use of this guidance series should lead to an improved approach.

8.1 General issues

Example 1

Some appraisals seem to start from an assumed solution, usually driven by historical practice or engineering considerations, on which a justification is subsequently attempted. In some extreme cases an option is selected and extensively consulted upon (even up to planning approval) with only an outline benefit assessment being in place. What purports to be a full economic and environmental assessment is then undertaken in parallel with the detailed design. This can lock a project into an option that is not appropriate and it can be very difficult and embarrassing for the operating authority when they have to change a project at that late stage.

If the principle of appraisal-led design promoted throughout this series is followed and basic objectives are defined before going through the cycle of developing, comparing and selecting options on the basis of economic, environmental and risk evaluations, the danger of selecting an unsuitable option at too an early stage should be avoided. Although this may appear to add delay at the start of the project development process, it will be outweighed by the savings in time made later.

Example 2

Failure to provide clear information in the appraisal document on:

- a statement of the problem;
- a statement of the existing standard of defence; or
- a valid failure scenario of the existing defence (e.g. potential breach locations, size and number) where one is present.

This may be due to inappropriate approaches to the appraisal or to poor drafting of the report. However, the lack of such information clearly throws doubt on the quality of the appraisal that has been undertaken. Justification of expenditure on the basis of improvement cannot be made if the current situation has not been adequately assessed to act as a baseline.

Example 3

There is a tendency to concentrate on using set standards e.g. 10% (1 in 10-year), 5% (1 in 20-year) and 2% (1 in 50-year) annual probability events when developing defence option proposals as opposed to identifying more meaningful thresholds relating to actual flooding of risk areas.

A better appraisal is achieved if it reflects the real issues of the area affected. Consider the case where only a few properties are affected between the 10% annual probability (1 in 10-year) and 2% (1 in 50-year) event standards and then increasingly large numbers are affected in say the 1.5% (1 in 67-year), 0.9% (1 in 110-year) and 0.65% (1 in 150-year) events. There is more to be gained by looking at the relative merits of options protecting to the levels of the 2%, 1.5%. 0.9% and 0.65% probability events than in carrying out detailed analysis for an arbitrary set of return periods. (See FCDPAG3.)

Example 4

The use of inexperienced staff to prepare appraisals can result in poor quality or erroneous proposals, which have to be reviewed and rejected, wasting considerable time by all concerned.

Flood and coastal defence problems are rarely amenable to 'off the shelf' or text book solutions. Adequate appraisal leading to appropriate solutions requires the involvement of properly trained and experienced individuals or teams who can appreciate all aspects of the problem to be solved.

8.2 Strategic considerations

Example 5

Where extensive low-lying areas are protected by a number of unconnected defences, the benefits derived from the whole of the flood risk area have been used to justify works each time a part of the defence system requires upgrading. The justification given is that the loss of any part of the defence will cause flooding to the whole area. Over a period of time with different lengths of defence requiring works, the same benefits could potentially be counted many times over if this argument were to be accepted.

Multiple counting of benefits over different schemes is clearly unacceptable. The most appropriate and logical approach is to consider a long-term strategy for the whole area with appropriate phasing of the works on individual defences to minimise the overall risk. This will avoid the risk of double counting of 'do-nothing' benefits. A strategic approach will provide a means to determine the most effective way of managing all risks to the area in a proactive manner over a long time period. It will also provide the basis to decide whether a long-term protection policy is viable and, if so, the appropriate standard(s) that should be adopted (or if a policy of managed realignment should be considered). Realistic limits on the areal extent of flooding in any breach or overtopping scenario also need to be considered for any active response options and care is needed to ensure that double counting of these 'with project' damages is avoided.

8.3 Option selection

Example 6

Making the assumption that something has to be done even when it is not justified. This can typically arise from political pressure after an event.

If a full range of options is considered, and most importantly a 'do-nothing' option, this situation should not occur. A well considered 'do-nothing' option could temper political pressure when it is viewed in the light of making the best use of public funds.

Example 7

Failure to grasp the role of properly considering 'do-nothing' as the baseline against which other options are considered. The cause of this can be a misunderstanding of the principal assumptions of the 'do-nothing' case or a belief that it is simply not an acceptable option and therefore does not justify detailed consideration.

FCDPAG3 stresses the importance of properly considering the 'do-nothing' option. Even where 'do-nothing' is not a viable option, it is important as a common baseline against which other options can be compared through economic analysis. The economic benefits generated by completely different types of scheme can then be compared when considering programme prioritisation.

