

Developing the Cost-Benefit Framework for the Appraisal of Flood and Coastal Erosion Risk Management Projects

R&D Project Record FD2018/PR1



Joint Defra/EA Flood and Coastal Erosion Risk
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Developing the Cost-Benefit Framework for the Appraisal of Flood and Coastal Erosion Risk Management Projects

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Developing the cost-benefit framework for the appraisal of flood and coastal erosion risk management projects

Foreword

As part of the process of implementing the New Government Strategy for Flood & Coastal Erosion Risk Management (*Making Space for Water*), Defra is planning to revise the Flood and Coastal Defence Project Appraisal Guidance (FCDPAG) .

Defra will work closely with the Environment Agency to develop, by 2007, an updated suite of appraisal guidance that reflects the strategic and policy principles set out in the new strategy. The revised guidance will take account of latest research and best practice in flood and coastal management and wider policy areas, including techniques such as multi-criteria analysis and sustainability assessments. In particular, in the context of this note, it is expected to include revised approaches in the following areas:

- links with the Water Framework Directive; and
- better guidance on social costs and benefits, so as better to identify gains and losses to individuals and different sectors. This will also enable the development of more transparent assessments of schemes involving multiple sources of funding, including third party contributions.

The objective of the project appraisal process is to ensure that proposed programmes and projects are fully assessed against accepted criteria for public sector investments and take account of the principles of sustainable development. This involves full consideration of economic, social, technical and environmental issues in a logical framework.

Cost-benefit analysis, which forms the basis of PAG3, can be described in two different ways – as a *calculus of willingness-to-pay* (WTP) or as a *calculus of social costs and benefits* (SCB). The current PAG3 framework adopts the calculus of social costs and benefits, as it seeks to measure the costs to be incurred, and the benefits created by a project in national economic terms. The willingness to pay approach differs in that it measures the net welfare change brought about by the project under consideration for each individual interest group. The summation of individual welfare changes leads to the same valuation of net social costs and benefits as the SCB approach.

The principle advantage of the WTP approach is that it leads naturally to a presentation of results which makes clear how a project impacts on the members

of different economic interest groups (e.g. in a flood defence context house owners, farmers, taxpayers), how it impacts on different financial budgets (e.g. the budgets of different branches of government, and those of project partners), and how far the benefits created by the project are of the kind for which the relevant public funds have primarily been allocated (through for example the Spending Review process). With the SCB approach, in contrast, whilst it would be possible to disaggregate results in many cases some significant transfers between groups are not generally evaluated and these distinctions are liable to be hidden in the aggregation of resource costs and benefits.

Given the potential advantages of the WTP approach, Defra commissioned Robert Sugden¹, Professor of Economics at the University of East Anglia, to investigate the feasibility of moving from the traditional SCB, as currently used in the economic appraisal process, to WTP and specifically the potential to resolve a number of problems with the current appraisal framework, particularly issues like the consideration of private contributions and social-economic equity.

As the distinction between the two approaches to cost-benefit analysis can appear to be slightly academic it is important not to lose sight of the policy imperatives which motivate consideration of such changes:

- **Income-distributional effects (fairness and equity issues)**

Flood Management (FM) decision-making typically involves the discretionary allocation of large benefits and raises questions of fairness. A particular concern is the influence of special interest groups in the decision making process. As such it is important to be able to explain how costs and benefits are distributed. A WTP approach would provide the information to discuss benefits and costs with interested parties in a clear and transparent way.

- **Private contributions**

Although present appraisal guidance attempts to encourage private contributions, they are treated as a “windfall” to national FM budget rather than featuring in the SCB accounts. This provides a reduced incentive for those contributions to come forward, as they are largely ignored in relation to the individual projects. The WTP approach could allow private contributions to play a more important role in option appraisal of specific projects by recognising how they effect the economic efficiency, and hence priority, of particular proposals.. Though it would require more explicit policy decisions to clarify the degree to which contributions should enable specific

¹ The Department of Transport (then the Department of the Environment, Transport and Regions) commissioned a review of cost/benefit analysis of transport projects from Professor Robert Sugden (*Developing a Consistent Cost-Benefit Framework for Multi-Modal Transport Appraisal*, January 1999). The Department has now changed its multi-modal transport appraisal framework from SCB to WTP following his report recommendation.

beneficiaries to buy advantage in prioritisation or purchase development rights in the floodplain.

- **Supporting the appraisal of multiple objective schemes**

Government Departments are allocated specific budgets for specific purposes but seek to maximise the public benefits of expenditure, often through multiple use schemes. At present appraisal guidance does not distinguish between types of benefit creation according to whether they fall under the remit of the department. WTP approach allows benefits of a project to be differentiated between *core* benefits to the department and *non-core* benefits, which fall elsewhere. Similarly, project costs can be disaggregated to fall on the budgets of the relevant department. Defra is committed to joined-up solutions and effective collaborative working with other departments and public bodies. A WTP approach will allow a clearer choice over options given the different outputs and a better ability to negotiate contributions from other government departments where relevant.

Sugden's paper also raises a number of other issues.

- Factor costs/Market prices - In moving to a WTP approach Sugden recommends that the appraisal approach is modified to take better account of whether benefits and costs are expressed at the *factor cost* unit of account or in *market prices*. It is likely that most cost and benefit items in the current PAG and supporting benefit assessment reports (e.g. from the Flood Hazard Research Centre) are intended to be expressed at factor cost as this is more consistent with the SCB approach. However, given some benefits are expressed in WTP (especially recreational benefits) it is necessary to consider whether there is any systematic bias in the current approach. On the basis of this we will then need to consider where adjustments in data or approach are worthwhile in relation to the relative precision of valuations and other sources of uncertainty.
- Summary statistic - The report suggests moving away from the benefit cost ratio as the key project appraisal summary statistic and towards the net benefit-public expenditure ratio (NPV/K rule). This would better reflect the constrained nature of the Flood Management (FM) budget. . New summary statistics would be calculated on a broad and narrow basis. On a *broad* conception of costs and benefits, the denominator is the net cost of the project to all forms of public expenditure and the numerator is the project's net benefit to all parties, including the government itself (as a proxy for taxpayers). For the *narrow* definition of this ratio, the constrained FM budget should be defined to include all public funds specifically allocated for FM projects and the corresponding narrow FM benefits should include all effects of projects (positive or negative) for which the impact on individuals is

mediated by flood or erosion, given existing land-use zoning, or by the recreational or environmental value of FM works.

[David Richardson Defra comment - could reduce current flexibilities where 'reasonable' amounts of environmental or amenity benefit are 'absorbed' in FM funded projects. – the difficulties of achieving multiple contributions should not be under-estimated as many environmental groups or tourist development authorities do not have large capital budgets.]

Implications for the PAG guidance

Implications for the PAG guidance are currently being considered. Initially this will be through selected pilots to better identify the value added of changing the approach, the associated costs (in terms of appraisal time and data needs) and key risks. Key issues which will need to be explored include:

- Adequacy of data on commercial losses,
- Relationship to the development of appraisal summary tables and incorporation of multi-criteria type approaches,
- Consideration of additionally of certain types of benefits at a national level,
- Relationship between costs and benefits and insurance.

