FLOOD AND COASTAL EROSION RISK MANAGEMENT

A Manual for Economic Appraisal

Edmund Penning-Rowsell, Sally Priest, Dennis Parker, Joe Morris, Sylvia Tunstall, Christophe Viavattene, John Chatterton and Damon Owen

ROUTLEDGE

Flood and Coastal Erosion Risk Management

This book is a successor to and replacement for the highly respected manual and handbook on the benefits of flood and coastal risk management, produced by the Flood Hazard Research Centre at Middlesex University, UK, with support from Defra and the Environment Agency. It builds upon a previous book known as the 'Multi-Coloured Manual' (2005), which itself was a synthesis of the Blue (1977), Red (1987) and Yellow (1992) manuals. As such, it expands and updates this work, to provide a manual of assessment techniques of flood risk management benefits, indirect benefits and coastal erosion risk management benefits.

It has three key aims. First, it provides methods and data which can be used for the practical assessment of schemes and policies. Second, it describes new research to update the data and improve techniques. Third, it explains the limitations and complications of benefit–cost analysis, to guide decision-making on investment in river and coastal risk management schemes.

All the authors work at or in conjunction with the Flood Hazard Research Centre (FHRC) at Middlesex University, London, UK. The FHRC has a distinguished 40-year history of interdisciplinary research in this field. It has been commended for this by two Chief UK Government Scientific Advisors, Sir David King and Sir John Beddington, and by the award of a prestigious Queen's Anniversary Prize. This book is an output of new research projects and activities carried out under the joint sponsorship of the UK's Environment Agency and the Department of Environment, Food and Rural Affairs following the severe flooding in the UK in 2007.

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in partnership with Environment Agency

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Key contributors and acknowledgements

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Acronyms and abbreviations

AA	Automobile Association
AADs	Annual Average Damages
ABI	Association of British Insurers
ACC/ISGWR	UN Administrative Coordination Committee Intersecretariat Group for Water Resources
ADS	Above Design Standard
AEP	Annual Exceedance Probability
AES	Agri-Environment Scheme
ALC	Agricultural Land Classification
ARV	Average Remaining Value
AST	Appraisal Summary Table
AWB/HMWB	Artificial or Heavily Modified Water Bodies
B&Bs	Bed and Breakfast accommodation
BAP	Biodiversity Action Plan
BCA	Benefit–cost analysis
BCP	Business Continuity Planning
BCR	Benefit–cost ratio
'Blue Manual'	Penning-Rowsell, E.C. and Chatterton, J.B. (1977) *The Benefits of Flood Alleviation: A Manual of Assessment Techniques*, Gower Publishing, Aldershot
BPEO	Best Practical Environmental Option
BWL	Barrier With Locks
CBA	Cost Benefit Analysis
CCW	Countryside Council for Wales
CEA	Cost-Effectiveness Analysis
CEH	Centre for Ecology and Hydrology
CFMPs	Catchment Flood Management Plans
CHaMPs	Coastal Habitat and Management Plans
CPI	Consumer Price Index
CV	Contingent Valuation
CVM	Contingent Valuation Method
DCLG	Department for Communities and Local Government
Defra	Department for Environment, Food and Rural Affairs
DEM	Digital Elevation Model
DETR	Department of the Environment, Transport and the Regions

DfT	Department for Transport
DM	Do Minimum
DMAs	District Meter Areas
DNO	Distribution Network Operator
DoE	Department of Education
DQS	Data Quality Score
DTLR	Department of Transport, Local Government and the Regions
EA	Environment Agency
ECLAC	Economic Commission for Latin America and the Caribbean
ENA	Energy Networks Association
ESTDAM	Non-GIS-based model developed by FHRC in the 1970s to calculate damages (now obsolete)
ETR	Engineering Technical Report
EWATS	Extreme Weather Action Teams
FCERM	Flood and Coastal Erosion Risk Management
FCERM-AG	Flood and Coastal Erosion Risk Management Appraisal Guidance
FDGiA	Flood Defence Grant in Aid
FLOODsite	Integrated Flood Risk Analysis and Management Methodologies (EU funded project, Contract Number: GOCE-CT-2004-505420)
FOCs	Freight Operating Companies
FRM	Flood Risk Management
FWAGs	Farming and Wildlife Advisory Groups
FWR	Foundation for Water Research
FWRBP	Flood Warnings Response Benefit Pathways
GDP	Gross Domestic Product
GEP	Good Ecological Potential
GES	Good Ecological Status
GIS	Geographic Information System
HLF	Heritage Lottery Fund
HLS	Higher Level Stewardship
IBCR	Incremental Benefit–Cost Ratio
IEH	Institute for Environment and Health
IFP	Indicative Floodplain
LIDAR	Light Detection and Ranging
MAFF	Ministry of Agriculture, Fisheries and Food
MCA	Multi-Criteria Analysis
MCH	'Multi-Coloured Handbook': *The Benefits of Flood and Coastal Risk Management: Handbook of Assessment Techniques*
MCM	'Multi-Coloured Manual': *The Benefits of Flood and Coastal Risk Management: A Manual of Assessment Techniques*
MCM-Online	The companion website to this publication: http://www.mcm-online.co.uk
MDSF	Modelling and Decision Support Framework
NAAR	National Appraisal of Assets at Risk
NaFRA	National Flood Risk Assessment
NAO	National Audit Office
NBO	Next Best Option
NEA	National Ecosystem Assessment
NHS	National Health Service
NPD	National Property Dataset
NPV	Net Present Value

NRA	National Rivers Authority
NRD	National Receptor Database
NRPs	Non-Residential Properties
ODPM	Office for the Deputy Prime Minister
Ofgem	The Office of Gas and Electricity Markets
ONS	Office for National Statistics
PAG	Project Appraisal Guidance
PARs	Project Appraisal Reports
PF	Partnership Funding
PLP	Property-Level Protection
PVd	Present Value of damages
RAC	Royal Automobile Club
RBMPs	River Basin Management Plans
'Red Manual'	Parker, D.J., Green, C.H. and Thompson, P.M. (1987) *Urban Flood Protection Benefits: A Project Appraisal Guide*, Gower Technical Press, Aldershot
RPA	Risk and Policy Analysts Ltd
SAC	Special Area of Conservation
SDS	Strategic Direction Statement
SEA	Strategic Environmental Assessment
SEMD	Security and Emergency Measures Direction
SFVI	Social Flood Vulnerability Index
SMART objectives	Specific, Measurable, Achievable, Realistic and Timely
SMEs	Small and Medium-sized Enterprises
SMMT	Society of Motor Manufacturers and Traders
SMPs	Shoreline Management Plans
SPA	Special Protection Area
SSSI	Site of Special Scientific Interest
STW	Sewage Treatment Works
SUDS	Sustainable Urban Drainage Systems
TE2100	Thames Estuary 2100 (http://www.environment-agency.gov.uk/static/documents/Leisure/SE_TE2100_briefing.pdf)
The 'Green Book'	HM Treasury (2003) *The Green Book: Appraisal and Evaluation in Central Government*, HM Treasury, London
TOCs	Train Operating Companies
VAT	Value Added Tax
VOA	Valuation Office Agency
VOC	Vehicle Operating Costs
VOE	Value of Enjoyment
WAAD	Weighted Annual Average Damages
WDRM	Warning-Dependent Resistance Measures
WFD	Water Framework Directive
WIRM	Warning-Independent Resistance Measures
WIRMB	Warning-Independent Resistance Measures Benefits
WLC	Whole-Life Cost
WLMPs	Water Level Management Plans
WTP	Willingness To Pay
'Yellow Manual'	Penning-Rowsell, E.C., Green, C.H., Thompson, P.M., Coker, A.M., Tunstall, S.M., Richards, C. and Parker, D.J. (1992) *The Economics of Coastal Management: A Manual of Benefit Assessment Techniques*, Belhaven/Wileys, London

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Foreword

This Manual has been produced by the Flood Hazard Research Centre (FHRC) at Middlesex University, under the Modelling and Risk theme of the joint Defra and Environment Agency research and development programme.