Example 8

A wide range of options is initially considered prior to homing in on a few for detailed appraisal. The options are not discussed in the appraisal documentation or reasons for their rejection presented. During the review of the appraisal or consultation phase, questions are asked on why such other options have not been considered. Further work then has to be undertaken, possibly re-investigating these options, when this could have been incorporated at an earlier stage.

The appraisal process is identified as: define, develop, compare, select (FCDPAG2 section 2.3). The first stage of defining the problem and identifying all the options must be comprehensive if it is to be effective. All options considered should therefore be documented in the appraisal report (or strategy plan). If options are eliminated in the development, comparing or selection stage, reasons for this also need to be documented so that a clear audit trail of the appraisal process is retained.

8.4 Economic appraisal

Example 9

There can be a tendency to assume that a high capital cost/low maintenance cost option is better than a low capital/higher maintenance scheme, perhaps due in part to the provision of grant aid on capital expenditure. Economics may in fact favour the scheme with higher revenue costs than capital costs.

Good decision making requires that the scheme appraisal must consider all practical options and take due regard of economic efficiency. All things being equal, the scheme with the

highest benefit–cost ratio should be selected (as modified by the decision process set out in section 6.2 of FCDPAG3) unless other factors such as environmental, risk or sustainability considerations provide sound justification for choosing another option.

Example 10

Treatment of the impact of sea level rise (or other predicted change) is not always logically considered or well presented.

In general if a scheme appraisal requires assumptions about future change to produce a viable result it is not robust and it may be beneficial to delay action. Nevertheless, where defences are being renewed it is important that sea level rise and other predictable changes are taken into account when determining appropriate standards.

FCDPAG3 recommends that risk levels should be considered at 10-year intervals during the appraisal period taking account of progressive changes in sea level and the same approach should be used for changes in peak river flow in the sensitivity analysis. It will often be necessary to consider the alternatives of providing an increased standard of defence initially or providing the facility for improving the standard at a later date. (See section 6.3.)

Example 11

Schemes may incorporate significant non-flood defence features such as a flood bank widened to create road improvements or a beach recharge scheme where additional quantities of sand, beyond that required for coastal defence, are used to enhance tourism opportunities. The total cost of such schemes may be greater than the flood defence benefits alone, even though the overall benefits of the project may produce a scheme that is well justified in national economic terms.

In these circumstances, the total cost of the projects may not be justified for support with flood defence grant. Such situations should be approached as multi-functional projects and the approach should be that set out in section 2.7 of FCDPAG3. Flood and coastal defence funds are essentially provided by Parliament for the reduction of flood and erosion risks and their use for other purposes will ultimately mean that other projects with a legitimate call on such funding cannot be undertaken.

8.5 Environmental considerations

Example 12

There has been a tendency, particularly in strategy development, to go through the decision-making process of option selection based on technical and economic criteria and then check against environmental and heritage requirements afterwards.

Consideration of environmental issues should be brought into the appraisal process from the very start to ensure that options are identified and developed with environmental impacts and opportunities fully integrated. The broad-based approach to strategy development recommended in FCDPAG2 (strategic planning and appraisal) promotes this methodology.

8.6 Decision-making considerations

Example 13

In the appraisal documentation, there can be a failure to provide a well-reasoned case or explanation of the decision-making process undertaken to arrive at the preferred option.

It is essential that the appraisal documentation includes a description of the rationale for the selection of the preferred option in order to justify the choice. A good explanation is particularly important if the preferred option is not one that would be selected on economic grounds alone.

9 The way ahead

This series of Project Appraisal Guidance represents current best practice in relation to the current statutory framework in the UK. Research and project development are continually evolving and providing the possibility of new approaches. The individual volumes of the series will be reviewed and updated when appropriate, although it is not expected that the underlying principles will change significantly.

In the coming years, we can foresee that there will be easier methods for evaluating intangible human health impacts of flooding. There will probably be tools available to more readily compare the overall environmental, social and economic impact of using different materials and there will be major developments in process understanding and modelling that should enable better predictions to be made. However, the development of projects and rational decision making will still require the same fundamental approach.

At the time of writing in 2001, the first round of Shoreline Management Plans (SMPs) has been completed for the whole coastline of England and Wales. This will provide a solid baseline of collated data, and the plans have already led to initiation of a number of further strategic studies, following the principles set out in FCDPAG2, for relevant sections of the coast where specific problems have been identified through the SMP. Guidance for second-round SMPs should not only successfully build on what has already been achieved but also achieve a more consistent standard of review and provide greater confidence that future policies are deliverable.