Developing a cost–benefit framework for the appraisal of flood and coastal defence projects

1. Introduction

1.1 Objective

The main objective of this study is to investigate the feasibility of changing the appraisal framework for flood and coastal defence (FCD) projects from the traditional ‘calculus of social costs and benefits’ (SCB), as currently used by Defra, to the ‘calculus of willingness to pay’ (WTP), as now used for project appraisal by the Department for Transport. (The full terms of reference are in an Annex.) The main principles of Defra’s current methodology are described in *Flood and Coastal Defence Project Appraisal Guidance, Part 3: Economic Appraisal* [henceforth *PAG3*]. The Department for Transport (then the Department of the Environment, Transport and the Regions) changed its appraisal framework from SCB to WTP following the recommendations of my report of January 1999, *Developing a Consistent Cost–Benefit Framework for Multi-Modal Transport Appraisal* [henceforth *Consistent Cost–Benefit Framework*]. The current study uses the same principles as that report and applies them to the case of FCD projects. Paragraphs 2.1 to 2.5 and 5.1 to 5.7 of the current report are adapted from *Consistent Cost–Benefit Framework*.

2. The advantages of the WTP calculus

2.1 Cost-benefit analysis

A cost–benefit analysis (CBA) aims to take account of all the ways in which a project affects people, irrespective of whether those effects are registered in conventional financial accounts. It can be described in two different ways – as a *calculus of willingness-to-pay* (WTP) or as a *calculus of social costs and benefits* (SCB). These lead to two different ways of presenting the cost-benefit accounts, but (if properly carried out) both lead to the same valuation of net social benefit.

2.2 Willingness-to-pay approach

The basic strategy of the WTP calculus is to arrive at a money measure of the net welfare change for each individual that is brought about by the project under consideration, and then to sum these. The welfare change for any individual is measured by the *compensating variation*, i.e. the individual’s WTP for benefits or the negative of his/her willingness to accept compensation for disbenefits. The principle behind this calculus is the Kaldor-Hicks *compensation test*: a move from

one state of affairs to another passes this test if, in principle, those who benefit from the move could fully compensate those who lose (without themselves becoming losers). When the cost–benefit accounts are presented in this way, there often are items which appear as benefits for one person and equally-valued costs for someone else: such items are *transfer payments* or *pecuniary externalities*. Items which do not cancel out in this way are *social* costs or benefits (sometimes called *resource* or *real resource* costs or benefits). The word ‘social’ is used to signify that these are costs or benefits which fall on ‘society as a whole’, understood as the aggregate of all individuals.

2.3 Social cost benefit approach

The SCB calculus seeks to measure the value of the ‘resources’ used by, and the benefits created by, a project. This approach distinguishes between social costs/benefits and transfer payments at the outset, and takes account only of the former. For example, consider a straightforward market transaction: a person buys and consumes a can of beer. In the calculus of social costs and benefits, the marginal cost of producing the beer is a social cost, while the consumer’s enjoyment of the beer is a social benefit; the actual payment made for the beer is a transfer payment, and is ignored. (In contrast, the WTP calculus would record a benefit to the consumer equal to the consumer’s surplus on the beer, i.e. the excess of WTP over the price paid, and it would record a benefit to the producer of the beer equal to the producer’s surplus, i.e. the excess of price received over marginal cost.) Because the SCB calculus nets out transfer payments, this approach does not allow the net social benefit of a project to be disaggregated into impacts on different economic interest groups.

2.4 Similarities between WTP and SCB

Clearly, the two methods are equivalent. It is important to realise that the difference between the two methods is simply a difference in presentation. It is *not* a difference between wider and narrower ways of defining the class of effects that ultimately count in CBA. When CBA was first widely used in the 1960s, it was conventional to use the SCB calculus. More recently, however, there has been a tendency for cost-benefit analysts to prefer the WTP calculus.

2.5 Differences between WTP and SCB

The principal advantage of the WTP approach is that it leads naturally to a presentation of results which makes clear how a project impacts on the members of different economic interest groups (e.g. house owners, farmers, taxpayers), how it impacts on different financial budgets (e.g. the budgets of different branches of government, and those of project partners), and how far the benefits created by the project are of the kind for which the relevant public funds have primarily been allocated. With the SCB approach, in contrast, all these

distinctions are liable to be hidden in the aggregation of resource costs and benefits. At the same time, the WTP approach allows the traditional bottom line of a CBA – the net social benefit of a project – to be presented as the sum of the net benefits of all relevant interest groups.

2.6 Green book considerations

Current Treasury guidance on project appraisal gives considerable emphasis to the distributional impacts of projects (*Green Book* [not dated], paragraphs 5.33 to 5.41 and Annex 5). The *Green Book* is primarily concerned with distribution as between social and economic groups defined by such general characteristics as income, gender, ethnicity, health, disability, age and geographical location. On the grounds that ‘other distributional issues are largely correlated with income’, it recommends that distributional analysis should classify individuals or households by relative income. It is a prerequisite for such analysis that the impacts of projects are identified separately for different economic interest groups. In most cases, the data used in project appraisal do not *explicitly* differentiate between individuals with different incomes, but if impacts are identified for economic interest groups, it is often possible to make reliable inferences about impacts on interest groups by using national data. For example, FCD appraisals estimate the social costs of flood risks by using project-specific data on risks of flooding of different depths to houses of different types and sizes, and then using standard formulae to arrive at monetary valuations of social cost. Using the same data, an appraisal using the SCB calculus would estimate the losses imposed by flood risks on the interest group of ‘households subject to flood risk’. If desired, these losses could be disaggregated by type of house; then, using national or regional data on the relationship between income and type of house, the impact of the relevant project on different income groups could be estimated.

2.7 Income-distribution effects

In the case of FCD, income-distributional effects have clear policy significance. For example, in terms of the definitions used in CBA, the loss imposed on a householder by flooding increases with the value of the house and its contents. Since richer individuals tend to live in more valuable houses with more valuable contents, CBA gives greater value to flood defence for richer people. But (in contrast to the market, where richer people end up with better-quality goods than poorer people, but have to pay more too) the benefits of flood defence are provided by government free of charge. Policy-makers may wish to introduce some counterweight into the appraisal process. Currently, such counterweighting is introduced only at the post-appraisal stage, when projects are assigned ‘priority scores’. A project’s priority score depends on the *number* of houses protected, per unit of cost, as well as on the benefit–cost ratio.

2.8 Fairness and equity

FCD projects also raise distributional issues of a different kind, perhaps better described as issues of *fairness* or *equity*. To a greater extent than in many other areas of public policy, even relatively minor FCD decisions can have large impacts on identifiable individuals. In the UK, private individuals do not generally have any *entitlement* to government-financed FCD, but government has a permissive power to supply FCD without levying any corresponding charge. Thus, FCD decision-making typically involves the discretionary allocation of large benefits. Such situations inevitably provoke questions of fairness. (For example, for the owner of a seaside house, the difference between alternative options for coastal defence may be the difference between the preservation and the loss of an uninsured – because uninsurable – house. Marginal differences in project cost, which have no connection with the situation as faced by the house owner herself, may tilt the balance one way or the other.) They also raise public concerns about the lobbying power of special interest groups. For these reasons, it is particularly important that project appraisal is transparent. One aspect of such transparency is the provision of information about the separate impacts of projects on different economic groups, which is a feature of the WTP approach.