It draws on collaboration between the FHRC, Defra, the Environment Agency and other stakeholders, and we recommend its use and the accompanying MCM-Online for benefit assessment as part of flood and coastal erosion risk management appraisal. Application of the principles, methods and supporting data provides clarity and robust evidence to underpin investment decisions. This updated version of the Manual provides users with:

- A completely new set of data on the potential flood damage to non-residential properties (such as businesses, industry and public buildings) vulnerable to flooding.
- Methods for assessing benefits in sectors not previously covered by MCM.
- Access to the rationale and background on the appraisal techniques, with links to the practical methods presented on a new web-based MCM (which now supersedes the previous 'Handbooks').
- A single compendium of a decade of research by the FHRC.

Importantly, the Manual provides approaches to implement the policies set out in the HM Treasury 'Green Book', and complements the *Flood and Coastal Erosion Management Appraisal Guidanc*e (FCERM-AG), published by the Environment Agency in March 2010. The Manual also complements Defra's *Making Space for Water* principles.

This Manual represents the results of intensive high-quality research to update completely the data and techniques in the previous 2005 version, which it now fully supersedes.

For the first time, this Manual is jointly published by the Flood Hazard Research Centre and the Environment Agency, representing the continuing close collaboration between us.

We hope you find this Manual and MCM-Online useful.

Jonathan Day
Head of Investment and Programmes
Environment Agency
August 2013

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1 Introduction

The purpose and contents of this Manual

This chapter sets the scene for the appraisal of the benefits of flood and coastal erosion risk management in England and Wales. It discusses in Section 1.1 the purpose of this Manual, and locates this in the wider context of environmental assessment.

Section 1.2 is designed to guide the reader through the Manual, including 'How to get started' and 'Where to find what'. Reference is made to underpinning documents produced by the Treasury on public sector investment (HM Treasury, 2003) and by Defra on appraisal policy (Defra, 2009). In this respect some significant changes have occurred in the field of project appraisal and flood and coastal risk management since 2005, when our last Manual was produced (Penning-Rowsell *et al.*, 2005a), in terms of both approach and the use of different techniques (e.g. providing some financial data for local rather than national application).

Government policy for flood and coastal erosion risk management (FCERM) has also changed since the beginning of this century (Section 1.3). The Department for Environment, Food and Rural Affairs (Defra) is the government department responsible for flood and coastal erosion risk management (previously 'flood defence' and before that 'land drainage'). In the mid-2000s Defra developed a new policy framework in the form of 'Making Space for Water' (Defra, 2004a; 2005) which has had implications for project appraisal – e.g. balancing national and local priorities – and for government investment priorities. The Pitt Review (Pitt, 2008), following the 2007 floods, has also led to changes in flood management policy, enacted through the Flood and Water Management Act 2010 (HM Government, 2010a). This has primarily given new responsibilities to bodies at the local level to co-ordinate and participate in managing flood risk, within a new National Strategy developed by the Environment Agency (2011a). Defra has also developed an important new 'partnership funding' approach (Defra, 2011a) and at the same time delegated many responsibilities for project appraisal to the Environment Agency, and the Agency in turn has developed considerably more documentation on this subject than has ever existed before (Environment Agency, 2010a; see Table 1.1).

Section 1.4 outlines the aims and assumptions of benefit–cost analysis, before Section 1.5 discusses the difficulties of, and uncertainty in, predicting the future

SUPPORTING INFORMATION ON MCM-ONLINE

Throughout this Manual, readers will find reference to Supporting Information on MCM-Online. This is the supplementary material provided for many chapters. In addition to this Supporting Information, certain chapters herein are based on direct and indirect damage data contained previously on the Multi-Coloured CD (2010). These data are now replaced by those available on the new Multi-Coloured Manual website: http://www.mcm-online.co.uk.

Table 1.1 Sources of guidance on appraising flood and coastal erosion risk management schemes and plans

Source reference	Document	Purpose
HM Treasury 2003	The 'Green Book'	Identifies the preferred approach to public sector investment appraisal
Environment Agency 2010a	Flood and Coastal Erosion Risk Management Appraisal Guidance (FCERM-AG)	How a project appraisal and cost benefit analysis (CBA) should be completed for flood and coastal erosion risk management projects
Flood Hazard Research Centre and the Environment Agency 2013	The new 'Multi-Coloured Manual' (MCM)	This volume: gives details of relevant research and detailed guidance on benefit assessment methods and data
http://www.mcm-online.co.uk http://www.fhrc.mdx.ac.uk	Middlesex University FHRC MCM-Online	Provides data and other information (including questionnaires) for the support of flood and coastal erosion risk management project appraisals

for which risk management is planned in a 'non-stationary' world. More pragmatically, Section 1.6 lays out a framework for different levels of project appraisal – generalised and detailed – and Section 1.7 gives some guidance about the time and resources needed. There follow a few words on estimating scheme costs, and on how to update the data contained in this Manual by using its parallel web-based 'Multi-Coloured Manual Online' (termed herein 'MCM-Online'), containing the data and techniques covered by this Manual (Sections 1.8 and 1.9, respectively). Finally, we outline what is new in this volume in relation to our previous Manual publications, and provide a list of some of the papers that we have published in the last eight years from the Flood Hazard Research Centre.

1.1 THE RATIONALE, PURPOSE AND STRUCTURE OF THIS VOLUME: THE NEW 'MULTI-COLOURED MANUAL' ANALYSIS (MCA)

1.1.1 The rationale

The rationale of this Manual is to aid and improve decision-making. The relevant decisions are about investment in fluvial flood risk management policies, plans or schemes, and at the coast in policies, plans and schemes to manage the risks of both coastal flooding and the erosion of the land by the sea. These decisions should be seen in the context of the modern philosophy of an integrated and holistic approach to sustainable catchment and coastal management, with stakeholder engagement embedded in the decision process, and sustainability and adaptive management always foremost in our thinking and in the processes that we design to guide this thinking and our decisions.

The focus of this rationale should not be misinterpreted. Although much of this Manual is aimed at 'projects' or 'schemes', by which it is usually meant any plan, programme or engineering works for which appraisal and decision-making are required, this should by no means be the only or indeed the primary outcome from using this Manual. There are many alternative strategies which should be reviewed for catchments and for the coast within the modern approach, including the 'do nothing' option which would let flooding and erosion continue. In summary, the term 'scheme' here is not meant to imply an engineering scheme but includes both structural engineering ways to reduce flood or erosion risks and non-structural alternatives (flood warning, emergency response, land use planning, etc). The term 'scheme' is used hereinafter for the sake of simplicity alone.

Another caveat concerns the understandable tendency when evaluating investment projects to consider just the site in question. But it is clear that a

regional perspective is necessary in the planning of coastal erosion risk management policies and works, and that a whole-catchment approach gives a significant new dimension to the planning of particular fluvial flood risk management schemes.

This arises because there is a measure of hydrographic interdependency between locations along a coastline, such that erosion in one place can result in protective deposition elsewhere. In addition, flooding in particular catchment areas can be a function of problems created elsewhere, such as accelerated runoff caused by the urbanisation of upland areas, or the encroachment on to floodplains by urban land uses which thereby are threatened with inundation. A modern regional and catchment perspective – first pioneered in the UK by Gardiner (1991) – allows consideration of these factors, which may be missed in any purely local analysis.