Guidance is being developed for future Catchment Flood Management Plans (CFMPs) which are expected to provide a similar large-scale planning role for inland areas. Other plans that have been completed or that are in operation and have relevance to project appraisal include Coastal Habitat Management Plans (CHaMPs) and Biodiversity Action Plans (BAPs).

A first comprehensive assessment of flood and erosion risk in England has also been carried out and this confirmed that there are significant areas at risk from both river and coastal flooding. It would appear that current levels of investment are significantly less than theoretically required to maintain and replace the flood defence infrastructure protecting these areas as it reaches the end of its effective life. This must imply that risks are increasing, and predicted climate change is likely to add significantly to that risk over the coming decades.

Whilst SMPs and other initiatives have encouraged a comprehensive review of coastal risks, the national risk study and other research has clearly indicated that there is also a long-term risk to areas of development in river floodplains. It is intended that the development of CFMPs will identify those areas at particular risk and that broad-scale assessments will enable attention to be drawn to particularly high-risk areas. It is clearly beneficial both in economic terms and in terms of avoiding human misery if vulnerable areas can be identified and appropriate alleviation measures put in place before extreme events occur. It is also important, as set out in this guidance, that such alleviation methods are comprehensively

considered and that piecemeal solutions to individual problems do not unacceptably increase risks elsewhere.

Even where there are insufficient funds to carry out all works, the fact that strategic studies have been undertaken for significant risk areas should ensure that funds available are targeted in the most effective way. This should also provide decision-makers with clear and quantified assessments of the consequences and associated risks of not investing in defences.

In the UK there is no legal right to any particular standard of protection from flooding or coastal erosion or provision of flood warning. However there are often high public expectations of protection and it is in the public and national interest that appropriate measures are put in place in a timely and efficient way. Hopefully this series of guides will assist in that process.

References

1. MAFF/Welsh Office: *Strategy for Flood and Coastal Defence in England and Wales*. Publication PB1471, September 1993.

2. HM Treasury: *Appraisal and Evaluation in Central Government* (the Green Book), HMSO, 1997.

3. MAFF: *Flood and Coastal Defence – Post Project Evaluation Summary Report 1995/96*. Publication PB 3040, 1997.

4. Institute of Hydrology: *Flood Estimation Handbook*, Volumes 1–5, 1999.

5. Hulme, M. and Jenkins, G.J.: *Climate Change Scenarios for the UK: Scientific Report*. UKCIP Technical Report No. 1, Climatic Research Unit, Norwich, 1998, 80pp.

6. Hulme, M. and Jenkins, G.J.: *Climate Change Scenarios for the UK: Summary Report*, 1998.

7. McKenzie Hedger, M. *et al.* (eds): *Climate Change: Assessing the Impacts – Identifying Responses. The First Three Years of the UK Climate Impacts Programme*. UKCIP Technical Report, UKCIP and DETR, Oxford, 2000.

8. Environmental Resources Management: *Potential UK Adaptation Strategies for Climate Change*. DETR, 2000.

9. DETR/NERC: *Indicators of Climate Change in the UK*. NERC, 1999.

10. WCED: 'Our Common Future': The Report of the World Commission on Environment and Development (The Bruntwood Commission'). Oxford University Press, 1987.

11. *Strategy for More Sustainable Construction – Building a Better Quality of Life*. DETR, April 2000

12. Government Construction Client's Panel: *Sustainability Action Plan – Achieving Sustainability in Construction Procurement*. GCCP, 2000.

13. Environment Agency Research and Development: *Fluvial Freeboard Guidance Note*. Technical Report W187, Water Services Association, 2000.

14. *A Better Quality of Life – a Strategy for Sustainable Development for the United Kingdom*. DETR, 1999.

Glossary

Adaptation approach*	An approach being taken by Government to deal with climate change in the UK. The principle is to assess potential impacts from considering different climate change scenarios and then develop strategies, where appropriate, which enable society to adapt in a planned and appropriate manner and rate.
Benefit–cost analysis*	Comparison of present value scheme benefits and costs as part of an economic appraisal. The benefit–cost ratio is the total present value benefits divided by the total present value costs.
Climate change*	Long-term changes in climate specifically linked to those changes resulting from human intervention in atmospheric processes through, for example, the release of greenhouse gases to the atmosphere from the burning of fossil fuels.
'Do-nothing' scenario	An option used in benefit–cost analysis to act as a baseline against which all other options are tested. It assumes that no action whatsoever is taken. In the case of existing works it assumes walk-away: cease all maintenance, repairs and other activities immediately. In the case of new works it assumes that there is no intervention in natural processes. Politically this is often seen as a non-viable option but it is an important comparison tool in benefit–cost analysis.
Economic appraisal	An appraisal that takes into account a wide range of costs and benefits, generally those which can be valued in money terms.
Environment	Where environmental issues are referred to in this document, this term is used to encompass landscape/natural beauty, flora, fauna, geological or geomorphological features and buildings, air, water, sites and objects of archaeological, architectural or historical interest. (It is recognised that in other contexts the environment has much wider implications.)
Environmental appraisal	The process whereby the effects of a proposal on the natural environmental or heritage sites are identified, measured and assessed to determine their significance.