2.9 Beneficiary contributions?

Partly as a response to these equity concerns, and partly with a view to eliminating perverse incentives (for example, the absence of a disincentive to flood-plain development if flood protection is supplied free of charge), the Government is exploring the possibility of moving to a regime in which the beneficiaries of FCD contribute a greater share of the costs (see *The Flood and Coastal Defence Funding Review: A Discussion of Funding Options*, Oxford Economic Research Associates, 2001; and *Payment of Compensation, Relocation and Other Issues in Relation to Flood and Coastal Erosion Risk Management*, Defra Flood Management Division, July 2004). Current guidelines for FCD grant aid emphasise the desirability of private contributions from major beneficiaries. (For example, Defra's current *Memorandum Relating to Flood Defence Grants* [henceforth *Flood Defence Grants*] states that 'Operating authorities are expected to obtain contributions wherever possible towards the cost of a project from those who will derive benefit from it or whose actions or requests have led to the project being undertaken' [paragraph 87].) There is a particular expectation of private contributions in cases in which FCD projects create private benefits that are seen as incidental to the aims of Defra's FCD programme – for example, the enhancement of existing roads and bridges, and the development value of FCD protection for currently undeveloped land (*Flood Defence Grants*, paragraph 92). Defra's grant guidelines seem to be designed to give incentives to local authorities and internal drainage boards to *seek* private contributions. (Private contributions in respect of core FCD benefits are treated as 'windfall' income to operating authorities, rather than being deducted from the

total project cost that is eligible for grant aid [*Flood Defence Grants*, paragraph 89].)

2.10 Contributions and SCB / WTP

However, because the SCB approach is used, project appraisal takes no account of the distribution of costs between government and private contributors; since private contributions are transfer payments, they have no place in the cost–benefit accounts. Thus, private contributions can have no effect on the choice of options or on the benefit–cost ratio of the chosen option, and hence no effect of that option’s priority score. The implication is that there is no incentive for beneficiaries to make private contributions. A policy objective of ‘seeking’ private contributions is an empty gesture unless there is some mechanism by which a contribution to the cost of a project makes that project more likely to be undertaken. The WTP approach allows the appraisal results to be displayed in a form which identifies private contributions. It is then possible to use decision criteria which, other things being equal, favour projects for which there are private contributions.

2.11 Contributions examples

In terms of the pure logic of SCB appraisal, the ‘empty gesture’ problem applies even to enhancements that are not strictly essential to an FCD project. For example, consider a flood defence project which necessitates the reconstruction of what is currently a narrow road bridge. Suppose it is possible to reconstruct the bridge to the current width, but the marginal cost of building it wider is small relative to the marginal benefits to road users. Should the highway authority contribute to the cost of a wide bridge? If this scenario is analysed as a bargaining problem, the agency sponsoring the project clearly has bargaining power: it can threaten to rebuild a narrow bridge unless a contribution is forthcoming. But this threat cannot be made if project decisions are strictly determined by SCB principles. Since the project as a whole will have a higher benefit–cost ratio if it includes the wider bridge rather than the narrower one, the wide-bridge option will be chosen whether the highway authority contributes or not.

2.12 Treatment of contributions in FCDPAG 3

The problems discussed in the preceding paragraph are connected to another limitation of the SCB approach. Traditional CBA does not distinguish between types of benefit according to whether or not the creation of those benefits is the particular responsibility of the agency which funds the relevant project. But, as a matter of political and administrative fact, agencies are allocated specific budgets for specific purposes. For example, *PAG3* states:

Development benefits arising from the intensification of land use should normally be excluded from the economic assessment of flood and coastal defence schemes. The primary reason for this exclusion is to preclude Government funding of works which would enable land to be developed for private gain. Where works are proposed for economic regeneration or similar purposes, there are other sources of funding available. (p. 21)

The implication is that Defra support for FCD projects comes from a specific 'source of funding' that has been allocated for FCD. When allocating funds for FCD, Defra is not expected to spend its budget on creating net social benefits wherever in the economy this can be done most effectively; its primary responsibility is to create what might be called 'FCD benefits' as cost-effectively as possible. The boundary between FCD and non-FCD benefits is not always clearly defined, but 'development of land for private gain' has clearly been classified as non-FCD by *PAG3*.

2.13 No FCD benefits in FCD appraisals

The problematic status of non-FCD benefits in FCD project appraisal is also revealed in *PAG3*'s treatment of private contributions:

Developers, highway authorities or others sometimes make contributions towards the costs of the project, but it is often incorrect to deduct these contributions from project costs. Generally such windfalls only affect the distribution of costs and not the total resources required for the project. If the benefits that accrue to the contributor are excluded from the evaluation benefits, then it is reasonable also to exclude their contribution. However, particularly when those contributions come from other budgets of public money, it is preferable to include all benefits and costs. In this way the benefit-cost analysis will demonstrate whether the project as a whole is justified. (p. 54)

The first two sentences present the standard SCB interpretation of CBA, according to which private contributions are transfer payments and hence irrelevant for project appraisal. The third sentence acknowledges the possibility of defining each project so that non-FCD elements, such as the enhancement of transport infrastructure and the intensification of land use, are excluded. If this practice is followed, non-FCD elements can be provided as optional extras if the beneficiaries will pay for them, but they do not appear in the appraisal at all. However, the final sentences of the paragraph draw back from this suggestion, favouring the traditional SCB approach in which all the costs and benefits of a project are treated equally.

2.14 Disaggregating benefits

The WTP approach allows the benefits of a project to be displayed in a form which differentiates between *core* benefits (i.e. benefits which fall within the special remit of the funding agency) and non-core benefits. Similarly, it allows the costs of a project to be disaggregated into those that fall on the budget of the funding agency and those that fall elsewhere.

3. Benefit–cost ratios

3.1 Introduction

Section 2 has argued that the WTP approach is much more flexible than the SCB approach, allowing the information generated by a project appraisal to be displayed in a form which can then be used in different ways. However, any project appraisal methodology needs to produce (at most) a small number of key summary statistics for each option or project, for use in decision-making. The statistics that are provided are useful to the extent that they provide relevant information for defensible decision-making criteria. Thus, before designing a cost–benefit framework for FCD appraisal, it is crucial to ask what criterion (or criteria) should be used in FCD decision-making.

3.2 PAG methodology

In the project appraisal methodology currently used by Defra, the key summary statistic for each option or project is the *benefit–cost ratio*. This is defined in *PAG3* as follows:

In deriving a benefit–cost ratio, there is no universally agreed basis for classifying a particular item either as a positive cost or as a negative benefit (disbenefit) or vice versa. While the particular approach that is adopted will have no effect on the net present value of an option, it can have a significant effect on the benefit–cost ratio. To ensure a consistent approach between options and between schemes, it is important to have a common rule. In the analysis of flood and coastal defence schemes, therefore, the following conventions should be adopted.