In addition, a range of alternative strategies needs to be reviewed and appraised. These can be structural engineering schemes or non-structural alternatives. The latter may take the form of stricter land use control in floodplain locations, or tighter designation of environmental 'no go areas', such as Sites of Special Scientific Interest, where no flood risk management schemes should be implemented. Equally valid may be insurance arrangements to spread the impact of floods, or warning systems to allow those at risk to reduce their vulnerability.

The modern integrated approach is needed, rather than one which looks at only local issues and uses a single-discipline approach to analysis and policy-making. A multi-functional approach is also needed in the management of river catchments, so that flood risk management plans and policies fit in with other water management objectives such as navigation, water supply and pollution control, in the spirit of the EU Water Framework Directive (Green, 2003). This is not easy, and makes many of the decisions on investment very complex and difficult. But only with a systematic approach to evaluation will decision-making improve, unintended consequences be minimised, and the nation's stock of economic and environmental resources along our rivers and at the coast be enhanced.

This Manual continues the designation as the 'Multi-Coloured Manual' because it embraces techniques contained in previous Middlesex University volumes in this series: the 'Blue Manual' (Penning-Rowsell and Chatterton, 1977), the 'Red Manual' (Parker *et al.*, 1987), and the 'Yellow Manual' (Penning-Rowsell *et al.*, 1992). We also first produced an early draft of this 'Multi-Coloured Manual' in 2003 (Penning-Rowsell *et al.*, 2003), which MCM (2005) and its associated Handbook and CD then replaced (Penning-Rowsell *et al.*, 2005a; 2005b). Eight years later this volume adds new results and is accompanied by the 'Multi-Coloured Manual Online' (MCM-Online), the web-based repository for all the data to which we here refer.

This Manual is therefore an updated and improved version of all of those previous manuals, dealing as they did, respectively, with flood risk management benefits (1977), indirect benefits (1987), coastal erosion risk management and sea defence benefits (1992), and all three combined (2003 and 2005). Although the user of this Manual is occasionally referred to sections of those manuals, it is intended that this volume stands alone and readers should not need to refer to the previous publications.

Both this Manual (MCM) and MCM-Online build on the definitive Treasury 'Green Book' guidance on investment in public sector projects (HM Treasury, 2003), including, for example, the use of weightings to correct for distributional impacts, optimism bias considerations when assessing project costs, and variable discount rates for projects with long lives (Table 1.1). They also have both built on Defra's original Project Appraisal Guidance series (e.g. MAFF, 1999: PAG3) and are complemented now by the Environment Agency's own appraisal guidance, issued in 2010 (Environment Agency, 2010a), and its additional guidance documents on its website (Table 1.2). In this respect, and to be clear, references here and in the Handbook on MCM-Online are therefore to 'Environment Agency (EA) appraisal guidance' (Environment Agency, 2010a) and to Defra's 'appraisal policy' (Defra, 2009).

1.1.2 The purposes of this Manual

This Manual has three main purposes, which interconnect and permeate the whole volume:

1 The primary aim is to present the user with a range of techniques and data that can be used in a practical way to assess the benefits of: (a) fluvial flood risk management schemes and policies; and (b) plans and schemes to alleviate the impact of

Table 1.2 Additional guidance on aspects of FCERM appraisal provided by the Environment Agency and Defra

Environment Agency FCERM Appraisal Guidance documents	Reference
Flood and Coastal Erosion Risk Management: Appraisal Guidance – Main Report (FCERM-AG)	Environment Agency (2010a)
Environment Agency supporting guidance for the flood and coastal erosion risk management appraisal guidance (FCERM-AG).	
Economic appraisal spreadsheets are available to assist economic analysis (Excel, 775KB)	Environment Agency (undated a)
Supporting document for the appraisal summary table (PDF, 396KB) – enables the clear presentation of negative and positive impacts to aid the consideration of wider issues within the appraisal	Environment Agency (2010b)
Guidance on applying the scoring and weighting methodology (PDF, 410KB) – enables the economic valuations of more intangible benefit types	Environment Agency (2010c)
Economic Valuation of Environmental Effects (PDF, 2.7MB)	Eftec (2010a)
Assessment of coastal erosion and landsliding for the funding of coastal risk management project guidance notes (PDF, 2.9MB)	Environment Agency (2010d)
Adapting to climate change: advice for flood and coastal erosion risk management authorities (PDF, 411KB) – this advice replaces the Defra 2006 guidance 'Treatment of climate change impacts' using the latest science from UK Climate Projections 2009, UKCP09. This applies to England only	Environment Agency (undated b)
Managing flood risk by working with natural processes	Environment Agency (2010e)
The following Defra Supplementary Notes support the use of the FCERM-AG	
Treatment of climate change impacts (PDF, 70KB) – following the publication of new climate change advice for England (above) this guidance now applies to Wales only. The Welsh Government is working with the Environment Agency to produce revised guidance using the latest science from UKCP09	Defra (2006)
Treatment of agricultural land – May 2008 (PDF, 104KB)	Defra (2008a)
Risk to people guidance – May 2008 (PDF, 170KB) – covers a method for the evaluation of the risk to life associated with flood risks	Defra (2008b)
Interim guidance note – July 2004 (PDF, 161KB) – which takes account of Defra's policy on socio-economic equity and appraisal of human-related impacts of flooding	Defra (2004b)
Treatment of risk (optimism bias) (PDF, 235KB) – guidance for applying optimism bias is covered in Revisions to economic appraisal procedures arising from the new HM Treasury Green Book March 2003	Defra (2003)

Source: All are accessed through the Environment Agency's website: http://www.environment-agency.gov.uk/research/planning/116707.aspx

erosion at the coast. The Manual is orientated to practising engineers, and river or coastal zone managers who wish to see their schemes represent good value for funders' money and a sustainable contribution to environmental management. In this way we aim to promote good designs through emphasising the need to evaluate the impacts of the plans or works that are proposed, in both economic and environmental terms. Indeed, this Manual may well be used to determine that plans or works to alleviate flooding or erosion are not appropriate, either because they are not cost-effective or because they will be so environmentally damaging that they should not proceed; or a mixture of both.

2 Second, the Manual describes the results of research at Middlesex University between 1999 and 2013 designed to update the data and improve the techniques that are contained in the previous manuals. We have attempted, in writing this Manual, to complement the production of the methods and techniques presented here with an explanation of the research undertaken to derive them and some of its limitations. This will give a context to the methods that we have produced and recommend. In certain areas of this Manual we present research results from previous investigations. Since we produced the 'Yellow Manual' in 1992 we have undertaken a number of project appraisals at Middlesex University which feed into this Manual. Particularly important has been our work on 'social issues', attempting to gain a better understanding of the 'intangible' benefits of managing flood and coastal erosion risks (e.g. Tapsell *et al.*, 2002).

In addition, we have also undertaken more conceptual development in the area of benefit–cost analysis, focusing particularly on choices and the way that choices conflict and also on the distributional consequences of flood risk management decisions (e.g. Penning-Rowsell and Pardoe, 2012a; 2012b; see Chapter 2). Some of this will be controversial and we do not pretend that any of this conceptual material necessarily makes benefit–cost analysis any easier to use, but we consider that it provides some enhanced understanding that project appraisal involves decisions about alternatives and their consequences, rather than just providing the justification of pre-determined policies, plans or schemes.

