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# A COMMON FRAMEWORK OF FLOOD RISK MANAGEMENT COST BENEFIT ANALYSIS FEATURES

Flood-CBA

## Knowledge Platform for assessing the costs and benefits of flood prevention measures

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# INTRODUCTION

The purpose of Action C.1 is to create a 'characterization framework' of Cost Benefit Analysis features that will provide a common terminology and be used to achieve a better understanding of the state of the method, its distinguishing capabilities and its leading–edge functionality.

This framework will be developed iteratively, beginning with features identified in Action B.3 and targeting the various approaches that are currently considered or used for the economic appraisal of flood prevention measures. ***This paper is the beginnings of this process.***

# CHAPTER 1

# MEASURES TO BE INCLUDED IN FLOOD RISK MANAGEMENT PLANS

The EU Floods Directive[1] requires that *"by 2015* ***flood risk management plans*** *must be drawn up for areas with a medium likelihood of flooding (at least a 1 in 100 year event) and extreme events or low likelihood events, in which expected water depths should be indicated.*

*These plans are to include measures to reduce the probability of flooding and its potential consequences. They will address all phases of the flood risk management cycle but focus particularly on* ***prevention*** *(i.e. preventing damage caused by floods by avoiding construction of houses and industries in present and future flood-prone areas or by adapting future developments to the risk of flooding),* ***protection*** *(by taking measures to reduce the likelihood of floods and/or the impact of floods in a specific location such as restoring flood plains and wetlands) and* ***preparedness*** *(e.g. providing instructions to the public on what to do in the event of flooding).*

*Due to the nature of flooding, much flexibility on objectives and measures are left to the Member States in view of subsidiarity".*

In an ideal world, at least the elements in Table 1 should be included in any flood risk management plan, which should look many years ahead.

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[1] http://ec.europa.eu/environment/water/flood_risk/implem.htm

The **risk assessment** is the cornerstone of any plan, as it defines the nature of the problem in terms of extent and severity, usually in the form of a flood risk map. Such a risk assessment can be undertaken at a broad-brush scale, in order to identify "hotspots", but the plan will be more valuable if these areas are then identified in detail, and assessed for differential risk in different parts of each area. It will be important for cost-benefit analysis that the effect of floods of different return periods is identified in this risk assessment, because this differentiation affects both the calculation of benefits and the selection of different scheme[2] options. Without a proper risk assessment, no flood risk management plan can be viable.

**Table 1. A categorization of measures included in flood management plans**

| ***Plan element*** | ***Link to CBA and similar appraisal arrangements*** |
|---|---|
| Hazard/risk assessments | Defines the area to be analysed, and assesses the probability and consequences of floods of different severities (with which to assess benefits) |
| **Preventative** measures: Spatial planning arrangements | Zones areas at risk to define future development, which can be used to assess benefits occurring in the future (although this is unusual) |
| Investment priorities: flood defence capital schemes for **protection** | Classic CBA of engineering works |
| Incident related **preparedness** measures<br>Forecasting and warning arrangements<br>Emergency response systems | CBA of non-structural measures, in terms of losses prevented. |
| R&D requirements | Knowledge acquisition and improvement |

All flood risk management plans should attend some degree of prioritisation of action, in particular to emphasise areas which need to be studied in more detail, and areas where it is likely that flood protection

[2] Please note that the term "scheme" here is used to denote any flood risk management measure, and should not be interpreted as an engineering scheme or some other form of structural intervention.

will be necessary. This prioritisation can be based on benefit-cost analysis, or something simpler at an exploratory stage. Without prioritisation, no flood risk management plan can be viable in guiding future decisions.

In the modern world, any flood risk management plan should attempt to identify preventative measures which can halt the rise in potential flood damage, using spatial planning and building regulations. There is a danger, without these measures, that flood risk management plans will become simply a catalogue of engineering works designed to protect particular communities at risk. This should be avoided: a thorough-going flood risk management plan should identify structural and nonstructural measures for flood risk management, and identify areas (at least at an exploratory stage) where each type of measure should be investigated and implemented.

All flood risk management plans should identify areas for investment, whether in structural or nonstructural flood risk management measures. This then provides a programme of capital spending, stretching many years into the future, and forms the basis of a bid to central government or other interested parties for the necessary funds to carry this out. Again, prioritisation will be essential part of this cataloguing of possible investment needs.

Flood risk management is more than about capital projects and others nonstructural measures, is also about preparedness for floods which exceed design standards of known defence works, and the residual flood risk that this entails. The plan should encompass preparedness strategies, to be implemented locally, within a knowledge framework that serves to accurately predict risk and the communities liable to be vulnerable. Flood forecasting warning systems are part of this, but so is emergency response and recovery planning.

Finally, it will be sensible to include in any flood risk management plan a strategy for developing knowledge and research suggestions. This will again form some sort of bid to those who fund research in the countries concerned, which will be all the more credible if it is based on a plan for managing flood risk stretching many years into the future. This is because there will be opportunities within the program of risk management for new research to influence both the direction of travel and the efficiency of implementation.

# CHAPTER 2

# FLOOD RISK MANAGEMENT MEASURES

A wide range of measures can be used to mitigate flood risk, and each needs to be tailored to its particular geographical and economic circumstances.