Any ‘negative costs’ should be regarded as benefits.

Any ‘negative benefits’ should be regarded as costs. (pp. 14-15)

This definition adheres to the spirit of the SCB approach in not recognising any distinction between financial and non-financial costs or benefits; the only distinction it recognises is between ‘positive’ and ‘negative’. Any given impact of

a project (defined relative to a do-nothing option) is a 'cost' if it counts negatively in the appraisal and a 'benefit' if it counts positively. In a rough and ready way, the benefit–cost ratio measures the net benefit of a project relative to its scale. However, as *PAG3* acknowledges, this definition of the benefit–cost ratio is in some respects arbitrary, chosen merely as a salient convention. For example, if widening a river for flood alleviation yields gravel that can be sold, the *PAG3* convention treats the value of the gravel as a benefit (*PAG3*, p. 15). But it would be equally natural to treat this as a factor which reduces the engineering cost of the project.

3.3 Indicative standards

The practical significance of the benefit–cost ratio in the *PAG3* methodology emerges in the methodology for 'choosing the option', i.e. choosing which variant of a project to undertake. This methodology integrates information about benefit–cost ratios with information about *indicative standards*. For each of five land use bands, ranked from A to E in decreasing intensity of land use, there is an 'indicative' range of levels of flood risk; thus, the protection at a given site can be below, within, or above the relevant indicative standard. The principle behind the *PAG3* procedure is that, other things being equal, increases in the level of protection below the indicative standard should have priority over increases within that standard, which in turn should have priority over increases above that standard.

3.4 Existing decision rule

The procedure is applied to a situation in which, for a given site, there is a range of alternative *options*, including the default possibility of doing nothing. It takes the form of the following algorithm:

- (1) Find the do-something option with the highest benefit–cost ratio. If this ratio is less than 1, do nothing.
- (2) If the option with the highest benefit–cost ratio has a ratio greater than 1, then either this option or one which gives greater protection should be chosen.
- (3) Increases in protection (beyond that provided by the project with the highest benefit–cost ratio) up to the bottom of the indicative range should be chosen if and only if the incremental benefit–cost ratio is 'robustly greater 1' (i.e. greater than about 1.5).
- (4) Increases in protection within the indicative range should be chosen if and only if the incremental benefit–cost ratio is 'comparable with other funded schemes' (i.e. greater than about 3).
- (5) Increases in protection above the top of the indicative range should be chosen if and only if the incremental benefit–cost ratio is 'exceptional'.

3.5 Decision rule rationale

The rationale of this procedure seems to depend on the implicit (and, in most practical cases, realistic) assumption that the do-something option with the highest benefit–cost ratio is one which provides relatively little protection, but at low cost. The procedure works by considering progressively higher-protection options. At each stage, a higher-protection option is accepted in preference to a lower-protection option if the incremental benefit–cost ratio is greater than some critical value (1 for the move from the do-nothing option to the option with the highest benefit–cost ratio, ‘robustly greater than 1’ for further improvements below the indicative range, and so on.)

3.6 Priority scoring

Benefit–cost ratios also contribute to the ‘priority scores’ that are used to determine which projects are actually undertaken in each financial year. The priority score of a project has various components (including the number of houses protected per unit of cost, and an assessment of the project’s environmental value), but the benefit–cost ratio is the summary statistic that is used to represent the information generated in the appraisal process. A project is chosen to be undertaken if its priority score is greater than some critical value, set each year as a rationing device. The rationale of this methodology seems to include the principle that, as far as economic appraisal is concerned, the criterion for project selection should be that of ranking projects by their benefit–cost ratios.

3.7 NPV/K rates approach

What is the rationale for making decisions by comparing benefit–cost ratios with critical values? In the literature of CBA, this kind of procedure is standardly recommended for optimising in the presence of budget constraints, but on the condition that ‘cost’ is defined as *the project’s requirement of units of the constrained input*. The critical value of the benefit–cost ratio is then interpreted as the shadow price of the constrained input. In the context of capital rationing, this has often been called the ‘NPV/K’ rule, with NPV denoting the net present value of the project and K its capital cost. The overall objective is to maximise the total NPV of all projects undertaken, subject to a total capital constraint. The optimal solution can be described in terms of a ‘shadow price of capital’ or critical value of NPV/K. This solution can be implemented in a decentralised way by stipulating that a project is undertaken if and only if its NPV/K ratio is greater than the critical value. When choosing between mutually exclusive variants of a given project, the optimal rule is to select a higher-K variant rather than a lower-K one if and only if the incremental NPV/K ratio is greater than the critical value. The NPV/K rule is endorsed by the *Green Book*:

If there is a budget ceiling, then the combination of proposals should be chosen that maximises the value of benefits. The ratio of the net present value to the expenditure falling within the constraint can be a

useful guide to developing the best combination of proposals.
(paragraph 6.4)

3.8 NPV/K ratio rationale

The NPV/K rule can be described in a logically equivalent way in terms of the critical value of $(NPV - K)/K$. (That the two presentations are equivalent follows immediately from the fact that $(NPV - K)/K \equiv (NPV/K) - 1$; subtracting 1 from the summary statistic for each project, while also subtracting 1 from the critical value of that statistic, makes no difference to the selection of projects. Notice that the baseline value of the ratio which indicates that, in the absence of budget constraints, a project is just worth carrying out is 1 for the $(NPV - K)/K$ rule and 0 for the NPV/K rule.) Since $NPV - K$ is the net present value of the project excluding its capital cost, $(NPV - K)/K$ can be interpreted as a benefit–cost ratio. However, it is crucial for the rationale of this rationing procedure that the distinction between ‘cost’ and ‘benefit’ is not between ‘positive’ and ‘negative’, but between ‘inside’ and ‘outside’ a budget constraint.

3.9 ‘Broad’ and ‘Narrow’ arguments

For consistency with the *Green Book*, and for comparability with my report on transport appraisal, *Consistent Cost–Benefit Framework*, the current report will use the ratio in the NPV/K form, which will be called the *net benefit–public expenditure ratio* or, for short, the *benefit–expenditure ratio*. When such a ratio is used as the summary statistic for a project, the denominator of the ratio should be the project’s net cost to the relevant constrained budget, and the numerator should be the project’s net contribution to the objective of the decision-making agency. On a *broad* conception of costs and benefits, evaluated from the viewpoint of ‘the government’ as a unified decision-making agency, the denominator is the net cost of the project to all forms of public expenditure and the numerator is the project’s net benefit to all parties, including the government itself (as a proxy for taxpayers). On a *narrow* conception, evaluated from the viewpoint of a particular agency charged with the particular responsibility of producing benefits of a certain type, the denominator is the net cost of the project to the budget allocated for the production of those benefits and the numerator is that part of the project’s net benefits which are of the relevant type, minus the costs to the relevant budget.

3.10 Conclusion on NPV/K ratio

In the light of this analysis, the ambivalence of current practice in FCD appraisal with respect to non-FCD benefits (discussed in Section 2) can be interpreted as ambivalence between the broad and narrow conceptions of cost and benefit. I recommend that, as an aid to clear thinking, the summary statistics for a project appraisal include both broad and narrow forms of the benefit–expenditure ratio.