3 We explain, third, the limitations and complications of benefit–cost analysis to potential users. This is done so that they can use it in a thoughtful and critical way, to guide their decision-making on investment in river and coastal risk management schemes. Therefore, the users of this Manual will be those who are analysing problems of flooding from rivers and at the coast, or erosion in coastal situations, and who are considering the possibility of proposing some plan or works to lessen these risks or reduce their impacts. It should be noted, however, that the approach to project appraisal adopted throughout the Manual is generally the efficient investment of resources by the *nation* – not the Agency, local authorities or individuals – and users must take this important point into consideration in their use of its contents. The focus therefore is primarily still on benefit–cost analysis to aid the allocation of the nation's scarce economic resources, not the financial appraisal of investment for individual private or corporate gain.

Notwithstanding this point, we provide in parts of this Manual (in contrast to all the results in all previous manuals) some data on the *financial* consequences of floods and coastal erosion, because since the development of 'partnership funding' (Defra, 2011a) the locus of fundraising and consequentially of decision-making has somewhat changed. Instead of all the resources required for interventions in these fields being raised nationally, from national taxpayers, some of the resources are now being raised locally, for example via local authorities. This means that decisions may well be made on the grounds of the financial returns to the locality from these interventions, rather than economic returns to the nation. If this is the case, then decision-makers need to know of these financial returns in order to know whether or not to make their investments. Users of this Manual should be aware of the difference between economic and financial benefits and be careful not to confuse the two.

This Manual complements the guidance volumes provided by the Department for Environment, Food and Rural Affairs and the Environment Agency (Defra, 2009; Environment Agency, 2010a). It adopts a critical perspective about investment appraisal: the data and techniques do not aim to justify pre-determined

designs, but to analyse the extent and character of a flooding or coastal erosion risk management risk problem prior to making decisions about whether to intervene or to do nothing. The main discussion about the critical use of economic appraisal is in Chapter 2. But throughout the Manual we stress that there are pitfalls and complications throughout the benefit assessment part of benefit–cost analysis, and that an understanding of its principles is essential to its appropriate use. Furthermore, benefit–cost analysis inherently involves some assumptions about the distribution of income and wealth in society (Mishan, 1971) – notably that the current distribution is optimal – and thus its use involves some moral decisions as to what is 'right' or 'wrong', as well as the purely technical considerations. Moreover, even at the technical level, incorrect understanding, incorrect assumptions and the wrong data can produce benefit–cost analysis results which are meaningless and indeed dangerous in that unwise decisions would result. We provide some guidance so that these pitfalls are minimised.

The first of these aims is facilitated by providing an electronic web-based version which contains all the data that are within the printed volume, plus extensive other datasets which previously were reproduced only in hard copy form or on the 2005 and 2010 CDs. By providing these datasets as readily accessible electronic versions we aim to facilitate the use of the data in all of their various forms, rather than the kind of limited use that follows when data are not easily accessible. We also produce, on the web-based MCM-Online, model versions of the questionnaires that we advocate are used to assess a range of benefits, so that they can easily be used in the appropriate circumstances.

The parallel MCM-Online has three elements. The most readily accessible is a free-of-charge part of that platform, which will contain a limited dataset so that all users can benefit from that set of basic data. The second is a companion to this manual: Providing Supporting Information. The third part of the platform has much more detail and considerably larger datasets, and this is available on a charged-for basis, accessible at http:www.mcm-online.co.uk or through the website of the Flood Hazard Research Centre at Middlesex University.

1.1.3 Benefit–cost analysis (BCA), environmental assessment, and multi-criteria analysis (MCA)

There is a range of techniques that can aid decision-making concerning investment appraisal, with benefit–cost analysis just one technique amongst many (Defra, 2009, 33). Similarly, there is a range of techniques that can be used to quantify the environmental impacts of a number of policy options, and this is an important component of the data that the decision-maker needs (see Chapters 2 and 10).

We see benefit–cost analysis as part of a more general procedure termed 'environmental assessment'. This is because BCA is concerned with a particular 'product' (the benefit–cost ratio or net present value as the measure of the economic return from that investment). Environmental assessment is first and foremost more concerned with a process of incorporating information on all environmental attributes, values and changes into the decision-making sequences.

On the other hand, 'multi-criteria analysis' attempts to quantify in some way all aspects of environmental and economic significance related to a particular decision, and weight them so that a simple range of indices can be developed that capture all adverse and beneficial results – or potential adverse and beneficial results – from an investment decision (Defra, 2009, 33).

So:

- Benefit–cost analysis can provide a sophisticated means of comparing very different investments and outcomes by reducing them all to a common monetary form. It is limited to consideration of those impacts to which a monetary value can be attached but it leads to a simple set of parameters on which choices can be made (e.g. the benefit–cost ratio).
- Multi-criteria analysis can be used to broaden the scope of analysis, but brings significant difficulties in terms of determining the appropriate weights to use or the different criteria involved.
- Environmental assessment is broader still, but lacks the precision (or apparent precision) of BCA, and can avoid the kind of discipline involved in quantification that both BCA and MCA bring to the decision-making process.

We do not recommend that decision-makers reject any vehicle which aids the elucidation of the decision that they are to make, but would always warn that excessive simplification brings dangers as well as advantages.

1.2 GUIDE TO CONTENTS AND THE USE OF THE MANUAL

This Manual is not intended to be read right through from start to finish (no doubt the typical reader will breathe a sigh of relief!). Rather, the component parts can be used in a 'standalone' fashion, and have been written with that in mind. However, the user should be wary of using parts of the Manual in a standalone fashion without considering the research base of the methods and data that are presented.

1.2.1 Advice to the reader as to how to get started

In summary, the user should therefore proceed as follows:

1 Read Section 1.4 on the aims and assumptions of benefit–cost analysis.
2 Review the contents of Table 1.3 to see where within the Manual are the parts that are relevant to the appraisal being prepared.
3 Read as much as possible of Section 1.3 on the development of sustainable, participative and catchment-based approaches to river and coastal management, as contained in agreements and conventions to which the UK Government has been a party.
4 Determine from Section 1.6 the scope of the analysis. Bear particularly in mind the need to take a broad perspective initially by evaluating the whole catchment as a context to the particular fluvial flooding problem being investigated and by evaluating the whole of the hydrographic cell in which the coastal problem is located.
5 Consider carefully the time required for any studies by consulting Section 1.7 concerning the phasing and timing of each part of the assessment and the resources needed for surveys and data processing. Many incomplete or flawed project appraisals result from an over-hasty approach, which leads to significant omissions in terms of the required data and the results obtained.
6 Be aware of the numerous 'health warnings' contained within the substantive chapters of this Manual, and therefore be aware of the limitations of the analysis you are undertaking.

Beyond this introductory chapter, Chapter 2 presents a critical analysis of the basis of benefit–cost analysis, and a number of warnings about its use. Thereafter, Chapters 3 to 10 analyse the different aspects of appraising river flood risk management and coastal erosion risk management, and give the approaches, techniques and datasets that we recommend are used.

To give a measure of consistency throughout this Manual, the user is given the following 'signposts':

- At the start of each chapter is a summary of information to be found in that chapter.
- In addition, within each chapter, there are sections which checklist important points, and some 'health warnings' about the problems of using the data and techniques that are recommended.
- We also provide at the end of each chapter several 'lessons from experience' which may help the user of this Manual to obtain results which are meaningful and appropriate.

1.2.2 The relationship with related plans and appraisal processes (e.g. CFMPs, SMPs, CHaMPs, WLMPs, etc.)

Since the production of our first Manual in 1977 the development of appraisal techniques and policies for rivers and the coast has continued apace. A range of policies and plans has been developed, and significantly more guidance is provided by central government through Defra.