Greenhouse gases	Naturally occurring gases, such as carbon dioxide, nitrous oxide, methane and ozone, and man-made gases like chlorofluorocarbons, which absorb some of the sun's radiation and convert it into heat.
High-level targets*	Targets set for operating authorities by MAFF to ensure and demonstrate the delivery of the Government's stated policy aims and objectives for flood and coastal defence.
Managed realignment	The management of a process of establishing a new defence line, often set back from the existing position, with the aim of improving the long-term sustainability of the defence, or contributing to other aims such as habitat creation.
'No-regrets' action*	Actions taken to respond to perceived climate change impacts whose consequences both economic and environmental will be beneficial (usually in the short term) without imposing any long-term commitments.
Operating authority	A body with statutory powers to undertake flood defence or coastal protection activities, usually the Environment Agency, local authority or drainage board.
Post project evaluation	A procedure to review the performance of a project with respect to its original objectives and the manner in which the project was carried out (see FDCPAG6).
Precautionary principle	An approach which takes avoiding action based on the possibility of significant environmental or other damage, even before there is conclusive evidence that the damage will occur.
Present value	The value of a stream of benefits or costs when discounted back to the present time at a prescribed discount rate.
Project	The undertaking of any discrete item or programme of work (or inter-related elements of work) for a specific purpose. The nature of work can take many forms such as procurement, design, construction, investigation or management.
Risk	A combination of both the likelihood and consequences of an event.

Risk assessment	Consideration of the risks inherent in a project, leading to the development of action to control them (see FDCPAG4).
Scheme	In the context of flood and coastal defence and the FCDPAG series, a scheme usually relates to the implementation of works on the ground. It is normally the case that a scheme (or schemes) is identified as a consequence of a broad-based investigation and has quite specific objectives. Stages of scheme development may include pre-feasibility studies, detailed appraisal and construction.
Sea level rise*	The rise in sea levels due to global warming causing thermal expansion of the oceans and to a lesser extent from melting of the ice caps and glaciers. Relative sea level rise refers to the effective change in sea level relative to the land surface and takes account also of long-term land movement.
Strategic framework*	A planning structure which has been developed using strategic principles within which layers of consistent and inter-related plans and strategies can be developed.
Strategy plan	(In the context of FCDPAG) A documented strategy which is developed from a strategic study of a problem and describes the course of action which has been determined to implement the preferred option.
Sustainability	The degree to which flood and coastal defence solutions avoid tying future generations into inflexible and or expensive options for defence. This will usually include consideration of inter-relationships with other defences and likely developments and processes within a catchment or coastal cell. It will also take account of long-term demands for non-renewable materials.

Whole-life costs*	The total costs associated with a scheme for its full design and potential residual life span, taking proper account of all aspects of design, construction, maintenance and external impacts. A particularly useful approach in helping to determine economic sustainability when used to compare the relative costs of long-life schemes such as flood defences and where decisions between short-term capital costs and long-term maintenance costs need to be made.

*Definitions written for this document.

Annex A: Suggested contents of an Appraisal Report:

A. Executive summary

B. Business case

1. Description of need and opportunity

Background

Problems and failure scenario

The opportunity for change

1. Project objectives

Policy and strategy

Specific elements

3. Existing situation and constraints

Existing installations and infrastructure

Related projects

Protection standards

4. Options appraisal

Description of alternatives considered ('do-nothing' as baseline)

Environmental considerations and mitigation measures

Costs of alternatives

Benefits of alternatives

Risk assessment and sensitivities

Economic appraisal

Consultation undertaken

Choice of scheme

Description of preferred option

5. Conclusions and recommendations

C. Appendices

These should include:

- a summary of the economic analysis (e.g. spreadsheets similar to those referred in annex A of FCDPAG3);
- a copy of the risk register or similar risk assessment for the project; and
- any environmental impact assessment or appropriate assessment (as appropriate).

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