3.11 Recommendation on NPV/K ratio

My provisional recommendation is that, for the narrow definition of this ratio, the constrained *FCD budget* should be defined to include all public funds specifically allocated for FCD projects, including Defra grant support and FCD expenditure by the Environment Agency, local authorities and internal drainage boards. The corresponding 'narrow' concept of *FCD benefits* should be defined to include all effects of projects (positive or negative) for which the impact on individuals is mediated by flood or erosion, given existing land-use zoning, or by the recreational or environmental value of FCD works. Thus, if an FCD project reduces flood-related disruption to road traffic, that is an FCD benefit, but if a road improvement is carried out as a by-product of FCD work, any resulting reduction in travel time is a non-FCD benefit. If an FCD project reduces the risk of flood damage to existing property, that is an FCD benefit, but if it allows development to take place on land that was previously zoned for agricultural use, the value of that development is a non-FCD benefit.

4. A note on private contributions

4.1 Effect of private contribution 1

Whichever variant of the benefit–expenditure ratio ('broad' or 'narrow') is used, private contributions to a project increase the value of the ratio. On either conception, a private contribution leaves the numerator of the ratio unchanged (since that is a measure of *net* benefit), while it reduces the denominator by taking some of the costs of the project 'off the budget'. For example, consider a project with costs of £1m falling on the constrained budget of a public agency whose responsibility is confined to FCD benefits. The project produces total benefits of £1.8m, of which £1.3m are FCD benefits and £0.5 are non-FCD benefits. Its benefit–expenditure ratio is 0.8 on the broad definition and 0.3 on the narrow definition. Now suppose that the non-FCD beneficiaries make private contributions of £0.25m. Then the cost to the constrained budget falls to £0.75m while there is no change in total benefits or FCD benefits. The benefit–expenditure ratio increases to $0.8/0.75 = 1.07$ on the broad definition and $0.3/0.75 = 0.4$ on the narrow definition.

4.2 Effect of private contribution 2

Once it is recognised that decision criteria based on benefit–expenditure ratios are devices for rationing constrained funds, the rationale for a procedure in which these ratios are sensitive to private contributions becomes obvious. In effect, private contributions allow the budget constraint to be relaxed. Given that public funds are constrained, private contributions increase economic efficiency. Private contributions have two overall effects on the FCD programme: they

increase the volume of FCD work carried out, by transferring some of the costs to beneficiaries, and they lead to an increase in the critical value of the benefit–expenditure ratio at which projects are accepted. Through the second mechanism, some FCD projects that would otherwise have been carried out can be crowded out. This is inevitable if the FCD budget is constrained and if there is to be an incentive for beneficiaries to make private contributions.

4.3 Private contribution recommendation

Because of this crowding-out effect, my recommendation about the treatment of private contributions is open to a possible objection on grounds of fairness. Although private contributions increase economic efficiency, a regime which allows such contributions to impact on project selection favours potential beneficiaries for whom the transaction costs of negotiating private contributions are lowest (e.g. small numbers of large beneficiaries rather than large numbers of small beneficiaries). This could be interpreted as favouring special interests (see paragraph 2.8 above). The fundamental policy issue to be resolved here is whether the government wants voluntarily negotiated private contributions to play a significant role in financing FCD; if it does, it must accept that contributions to a project will make that project more likely to be chosen.

5. The unit of account and the treatment of indirect taxes

5.1 Unit of account

Any CBA needs a numéraire, or unit of account. Obviously, the most convenient unit of account is money. But in an economy with indirect taxes, the unit of account can be *at factor cost* (i.e. net of indirect tax) or *at market prices* (i.e. gross of indirect tax). If we focus on the resources used to produce output, it is more natural to use a factor-cost unit, since most indirect taxes are levied only at the final consumption stage. But if we focus on people's willingness to pay for final consumption, a market-price unit of account may seem more natural, since prices to consumers are generally quoted gross of tax.

5.2 Consistency

Which unit is used in CBA is of no real significance (just as it is of no significance whether amounts of money are expressed in pounds or pence); but consistency is essential. The *indirect tax correction factor* is the conversion rate between the two units. If CBA uses the factor-cost unit, a correction factor has to be applied to any costs or benefits that have been measured gross of tax. Conversely, if the market-price unit of account is used, the reciprocal of that correction factor has to be applied to costs or benefits that have been measured net of tax. What *is*

crucial is that a consistent unit of account is used throughout an appraisal methodology. There seem to be no compelling reasons to prefer one unit of account over the other. For consistency with my previous report on transport appraisal, *Consistent Cost-Benefit Framework*, the market-price unit of account will be used in this report.

5.3 Indirect tax correction factor

The basic idea behind the indirect tax correction factor can be stated very simply. (This argument can be found in Department of Transport Highway Economics Note No. 3 [written by M.A. Schraer and dated December 1977] and in Robert Sugden and Alan Williams, *The Principles of Practical Cost-Benefit Analysis* [Oxford University Press, 1978; henceforth *Principles of CBA*], pp. 109-110. A fuller discussion is given in my report to the then Department of the Environment, Transport and the Regions, *The Treatment of Taxation in the Cost-benefit Appraisal of Transport Investment*, 1998.)

5.4 Indirect tax treatment

Denote the average rate of indirect tax on final consumption by t . Thus, goods which are valued at £1 net of tax are valued at $£(1 + t)$ gross of tax; of each £1 of consumer spending, $£1/(1 + t)$ goes to producers in wages, rents and profits and $£t/(1 + t)$ goes to the government. Assume that the government balances its budget. Now suppose the government increases its spending by £1, and wishes to finance this through direct taxation. To do this, it must raise direct taxes by *more than* £1, since the increase in direct taxation will imply a reduction in disposable income and hence a fall in indirect tax revenue. In fact, direct taxation must be increased by $£(1 + t)$. Disposable income will then fall by $£(1 + t)$. Since the proportion $t/(1 + t)$ of all consumer spending goes to the government as indirect tax revenue, indirect tax revenue will fall by $£(1 + t) \times t/(1 + t)$, i.e. by $£t$. Thus the net effect on government tax revenue is $£(1 + t) - £t = £1$. The implication of this example is that each extra £1 spent by the government is equivalent to a $£(1 + t)$ loss of disposable income by households.

5.5 Interpretation 1

This conclusion should not be interpreted as saying that resources have a different value when they are in the hands of the government than when they are in the hands of private consumers. The point is simply that we are using two different units of account. When we say the government spends £1, we mean that it spends £1 in terms of the factor-cost unit of account. The cost to households in terms of disposable income is $£(1 + t)$, but this is in terms of the market-price unit of account. Each factor-cost unit converts into $(1 + t)$ market-price units: this conversion rate (or its reciprocal, depending on which unit we treat as basic) is the indirect tax correction factor.