In general, the appraisal policies provided by Defra (Defra, 2001a; 2009; etc.) and the Environment Agency (Environment Agency, 2010a) give an overview of project appraisals and step-by-step procedures for calculating costs and benefits (Table 1.1). The documents provide very little data with which to calibrate those analyses, but make reference to the Middlesex manuals and other important sources of data (e.g. the work on agricultural benefit–cost analysis at Cranfield University). In contrast, the Middlesex manuals give both theoretical

Table 1.3 Where to find what in the Manual

Topic	Theoretical perspectives	Appraisal methods	Data requirements	Data in the Manual	Lessons from experience
Flood risk management					
Assessing flood losses to residential property	4.2	4.9	4.9	4.3	4.10
Indirect flood losses for residential property	Table 4.1	4.9.1	Table 4.31		
'Intangible' flood losses to householders	4.8	Tables 4.26, 4.27			
Flood damage to park homes	4.4	4.43	4.4.3		
Vehicle damages in floods	4.5	4.5	Tables 4.12, 4.13, 4.14	4.53, 4.55	
The damage reducing effect of property-level protection (PLP) and flood warnings	4.6	4.6.1–4.6.3	Table 4.16	4.6.1–4.6.3	
The impact of evacuation during flooding	4.7	4.7.1	Tables 4.17–4.25	4.7.2, 4.7.3	
Direct flood damage data for non-residential properties	5.6	5.6.1–5.6.9		5.6.1–5.6.9	5.12
Road traffic disruption during floods	6.5.1	6.5.1	Tables 6.15–6.18	6.5.1	Boxes 6.5, 6.6
Potential losses owing to rail disruption	6.5.2	6.5.2	Tables 6.19–6.22	6.5.2	Boxes 6.7, 6.8
Disruption to public services	6.6	6.6	6.6	Tables 6.25–6.31	Boxes 6.1, 6.3
Emergency services costs	6.8	6.8.1, 6.8.2	Tables 6.26–6.28	6.8	
Agricultural benefits of flood risk management	9.2, 9.3, 9.5	Figure 9.4, Table 9.21	9.8, Table 9.11	Tables 9.4–9.6	9.12
Protection against erosion from the sea					
The nature of erosion benefits	7.3.1				
Methods of project appraisal: property losses	7.4.1	7.3	7.3.3, 7.4, 7.4.3	Tables 7.3, 7.4	
Methods of project appraisal: infrastructure losses	7.5.1	7.5.5, 7.6			7.7
Loss of agricultural land to the sea	9.3.8		Table 9.7		

Table 1.3 continued

Topic	Theoretical perspectives	Appraisal methods	Data requirements	Data in the Manual	Lessons from experience
Flood risk management and protection against erosion from the sea					
Recreational gains and losses: fluvial sites	8.2	8.3, Figure 8.1, 8.6.2	Table 8.1	Tables 8.5, 8.8, 8.9	8.8
Recreational gains and losses: coastal sites	8.6	8.3, Figure 8.1, 8.6.1	8.7	Tables 8.6, 8.7, 8.10	Case study: 8.7, 8.8
Environmental gains and losses	10.1–10.3	10.5		9.7 (agriculture), 10.7, Table 10.4	10.10

considerations and data to be used. Thus we see the two sources of information and guidance as complementary. As with all Middlesex manuals, this Manual is acknowledged as a source of user guidance by Defra but the research results remain the responsibility of Middlesex University and the Environment Agency.

In addition to the formal appraisal techniques, catchment and coastal planning agencies have developed a series of additional approaches and procedures. Catchment Flood Management Plans (CFMPs) bring together a strategic-level hydrological and hydraulic analysis with similarly broad-scale economic and environmental evaluations to provide a holistic view of the long-term measures that will provide the most appropriate management of flood risk at the catchment scale. The results represent a broad-brush analysis rather than a detailed evaluation of particular site situations. The same applies to shoreline management plans (SMPs), water level management plans (WLMPs) and coastal habitat and management plans (CHaMPs). Each contains data as to regional and local situations, and suggested indicative solutions to particular large-scale risk management problems.

Thus CFMPs give an overview of the flood risk across each river catchment. They recommend ways of managing those risks now and over the next 50–100 years. These CFMPs also consider all types of inland flooding, from rivers, ground water, surface water and tidal flooding, but not flooding directly from the sea (coastal flooding), which is covered in SMPs. The CFMPs also take into account the likely impacts of climate change, the effects of how we use and manage the land within a catchment, and how areas could be developed to meet our present-day needs without compromising the ability of future generations to meet their own needs.

An SMP is also a large-scale assessment of the risks associated with coastal processes and is intended to help reduce these risks to people and the developed, historic and natural environments. Coastal processes analysed include tidal patterns, wave height, wave direction and the movement of beach and seabed materials. The Environment Agency has a legal duty to protect and enhance the natural environment through its operations: the management of important nature conservation sites that are at risk of coastal erosion or flooding is therefore considered in CHaMPs.

WLMPs explain the way the water levels are operated within an area, and try to balance the needs of agricultural and conservation interests there. They were developed to provide a means by which the water-level requirements for a range of activities within a particular area, including agriculture, flood risk management and conservation, can be balanced and integrated. An action plan is produced which sets out the investment that Internal Drainage Boards and others need to make to address these problems, allowing the Boards, for example, to plan for Grant in Aid applications and understand their appraisal needs.

We see these manuals, therefore, as complementing both government and Agency advice and

these local and regional plans. This Manual provides data and techniques appropriate to all levels of evaluation (from generalised to detailed) and the user should exercise judgement as to the appropriate level of analysis to be undertaken in support of any particular decision. Large-scale plans, such as SMPs and CFMPs, will normally provide the context for more detailed investigations within the areas covered.

1.3 FLOOD AND COASTAL EROSION RISK MANAGEMENT: STRATEGIES AND POLICIES

Underpinning flood risk management and coastal erosion risk management policies should be a number of key principles and strategies to ensure wise decision-making and beneficial outcomes. Generally these are codified in international agreements and conventions such as those discussed below but are also detailed in outputs having an international focus (e.g. Sayers *et al.*, 2013). International agreements are often transcribed into national legislation and regulations as appropriate, when accepted by the UK Government.

1.3.1 Sustainable flood risk management and coastal erosion risk management strategies

The United Nations Convention on the Protection and the Use of Trans-Boundary Watercourses and International Lakes recommended guidelines to 'prevent, control and reduce the adverse impacts of flood events on human health and safety, on valuable goods and property, and on the aquatic and terrestrial environment' (United Nations, 2000, i).

These guidelines recommend that there are at least seven principles and approaches regarding sustainable flood prevention. To implement them requires co-operation at all government levels and co-ordination of policies regarding environmental protection, land use planning, agriculture, transport and urban development. These principles are outlined in Box 1.1.

As with other strategies, the United Nations' guidelines on sustainable flood prevention emphasise a holistic approach, integration with other land use and water functions, and the development of adequate information systems so that project appraisals are soundly based. Whereas the guidelines are non-binding on member governments, they represent recommended measures and best practice in the development of sustainable policies.

BOX 1.1 SEVEN BASIC PRINCIPLES AND APPROACHES REGARDING SUSTAINABLE FLOOD PREVENTION

- Flood events are part of nature. They have always existed and will continue to exist.
- Human interference into the processes of nature has increased the threat of flooding. As far as possible, such interference should be reversed, compensated and, in the future, prevented.
- Structural measures will remain important elements of flood prevention and protection. However, these measures should primarily focus on the protection of human health and safety, and valuable goods and property.
- Requirements of nature conservation and landscape management should be taken into consideration.
- Everyone who may suffer from the consequences of flood events should also take his/her own precautions. To this end, an appropriate information and forecasting system should be established by the competent authority.
- Human uses of floodplains should be adapted to the existing hazards. Appropriate instruments and measures should be developed to reduce the risk of flooding.
- In flood-prone areas, preventive measures should be taken to reduce possible adverse effects of floods on aquatic and terrestrial ecosystems, such as water and soil pollution.

(United Nations, 2000)

1.3.2 A catchment focus and a participative approach: the Water Framework Directive and the Aarhus Convention

The Aarhus Convention (DETR, 2000a) and the Water Framework Directive (European Parliament, 1998) have fundamentally changed the nature of water management in Europe and, with that, the purpose and nature of project appraisal.

From the Dublin conference onwards (ACC/ISGWR, 1992), the holistic management of water and land across a catchment has been taken to be one of the defining criteria for the achievement of sustainable water management. The Water Framework Directive requires the introduction of such holistic catchment management within Europe. A second criterion that the Dublin conference established for sustainable water management was the involvement of the public in all levels of decision-making; the Aarhus Convention sets out the conditions for this to occur and was fully adopted by the UK Government in 2005.

The shift to stakeholder-driven decision-making requires a radical shift in the nature of project appraisal; the purpose of project appraisal is now to provide a rigorous analytical framework within which decisions can be argued, negotiated and debated by the stakeholders. It includes a key role in promoting communication between the stakeholders as well as in enabling them to assess and argue the consequences of adopting different alternatives (Green, 2002).

At the same time, the shift to holistic land and water management across catchments under the Water Framework Directive changes the nature of the options that will be considered. The implication is that there may cease to be single-purpose flood risk management schemes or wastewater treatment plants: actions will no longer be considered from a single functional perspective. Instead, the overall goal will be to improve the functioning of the catchment as a whole where one, and perhaps the primary, purpose of a possible set of interventions will be to improve the management of the variability of water quantity across the catchment and over time.

It is clearly intended that catchments should be managed as dynamic systems rather than just to address localised problems. As a result, the arbitrary differentiation between variations in water availability over time into droughts, water resources and floods may cease (Green, 2002). For example, in arid climates and regions, floods are the water resource. In turn, project appraisal techniques will also have to cover all aspects of the functioning of a catchment, and specifically the three fluxes that occur (of water, soil and pollutants). There is a similar requirement for coastal zone management (Green and Penning-Rowsell, 2011).

However, with the adoption of the Directive and the acceptance of the Convention it will not be enough to consider only the holistic functioning of the catchment or coastal zone. Actions within the catchment or at the coast will also have to mesh into national policies on, for example, urban and rural development (Green, 2002). In addition, the resources allocated towards improved catchment management will necessarily not be available for other purposes, such as health care and education.

1.3.3 The European Union's 'Floods Directive'

Under the Floods Directive (2007/60/EC) on the assessment and management of flood risks, which came into force on 26 November 2007, all EU countries are obliged to assess the risk and management of all types of flooding in their territories (European Parliament and the Council, 2007; European Commission, 2011, 1).

The Directive required member states to have carried out a broad-scale assessment by 2011 'to identify the river basins and associated coastal areas at risk of flooding', and to involve their government departments, agencies and other bodies in drawing up this preliminary flood risk assessment. This assessment needed to consider impacts on human health and life, the environment, cultural heritage and economic activity, with a completion date of December 2011. That information was then to be used to identify the areas at significant risk which would then be modelled in order to produce detailed flood hazard and flood risk maps.

These maps were to be in place by December 2013, and will include detail on the flood extent, depth and level for three risk scenarios (high, medium and low probability). Flood risk management plans then need to be produced to indicate to policy-makers, developers and the public the nature of the risk and the measures proposed to manage these risks,

focusing on prevention, protection and preparedness. The plans are to be completed by December 2015, and in order to ensure community/stakeholder buy-in they will require input from interested parties during their development.

In England and Wales the Flood Risk Regulations 2009 (HM Government, 2009a) transposed the EU's Floods Directive into domestic law, to implement its provisions. In particular, the Regulations placed duties on the Environment Agency and local authorities to prepare these flood risk assessments, flood risk maps and flood risk management plans. But EU directives are interrelated: the flood risk management plans that result from the Floods Directive should take into account the relevant environmental objectives of Article 4 of the Water Framework Directive.

1.3.4 Defra policy priorities and high-level targets

The UK Government's flood risk management strategy has continued to evolve and broaden since 2005 (Environment Agency, 2010a). For example:

- The Climate Change Act 2008 (HM Government, 2008) requires a UK-wide climate change risk assessment every five years accompanied by a national adaptation programme that is also reviewed every five years. The Act has given the UK Government new powers to require public bodies and statutory organisations, such as water companies, to report on how they are adapting to climate change.
- *FutureWater 2008* (HM Government/Defra, 2008), the UK Government's overall strategy for water, looks mainly at water supply and provision. However, it also reaffirms *Making Space for Water* as the basis for managing river and coastal flooding (see below). Furthermore, it sets out a vision for better management of surface water to address the dual pressures of climate change and housing development.
- The Pitt Review (Pitt, 2008), following the 2007 floods, made ninety-two recommendations, the government response to which culminated in the Flood and Water Management Act 2010. There is a particular emphasis in the Act's provisions on surface water and other local flood risk, a main cause of damage in the 2007 floods. The Act established lead local flood authorities and gave these and other local bodies, such as water companies, new powers and responsibilities to co-ordinate and participate in flood risk management. Among other things, it also gave the Environment Agency a duty to establish a national strategy for managing flood risk and coastal erosion in England. The aim of the national strategy, which builds on the earlier *Making Space for Water* (Defra, 2005), is shown in Box 1.2.

Sustainable schemes had been defined previously as 'projects which take account of the inter-relationships 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/Welsh Office, 1993). The more recent elaboration of this is given in Box 1.3, being the guiding

BOX 1.2 THE AIM FOR FLOOD RISK MANAGEMENT IN UNDERSTANDING THE RISKS, EMPOWERING COMMUNITIES, BUILDING RESILIENCE – THE NATIONAL FLOOD AND COASTAL EROSION RISK MANAGEMENT STRATEGY FOR ENGLAND

The overall aim of the strategy is to ensure the risk of flooding and coastal erosion is properly managed by using the full range of options in a co-ordinated way.

Communities, individuals, voluntary groups and private and public sector organisations will work together to:

- manage the risk to people and their property;
- facilitate decision-making and action at the appropriate level – individual, community, or local authority, river catchment, coastal cell or national; and
- achieve environmental, social and economic benefits, consistent with the principles of sustainable development.

(Environment Agency, 2011a)

principles from the national strategy (Environment Agency, 2011a).

In terms of project appraisal, what is sought for sustainable flood and coastal risk management is the achievement of long-term stable benefits rather than schemes with higher benefit–cost ratios where the standard of protection reduces over time. There is an emphasis on whole-life costs and benefits, to get a truer comparison between options than simply looking at limited, short-term-scheme life costs and benefits. In addition, there should be a proper consideration of the 'do nothing' option. The assumption that 'something must be done' is to be avoided, as it can lead to the introduction of non-sustainable regimes of flood risk management and coastal erosion risk management work.