5.6 Interpretation 2

This argument applies to the valuation of all goods, not merely those that are traded on markets. For example, suppose the government spends £1m (in factor-cost terms) on a project which creates a new habitat for some rare species. Suppose the benefits of this project are measured by the sum of individuals' WTP, as expressed in (or inferred from) stated preference surveys. How great must this sum be in order for the project to be worthwhile according to CBA criteria? The answer is $£(1 + t)$ million. In other words, if we are carrying out a CBA and are using the factor-cost unit of account, the WTP measure of benefit must be deflated by the tax correction factor. Why? Because stated preference surveys use the market-price unit of account. When a person says that she would be willing to pay up to (say) £1 for some environmental benefit, she is saying that, in order to gain that benefit, she would be willing to forgo consumption goods which are worth £1 *at market prices*. The same information could equally well be expressed by saying that she would be willing to forgo consumption goods which are worth $£1/(1 + t)$ at factor cost. It is simply an accounting convention of stated-preference surveys (when addressed to private individuals or households) that answers are expressed in the market-price unit of account. Correspondingly, if the market-price unit of account is used in CBA, expenditure by firms or government which has been valued net of indirect taxes should be scaled up by the reciprocal of the indirect tax correction factor, while individuals' WTP as expressed in stated-preference surveys does not need to be adjusted.

5.7 Factor cost and market prices

The distinction between factor-cost and market-price units of account must not be confused with the issue of whether the *relative* values which CBA assigns to different goods should correspond with relative pre-tax prices or with relative post-tax prices. It is a standard principle of CBA that relative pre-tax prices are used for evaluating changes in production, while relative post-tax prices are used for evaluating changes in consumption (see, e.g., *Principles of CBA*, pp. 99-112). In most practical CBA, the default assumption is that goods and services are produced under conditions of perfectly elastic supply, with the implication that relative pre-tax prices should be used to measure the relative social costs of goods and services consumed in a project. Given this assumption, a CBA which uses the factor-cost *unit of account* will also measure the social value of each good by *its* pre-tax price (i.e. by *its* factor cost). Correspondingly, a CBA which uses the market-price unit of account will measure the social value of each good by its pre-tax price, scaled up by the reciprocal of the indirect tax correction factor. Notice that this factor reflects the *average* rate of indirect tax in the economy as a whole, not the rate that is specific to each good. In this way, proper account is taken of differences in indirect tax rates.

5.8 Government role in indirect taxes

If the calculus of WTP is used, the treatment of indirect taxes requires that 'government', in its role as the agency which levies taxes, is treated as an economic interest group. For example, consider a road improvement project which, by reducing the travelling time required to make trips, induces an increase in car use. The resulting benefit *to car users* is measured by the change in consumers' surplus on trips. But (if fuel tax is interpreted as a revenue-raising device, and not as a charge for environmental damage) there is an additional source of benefit: there has been a switch of expenditure from goods in general to fuel, which is much more highly taxed. Equivalently, there has been a switch of expenditure towards goods for which, per pound of after-tax value, the social cost of production is relatively low. In the calculus of WTP, this element of benefit can be classified as a gain to 'the government' in the form of increased tax revenue.

5.9 Subsidies

An analogous case in FCD appraisal relates to subsidies rather than taxes. Consider an FCD project which leads to an increase in agricultural production. Because agricultural products are subsidised, the social value of each unit of extra production is less than the price. In the WTP calculus, this is represented by crediting farmers with the market value of the increased production (since this is the amount by which their incomes increase), while debiting 'the government' with the excess of market value over social value (representing increases expenditure on agricultural subsidies).

6. The main costs and benefits of FCD projects

6.1 Introduction

In this Section, I consider the main items of cost and benefit that appear in appraisals of FCD projects. For each item, I consider how it is treated in the *PAG3* methodology, and how it might be treated in an appraisal methodology which used the WTP calculus. In the course of this analysis, the components of a cost-benefit spreadsheet are being assembled. The spreadsheet itself will be presented in Section 7.

6.2 Assumptions

Throughout, I assume that social costs and benefits, or gains and losses to different economic groups, have been converted to expected present values and are expressed relative to a do-nothing option. I use the term 'project partner' to refer to any individual, firm or public agency who/which is involved in decision-

making or bargaining about the project as a potential *voluntary* contributor (rather than as a spender of funds from the FCD budget). It should be taken as read that each project partner is treated as a distinct economic group in the cost-benefit accounts. For example, if a retail business makes a private contribution to a project which will reduce its exposure to flood risk, the decomposition of items (c) (changes in risk of damage to buildings) and (e) (changes in risk of disruption to trade) should distinguish between ‘businesses other than project partner’ and ‘project partner’.

6.3 Positive and negative effects

In line with the recommendations in Section 3 about the definition of benefit–expenditure ratios, the classification of costs and benefits makes no distinction between ‘positive’ and ‘negative’ effects. For example, item (g) is ‘changes in environmental and heritage value’. Under this heading, a particular FCD project might contribute either positively (e.g. by protecting an important wildlife habitat from flood or coastal erosion) or negatively (e.g. by inhibiting the natural formation of a floodplain or coastal habitat). Unless otherwise stated, all items of benefit or disbenefit are (positive or negative) ‘FCD benefits’ for the purposes of calculating benefit–expenditure ratios (see Sections 3.9 to 3.11).

6.4 Construction and maintenance costs (a)

In the *PAG3* methodology, these are treated as social costs and valued at factor cost. In a WTP framework, with the market-price unit of account, they should be scaled up by the reciprocal of the indirect tax correction factor and attributed to the relevant economic interest group. Costs financed by Defra, the Environment Agency, local authorities or internal drainage boards as part of their FCD programmes should be attributed to the FCD budget. Costs financed by contributions from project partners are not charged to that budget; they should be attributed to the relevant partners, distinguishing between public-sector and private-sector contributors. (This distinction is needed for the broad definition of benefit–expenditure ratio, for which the denominator is the cost of the project to public funds.) In CBA, the conventional default assumption is that market prices are equal to marginal costs. On this assumption, there is no net gain or loss to the contractors who carry out construction and maintenance work, and so there is no need to treat them as an economic interest group.

6.5 Changes in risk of damage to buildings (b)

These (usually positive) effects of projects accrue to households, businesses and public agencies as owners or occupiers of property. They are currently valued at factor cost; these valuations should be scaled up by the reciprocal of the indirect tax correction factor.

6.6 Ex-ante and ex-post costs

In the SCB calculus, there is no need to take account of the extent to which costs of flood/erosion damage are transferred to insurance companies, since such transfers affect only the distribution of social costs (except for the effects of moral hazard). In the WTP calculus, however, the role of insurers becomes significant. In a fully competitive insurance market, insurance would not transfer the *ex ante* risks of flood/erosion damage between individuals; it would merely transfer the *ex post* costs of damage between individuals in a given risk class. Since the *PAG3* methodology uses *expected* values of damage, competitive insurance would have no effect on the distribution of flood damage risks. Currently, the market for household insurance for flood damage is clearly *not* competitive, as a result of the 'gentlemen's agreement' between the government and the insurance industry, under which insurance companies provide flood damage insurance in their standard household policies, while not normally charging higher premiums to higher risk groups. (See Michael Huber, 'Reforming the UK flood insurance regime: the breakdown of a gentlemen's agreement', Discussion Paper 18, ESRC Centre for Analysis of Risk and Regulation, 2004.) Under this regime, the costs of insured flood risks are transferred to insurance companies and then passed on in higher premiums to the whole insured population. However, this regime may prove vulnerable to the increasing availability of information about flood risks at a very local level and to increased competition in the insurance industry. My provisional suggestion is that, in recognition of the fragility of the gentlemen's agreement, insurance is assumed to be competitive. On this assumption, there is no transfer of *ex ante* risks from the households and firms on which they first fall. The same analysis applies to any other insurable risks.