BOX 1.3 EXTRACTS FROM THE 'GUIDING PRINCIPLES' IN THE NATIONAL STRATEGY

Flood and coastal erosion management may mean that difficult decisions have to be taken on where risk management activities can and cannot be carried out at both national and local levels. These decisions, and the processes by which they are taken, will be guided by a number of high-level principles. These are outlined below (extracts only):

Community focus and partnership working

The risk management authorities should work in partnership with communities to understand the community perspective of flooding and coastal erosion, help communities understand and actively prepare for the risks, and encourage them to have direct involvement in decision-making and risk management actions. This includes giving communities a bigger say in what action is taken, greater responsibility for managing their own risks and decisions on local funding priorities, and as a result greater accountability for the level of safety and protection achieved and the way in which the risks are managed. The aim is to ensure that decision-making and ownership of risk management measures are as local as possible but within a catchment, coastal cell and national framework that ensures a fair allocation of funds and avoids the transfer of risk elsewhere without prior agreement.

A catchment- and coastal cell-based approach

In understanding and managing flood and coastal risks locally, it is essential to consider the impacts on other parts of the catchment or coast. Activities must seek to avoid passing risk on to others within the catchment or along the coast without prior agreement . . . Catchment flood management plans (CFMPs) and shoreline management plans (SMPs), or equivalent, provide an important building block for this co-ordination.

Sustainability

Flood risk and coastal erosion management authorities should support communities by managing risks in ways that take account of all impacts and the whole-life costs of investment in risk management. The risk management solutions should be forward-looking, taking account of potential risks that may arise in the future and being adaptable to climate change. They should also work with natural processes where possible and enhance the environment.

Proportionate, risk-based approaches

It is not technically, economically or environmentally feasible to prevent flooding and coastal erosion altogether. A risk-based management approach targets resources to those areas where they have greatest effect. Risk management measures consider both the probability over time of a flood or coastal erosion happening and the consequences that might arise if it did, for example by assessing the average annual damages that arise from floods or coastal erosion. To do this the sources, pathways, receptors and consequences of risk need to be understood and addressed as appropriate to manage all of the factors that combine to create risk. Further detail on this approach is available in the Guidelines for Environmental Risk Assessment and Management (DETR/EA/IEH, 2000).

Multiple benefits

As well as reducing the risks to people and property, FCERM can bring significant economic, environmental and social benefits. It can enhance and protect the built, rural and natural environments, cultural heritage and biodiversity by preventing loss and damage to habitats and heritage assets and reducing pollution, for example through the use of sustainable urban drainage systems (SUDS). It can contribute to regeneration and income generation, protect infrastructure and transport links, and contribute to economic growth.

Beneficiaries should be encouraged to invest in risk management

The benefits achieved when flood and coastal erosion risks are managed are in many cases localised and lead to personal or private gain through the protection of specific individuals, communities and businesses. They can also be public, through the reduction of future costs to society arising from incident recovery. The private as well as public nature of the benefits suggests that costs should not fall to the general taxpayer alone . . . In his review of the summer 2007 flooding, Sir Michael Pitt suggested that better aligning beneficiaries with those that pay would create a more efficient and responsive system. To do this he recommended that 'Government should develop a scheme that allows and encourages local communities to invest in flood risk management measures' [and] that developers, in potentially increasing local flood risk, should 'make a full contribution towards both the costs of building and maintaining the necessary defences'. In taking this recommendation forward, the Government has made clear that 'we cannot continue all of the work that the Environment Agency has historically done at the taxpayer's expense. Government investment in flood and coastal erosion risk management is significant, but we need to ensure that we get best value for money.'

(Environment Agency, 2011a)

Again, in terms of project appraisal, this is not easy, and the aim of delivering 'environmental, social and economic benefits, consistent with the principles of sustainable development' (Box 1.2) raises the question of how benefits are to be identified, defined and measured. However, these difficulties are recognised, and Defra has indicated that this 'will be complex as will ensuring a good fit between national and local priorities' (Defra, 2005, 10). In this respect, appraisers of FCERM schemes should also be aware of the types of risk management expenditure that Defra currently funds, not least because some benefits might not be supported in this way. Those benefits (e.g. major recreational benefits) might currently need the support of other funding streams where they are not central to the relevant scheme.

Defra has also developed a formal appraisal policy (Defra, 2009, 4). This 'sets out why appraisal is necessary, and the principles and policies that should guide this work'. In particular, it emphasises the need to ensure that appraisals for all activities (whether strategic-level plans or individual projects):

- give more consideration to 'risk management' and 'adaptation', as opposed to only 'protection' and 'defence';
- are undertaken consistently, transparently, with value for money in mind and in a way that complies with the Treasury guidance on appraisal and evaluation in central government (the 'Green Book');
- help achieve better social and environmental outcomes as part of sustainable development, both by considering a broader range of issues and by using a broader range of analysis techniques; and
- adopt a risk-based approach, whilst considering impacts within the whole of a catchment or shoreline process area.

In addition, five principles have been enunciated to 'ensure that flood and coastal erosion risk management contributes to sustainable development' (Defra, 2009, 11). These principles are those of:

- living within environmental limits;
- ensuring a strong, healthy and just society;
- achieving a sustainable economy;
- promoting good governance; and
- using sound science responsibly.

The approach to appraisal is set out by Defra (2009, 26), involving three key stages:

1 Define the issue and consider the case for government intervention. Set SMART objectives if there is a case (SMART = Specific, Measurable, Achievable, Realistic, Timely).
2 Develop a full range of possible options, describe the options, and then value the positive and negative impacts of each of the options.
3 Compare options in a systematic way and select the most effective and deliverable solution

To complement Defra's policy framework, as indicated above, it defines a series of Outcome Measures against which Environment Agency performance is measured and which are used to set Exchequer funding contributions to risk management activities (see next section). These Outcome Measures are set out in Table 1.4.

1.3.5 'Partnership funding': a new FCERM financing scheme

A significant change in the funding of FCERM schemes was promoted by Defra in 2011 to launch a system of local/national cost-sharing. The significance of this change is that it introduced a far greater and critical element of 'localism' into what previously was a highly centralised arrangement. The pre-existing block grant system remains (whereby Defra allocated a block of money to the Environment Agency), at a somewhat reduced level, but projects or schemes in many cases can proceed only if the national contribution is complemented by locally derived resources.

The new 'partnership funding' arrangement (Defra, 2011a; Environment Agency, 2012) operates on a formula basis to determine the Flood Defence Grant in Aid (FDGiA) – how the reduced Environment Agency block grant (provided by Defra) is to be allocated, scheme by scheme (Johns, 2011).

Equation 1.1

$$£\text{FDGiA} = H + B + E$$

Where (see Table 1.4):

H is the value of qualifying Household benefits for that scheme, multiplied by the payment rate.
B is the value of Other Whole-life Benefits for that scheme, multiplied by their payment rate.
E is the number of Environmental Outcomes for that scheme, multiplied by their payment rates.

From this can be derived an Outcome Measure (OM) score (as a percentage) – being the £FDGiA sum divided by the scheme costs – and this metric can be used to prioritise decision-making.

Many schemes will have an OM value greater than 100 per cent, and then the full cost is available from the Defra-funded grant. In other cases there is a shortfall: the grant fails to cover the costs and this shortfall needs to be met from local contributions if

Table 1.4 The new payment rates for the partnership funding arrangement

OM no.	Outcome Measure definition	Benefits and outcomes qualifying for national funding	Payment rate	Examples of funding levels from Government
OM 1 OM 1a	Average benefit to cost ratio of schemes delivering OMs Present value of whole-life benefits per £1 of FDGiA	Under OM1, present value of whole-life benefits of the current investment, less benefits paid for or payments made under the other OMs	5.56p per £1 of qualifying benefit (i.e. seeking an 18 to 1 return from national investment)	These include avoidance of damages to e.g. business, agriculture, local government, communications, infrastructure, utilities and public health
OM 2	Households moved from one category of flood risk to a lower category Households must be at direct risk of flood damage and have been built or converted into housing before January 2012 to be counted	Under OM2, present value of direct damages to residential properties and their contents avoided, in the: 20% most deprived areas 21–40% most deprived areas 60% least deprived areas	45p per £1 30p per £1 20p per £1	Based on moving a single household from very significant risk to low risk for a duration of 50 years £15,399 per household protected £10,266 £6,844
OM 3	Households better protected against coastal erosion Households must be at direct risk of damage from coastal erosion and have been built or converted into housing before January 2012 to qualify	Under OM3, present value of the reduction in direct damages to residential properties, in the: 20% most deprived areas 21–40% most deprived areas 60% least deprived areas	45p per £1 30p per £1 20p per £1	Based on protecting a single household at risk of loss within 20 years, for a period of 50 years £35,601 per household protected £23,734 £15,822
OM 4	Statutory environmental obligations fully met through flood and coastal erosion risk management	Outcomes specifically funded under OM4:	£15,000 per hectare	
OM 4a	Hectares of water-dependent habitat created or improved to help meet the objectives of the Water Framework Directive	Water-dependent habitat created or improved		
OM 4b	Hectares of inter-tidal habitat created to help meet the objectives of the Water Framework Directive for areas protected under the EU Habitats or Birds Directive	Inter-tidal habitat created	£50,000 per hectare	

Table 1.4 continued

OM no.	Outcome Measure definition	Benefits and outcomes qualifying for national funding	Payment rate	Examples of funding levels from Government
OM 4c	Kilometres of river protected under the EU Habitats or Birds Directive improved to help meet the objectives of the Water Framework Directive	Protected rivers improved	£80,000 per km of river bed	

Source: Defra, 2011a

the scheme is to proceed. These contributions can come from a number of sources, with the three prime headings being the pre-existing 'local levy' raised by the Environment Agency, the public (e.g. local authorities) and the private sector (e.g. developers or industry).

In the expenditure programme for schemes active in the financial year 2012/13 there were 140 schemes (at an average cost of £4.078 million) for which a local contribution has been potentially forthcoming, out of a total of 398 schemes (i.e. 35 per cent), with that contribution varying from 0.3 to 95 per cent of total costs. Of the schemes with some local contribution, the total contributions as at early 2012 were £141 million out of total scheme costs of £585 million (i.e. an average of 24.1 per cent), representing a sizeable additional resource over and above that provided nationally. One might expect that these are the smaller schemes, which they are, but the schemes without a contribution average £5.403 million, or only 32 per cent larger by total cost than those with the local resources. Hence it is not simply the case that 'local' is small and 'national' is much larger.

One of the characteristics of this partnership funding is that any scheme delivering worthwhile benefits (as defined in the policy) can receive some level of central government funding, unlike the situation previously where, if the scheme did not warrant proceeding by the rules then extant (MAFF, 1999), the central government contribution was zero.

To be eligible for a grant, the partnership funding score (PF) must show that there are sufficient funds available: the PF score must be above 100 per cent (the score broadly is the maximum permitted grant for the scheme plus the local contribution divided by cost of scheme). To receive a grant in a particular year, a scheme must be successful in a process that prioritises funding against the PF scores and accommodates local choices.

Regarding the latter criterion, a stated objective of Defra's policy here is to enable more local choice in the solutions adopted to reduce flood risk, and Regional Flood and Coastal Committees now play a central part in ensuring that local choices are reflected in the programmes that they are now required to agree. One of the reasons why the contribution level for some schemes is so high (i.e. >90 per cent) is that previously they would probably have been funded entirely through the local levy but will now be attracting a modest level of government grant: the level of local contribution is not capped and can form any proportion of the total cost needed to implement the scheme.

In terms of rationale, Environment Minister Richard Benyon has indicated that:

> This new funding system means more flood defence schemes will benefit from [central] government money so we can protect more people and properties. Many schemes in areas at high risk will continue to receive full funding from government, whilst others will receive large contributions that will go a long way towards meeting the amount needed for the defence to be built . . . This will mean that local communities have a much greater say in how and where schemes are built and are no longer hampered in their ambitions by what [national] government alone can afford.
>
> (Defra, 2011b)

In this respect, the term 'defence' should be seen broadly, because the partnership funding scheme is

certainly not meant to be restricted to engineering solutions to flood risk and coastal risk management problems.

There are significant implications of the move towards partnership funding for the contents of this Manual. Fundamentally, the national economic perspective that has pervaded all our manuals since 1977 is no longer fully appropriate for the schemes that are part funded by local communities. These communities will be motivated by financial (local) impacts from floods, rather than their – lesser – economic (national) effects. That is to say, a local community faced with shops losing business as a result of flooding will want to see this business restored or the losses mitigated. On the other hand, a national economic analysis would accept that losses to one shop would be recouped by sales increases elsewhere, rendering the national economic loss to be close to zero (see Chapter 5).

We have responded to this change by providing financial (local) flood damage figures on MCM-Online to complement the economic (national) figures that we have provided previously. On MCM-Online we have indicated very clearly which figures are economic values and which are financial values, and users should be careful not to confuse the two.

1.3.6 Environment Agency perspectives

The Environment Agency in England and Wales is the principal organisation implementing the UK Government's fluvial flood risk management plans and schemes, while local authorities are the principal organisations tackling 'surface water flooding' (the lead local authorities in England and all local authorities in Wales) and implementing coastal erosion risk management and coastal flood risk management schemes.

Here the most common forms of floods (Environment Agency, 2009a: England) are:

- River flooding that occurs when a watercourse cannot cope with the water draining into it from the surrounding land. This can happen, for example, when heavy rain falls on an already waterlogged catchment.
- Coastal flooding that results from a combination of high tides and stormy conditions. If low atmospheric pressure coincides with a high tide, a tidal surge may happen which can cause serious flooding.
- Surface water flooding which occurs when heavy rainfall overwhelms the drainage capacity of the local area. This is difficult to predict and pinpoint; much more so than river or coastal flooding.
- Sewer flooding that occurs when sewers are overwhelmed by heavy rainfall or when they become blocked. The likelihood of this flooding depends on the capacity of the local sewerage system. Land and property can be flooded with water contaminated with raw sewage as a result. Rivers can also become polluted by sewer overflows.
- Groundwater flooding that occurs when water levels in the ground rise above surface levels. It is most likely to occur in areas underlain by permeable rocks, called aquifers. These can be extensive, regional aquifers, such as chalk or sandstone, or may be more local sand or river gravels in valley bottoms underlain by less permeable rocks. This type of flooding is not significant in Wales (Environment Agency Wales, 2009).

1.3.7 Some key project appraisal differences between the coastal and the fluvial environment

In flood and coastal erosion risk management, there is a fundamental difference between alleviating flooding and alleviating erosion. Flood losses have the potential to be recurrent: there is a risk of flooding in a given low-lying area in any single year and it is possible that floods of different magnitudes may occur in any combination of years. Erosion is an ongoing process that can normally only be delayed.

Hence we generally assume in assessing the impacts of flooding that the same land uses will continue in that area and that they may repeatedly suffer flood damage.

However, where as a result of repeated flooding problems more land might become permanently inundated, or is flooded repeatedly with a frequency of, say, once every two years, then it is almost inevitable that the existing land use will change permanently. In these cases property will become abandoned and in the benefit assessments it is 'written off', just as where property lost to the sea is deemed to be lost for ever in the case of coastal erosion.