6.7 Treatment of Groups

In the provisional cost-benefit spreadsheet, these effects are attributed to functionally-defined economic groups (households, businesses, and public agencies). If desired, the 'household' group could be disaggregated to reflect distributional concerns, e.g. between different income groups.

6.8 Abandonment of buildings (c)

An FCD project may prevent or delay the necessity to abandon a building (or in rare cases, create or bring forward this necessity). The analysis of this item is essentially the same as for item (b). One special but minor issue is the treatment of the 'goodwill' of a business when this is specific to a building (e.g. a pub, shop, hotel or restaurant). Goodwill is the excess of the value of the property with the business as a going concern over the value of the property without it. *PAG3* treats goodwill as a transfer on the grounds that 'If a hotel or pub were lost through erosion, the trade would simply transfer to other outlets' (p. 25). I suggest that it would be more consistent with the conventions of CBA to use the default assumption that market prices reflect social value. If, say, a hotel is lost

to erosion, then consumers' *expenditure* will obviously be diverted to other goods and services. But goodwill is not a measure of expenditure; it is a measure of the component of surplus that the business is able to capture by virtue of its special features (e.g. location, reputation, history). Since there seems no reason to assume that when surplus is lost in one part of the economy there will be a compensating creation of surplus elsewhere, goodwill should be treated like other components of the market value of property.

6.9 Changes in risk of loss of agricultural output (d)

These (usually positive) effects are currently valued at factor cost after subtracting agricultural subsidies. In the WTP calculus, the value of changes in agricultural output *at market prices* should be attributed to agricultural businesses. This implies two revisions to the valuations that are used in the *PAG3* methodology: subsidies should not be deducted, and values should be converted to the market-price unit of account by scaling up by the reciprocal of the indirect tax correction factor. Net increases in agricultural subsidy should be attributed (as a loss) to 'government'. These too should be scaled up from their *PAG3* values to the market-price unit of account.

6.10 Abandonment of agricultural land (e)

An FCD project may prevent or delay the necessity to abandon agricultural land (or in rare cases, create or bring forward this necessity). The analysis of this item is essentially the same as for item (d).

6.11 Changes in risk of disruption to trade (f)

This item refers to the 'indirect losses' incurred by businesses when trade is disrupted by flooding. Such losses result from a business having to continue to pay rent, wages, capital charges, and so on while its revenue stream is reduced. It is measured by the loss of *profit* to the business (not the loss of gross revenue). The *PAG3* methodology normally treats indirect losses as transfers:

Losses of trade to commercial or retail outlets will be a transfer payment except [in the following circumstances]... Losses of trade to commerce and retail outlets result in real losses if the consumer cannot obtain an equivalent good at the same time and at the same cost... [But the] normal expectation is that consumers will be able to obtain equivalent goods at no extra cost and therefore any differences will not be worth evaluating. (pp. 25-26)

However, Section 5.11 of the 'Multi-Coloured Manual' [...] allows some indirect losses to count as social costs. Conceptually, indirect losses are similar to goodwill. Loss of profit is a genuine loss to a flood-affected business. It would be contrary to the conventional default assumption that market prices reflect

social costs to assume that the diversion of consumer expenditure to other businesses induces an offsetting increase in profit. Thus, loss of profit should be scaled up to the market-price unit of account and recorded in the cost–benefit accounts as a loss to businesses.

6.12 Effects on transport/utilities/emergency services (g)

These effects (normally positive) occur when FCD work reduces the risk of disruption to transport or utilities or removes the necessity for abandoning transport or utility infrastructure, or when the reduction of flood risk reduces the demands made on emergency services. Depending on the case, they may be attributed either to the relevant agency (e.g. highway authority, police service) or to private individuals (e.g. savings in travel time as result of a reduction in flood risks). These effects are treated as FCD benefits in so far as they do not involve enhancement of existing transport/ utility infrastructure; enhancements are treated as non-FCD benefits.

6.13 Intangible effects of flooding (h)

The current methodology uses a notional value per flooding incident to take account of intangible effects (e.g. on health). It should be included in the cost–benefit accounts, attributed to households. Since the value is notional, it is not clear whether it needs to be scaled up in order to expressed in the market-price unit of account.

6.14 Changes in environmental and heritage value (i)

As noted above, these effects can be positive or negative. Where a FCD project leads to the conservation, loss or gain of a significant environmental or heritage asset, the *PAG3* methodology normally values that asset at the lowest of (i) the cost of creating a similar asset elsewhere, (ii) the cost of relocating the asset to another site, and (iii) the cost of local protection, for example, by a local embankment (*PAG3*, pp. 28-29). No distinction is made between cases in which the asset would in fact be relocated/ re-created if not protected (e.g. because this is a requirement under European law) and those in which the option of relocation/ re-creation is merely being used to derive a proxy valuation. If the WTP calculus is used, this distinction has to be made. If the actual effect of a project is a net environmental/ heritage gain or loss, the corresponding valuation should be recorded as such (i.e. attributed to individuals in the role of ‘consumers’ of the services provided by environmental/ heritage assets), even if the valuation has been arrived at by considering hypothetical relocation/ re-creation. If the actual effect of the project is an asset relocation/ re-creation, the corresponding valuation should be recorded as a cost to the agency which in fact will incur it. Thus, the WTP approach reports each project’s environmental impact (however imperfectly measured in money terms), while the SCB approach conceals this.

6.15 Changes in recreational value (j)

These effects can be positive or negative. The current methodology normally measures these by stated preference methods and 'benefit transfer' based on visitor numbers. That is, visitor numbers are estimated for the relevant sites, and then multiplied by generic 'values of enjoyment per adult visit' taken from stated preference studies of recreation sites of a similar kind ('Multi-Coloured Manual', Chapter 8). These valuations are already in the market-price unit of account (see paragraph 5.6 above). They should be attributed to individuals in the role of consumers of recreation.

6.16 Intensification of land use (k)

In the *PAG3* methodology, these benefits are not measured (see paragraph 2.12 above). In the methodology proposed in this report, if FCD projects create development benefits through the intensification of land use, these should be included in the cost-benefit accounts but classified as non-FCD benefits. The most obvious method of valuing these benefits is by the increase in the value of the relevant land. This method treats land zoned for development as a result of FCD work as a net addition to the stock of development land, and follows the standard convention of using market prices as measures of social value. Of course, any loss of environmental or recreational value through development should also be included in the appraisal, as should any increases in downstream flood risks that result from development.

6.17 A 'secondary' rationale

As a 'secondary' rationale for excluding development benefits from FCD appraisals (the 'primary' reason being that the FCD budget is not intended to be used to create such benefits), *PAG3* invokes the precautionary principle: 'Intensifying development of flood plains and areas of erosion risk is, generally, undesirable because of the restrictions that it will place on the future management of the river or coastal zone' (p. 22). This argument does not cohere with the logic of CBA. If Defra's judgement is that new development on land protected by FCD should be prohibited, this should be expressed as a constraint on project design (for example, by making it a condition of grant support that newly protected land is not zoned for development, or by designing projects so that undeveloped land is not protected). Alternatively, if Defra is prepared to countenance such development, it should make a realistic assessment of its benefits and disbenefits, rather than merely assuming that they cancel each other out.

6.18 Changes in tax revenue and subsidy payments (I)

This item does not appear explicitly in an SCB calculus, and accordingly is not discussed in *PAG3*. Its meaning and rationale are described in paragraphs 5.8 and 5.9 above. The net increase in government tax revenue, plus the net decrease in subsidy payments, is attributed to 'government' but is outside the FCD budget.

7. A cost–benefit spreadsheet

7.1 Spreadsheet

Table 1 presents, in stylised form, a cost–benefit spreadsheet for a representative FCD project. It is assumed that the project receives private contributions from two 'project partners' – a highway authority, which contributes towards the additional cost of enhancements to infrastructure, and a private developer, who contributes towards the cost of flood defence of land on which he has planning permission to build, conditional of flood defence.

7.2 Entries

All entries (other than the ratios x_{29} and x_{30} , which are pure numbers) are present values in money units. Costs are expressed as negative entries; entries which would be negative for a typical FCD project are enclosed in brackets. (Thus, for example, 'total FCD costs' are denoted by the negative value (x_2) ; 'total FCD benefits' are denoted by the positive value x_{19} ; 'net FCD benefit' is denoted by $(x_2) + x_{19}$, i.e. the sum of a negative and a positive value.) The letters in square brackets refer to the paragraphs of Section 6 in which the relevant item is discussed.

7.3 Use 1

Rows 1 to 23 list the costs and benefits of the project. Each entry is classified by whether or not it is an FCD cost or benefit, and by the economic group to which it accrues. Gains or losses to project partners are identified separately. The sum of all these entries, x_{26} , is 'total net benefit'. This is identically equal to the net sum of social benefits and costs that would be reported in an SCB calculus (except that it is in the market-price unit of account). Rows 29 and 30 report the two crucial benefit–expenditure ratios.

7.4 Use 2

The final rows of the spreadsheet summarise the attribution of the net benefit of the project between economic groups. This is described as attribution *by initial incidence* to signal that no attempt has been made to predict how costs and benefits might be transmitted through the economy through changes in market prices. For example, benefits from reduced risks of flood damage to houses are attributed to 'households' as occupiers of houses. In the case of rented housing, one might expect that increased flood defence would lead to increases in rents, so that the final incidence of these benefits would be a gain to *owners* of houses; occupiers' gains from reduced flooding would be offset by higher rents. Thus, one must be careful about interpreting the entries in these rows as measures of the distributional effects of the project. However, they provide a broad indication of how the project impacts on different classes of economic actors.

Table 1: Cost–benefit spreadsheet for an FDC project

FCD costs

Construction and maintenance [a]
cost to FCD budget (Defra, LAs, IDBs) (X₁)

Total FCD costs (X₂) = (X₁)

Non-FCD costs

Construction and maintenance [a]
project partner 1 (highway authority: government) (X₃)
project partner 2 (developer: non-government) (X₄)

Total non-FCD costs (X₅) = (X₃) + (X₄)

FCD benefits

Net reduction in flood damage to/ abandonment of buildings [b, c]
households X₆
businesses (excluding partner 2) X₇
public agencies (excluding partner 1) X₈
total X₉ = X₆ + X₇ + X₈

Net reduction in flood damage to/ abandonment of agricultural land [d, e]
businesses (excluding partner 2) X₁₀

Net reduction in disruption to trade [f]
businesses (excluding partner 2) X₁₁

Net positive effects on transport, utilities, emergency services [g]
households (e.g. as transport users) X₁₂
businesses (excluding partner 2) X₁₃
public agencies (excluding partner 1) X₁₄
total X₁₅ = X₁₂ + X₁₃ + X₁₄

Net reduction in intangible costs [h]
households X₁₆

Net increase in environmental/heritage value [i]
households (as environmental/ heritage consumers) X₁₇

Net increase in recreational value [j]
households (as recreational consumers) X₁₈

Total FCD benefits
+

$$X_{19} = X_9 + X_{10} + X_{11} + X_{15} + X_{16} \\ + X_{17} + X_{18}$$

Non-FCD benefits

Enhancements [g]

project partner 1 (highway authority)

$$X_{20}$$

Development benefits [k]:

project partner 2 (developer)

$$X_{21}$$

*Net increase in government revenue (indirect taxes
minus subsidies) [l]:*

government

$$X_{22}$$

Total non-FCD benefits

$$X_{23} = X_{20} + X_{21} + X_{22}$$

Net FCD benefit

$$X_{24} = (X_2) + X_{19}$$

Net non-FCD benefit

$$X_{25} = (X_5) + X_{23}$$

Total net benefit

$$X_{26} = X_{24} + X_{25}$$

Cost to FCD budget

$$(X_{27}) = (X_2)$$

Net cost to public funds

$$(X_{28}) = (X_2) - X_8 - X_{14} -$$

$$X_{20} - X_{22}$$

(Net FCD benefit)/(net cost to FCD budget)

$$X_{29} = X_{24} / X_{27}$$

(Total net benefit)/(net cost to public funds)

$$X_{30} = X_{26} / X_{28}$$

Attribution of net benefit by initial incidence

cost to FCD budget

$$(X_{31}) = (X_{27})$$

project partner 1 (highway authority)

$$X_{32} = (X_3) + X_{20}$$

project partner 2 (developer)

$$X_{33} = (X_4) + X_{21}$$

households: flood risk

$$X_{34} = X_6 + X_{12} + X_{16}$$

households: environmental/ heritage/ recreation

$$X_{35} = X_{17} + X_{18}$$

businesses (excluding partner 2): flood risk

$$X_{36} = X_7 + X_{10} + X_{11} + X_{13}$$

public agencies (excluding partner 1): flood risk

$$X_{37} = X_8 + X_{14}$$

government: indirect tax/ subsidies

$$X_{38} = X_{22}$$

total

$$X_{39} = (X_{31}) + X_{32} + X_{33} + X_{34} +$$

$$X_{35} + X_{36}$$

$$+ X_{37} + X_{38} = X_{26}$$

Annex: Terms of reference

The study is to have two main aims.

- A. The primary aim is to scope out the ease of moving the cost benefit analysis of Flood and Coastal Defence appraisal projects from the calculus of social costs and benefits to the calculus of willingness-to-pay. Including, to give specific consideration to how such a framework would help deal with issues of:
- Private contributions and non standard sources of funds (e.g. EU grants);
 - Equity and distributional impacts between interest groups;
 - Transfers and cross-subsidies between interest groups (e.g. insured and uninsured households or insurance and construction industry);
 - Compensation for welfare losses;
 - Prioritisation.
- B. A secondary aim is to give consideration to coherence of current PAG3 and associated supplementary guidance and to advise on improvements for the revised version.

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