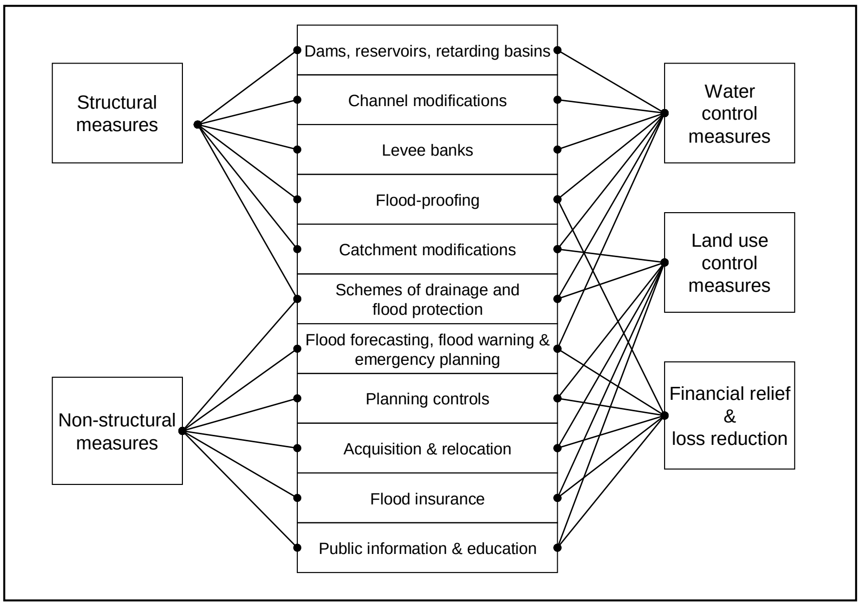


Figure 1. A typology of flood risk management measures (Note: the connecting lines from the three boxes on the right side should be all be read as  straight lines, as on the left side, not zig-zag)

Figure 1 gives a typology of these measures, categorised on the left hand side by the conventional differentiation into structural and non-structural measures, the former better described as engineering measures. These structural measures include modification of the “sources” of flooding, in terms of up-stream dams and reservoirs, and catchment modifications to attenuate flood flows or delay their onset. In addition, many engineering measures tackle the "pathways" whereby flood waters arrive. This will often involve channel modifications to the rivers where flood risk is greatest, including the construction of levée banks and bypass channels. It has to be acknowledged that sometimes the former measure can exacerbate flood risk, by making the consequences of failure even more catastrophic than would be caused by floods before construction.

Non-structural measures are usually associated with modifying the “receptors” at risk from flooding, either preventively with spatial planning to restrict the urban development in floodplain areas, or reactively in managing flood incidents so as to minimise hazard and risk. In relation to flood incidents, flood forecasting and warning systems are important non-structural measures (as indicated in the report from the stakeholders surveyed in Task B3 (B3 report, Table 4)), not least in providing the opportunity to minimise injury and loss of life in floods. In many cases non-structural measures require good public education to make those at risk aware of the risks they face, and encourage them to take measures themselves to reduce the potential harm from flooding when it comes. Often these measures are difficult to appraise, not least because they have functions beyond flood risk management: spatial planning systems have a multitude of uses, related to the control of development, in all areas of every country, rather than just in those areas at risk of flooding.

An alternative way of looking at the same list of flood risk management measures is provided by the right-hand side of the diagram in Figure 1. This differentiates between measures which are aimed at altering and controlling the water environment (again, principality, through engineering works to reduce the probability of flooding) and those seeking to change the land use and other characteristics of at-risk areas. The emphasis here is attempting to prevent the build-up of flood damage potential in at-risk areas, thus seeking not to repeat the mistakes of the past which have involved locating vulnerable property and people in areas where floods are dangerous or damaging (again, some of the stakeholders surveyed in Task B3 made this key point).

The third element in this alternative view of flood risk management measures is seeing measures to redistribute the losses incurred in floods, either through insurance or other compensation measures. In certain circumstances this can involve the acquisition of properties at risk from flooding, and their demolition, or relocating properties if this is technically possible.

This alternative interpretation of the typology of flood risk management measures is more insightful in some respects, not least because the term "non-structural" is somewhat vague and simply a definition by antithesis.

It is clearly the situation that different flood risk management measures are more suitable in different locations. For example:

- Where there is a serious risk to life, it will be important to seek to reduce the probability of flooding, usually by engineering means. Thus in the case of the Netherlands, it is imperative that high design standards for structural engineering works are implemented, because of the potential for serious loss of life and huge economic damages there.

- In other circumstances, major embankments can exacerbate flood risk, and inhibit the agricultural development of floodplain areas such as deltas by restricting drainage and themselves exacerbating risk from pluvial events. This would be the case in Bangladesh, where embankments are a necessary condition for flood risk management in many areas, but are undesirable in others.
- In mountainous areas, where flash floods occur, it will again be important to implement measures designed to reduce injury and loss of life, and this may well mean the canalisation of river channels, to keep flood waters contained, despite the dangers that this may induce if these channels are overtopped.
- Alternatively, in areas where the rise of flood waters is slow and warnings can be given well in advance, temporary flood risk management measures may be introduced, such as temporary walls, sandbagging, and similar interventions.
- In many countries, compensation is provided to flood victims so that they can recover quickly from any flood from which they suffer. In some countries flood insurance is provided, with the same aim and objectives. This is an important flood risk management measure, but can encourage occupation of risky areas, to the detriment of sustainability.

In many situations, a combination of flood risk management measures will be a most satisfactory solution. Thus some engineering works will reduce the probability of flooding, perhaps by providing embankments or flood storage, but this is best accompanied by spatial planning and building regulation restrictions in areas liable to flooding, or else flood damage potential will simply increase in the future, in areas seen to be ‘protected’, necessitating further engineering works. This "escalator effect" is a perverse consequence of reducing risk whilst not preventing further risk enhancement into the future.

A further element in a wide flood risk management portfolio of measures (Evans et al, 2004) would be those designed to tackle flood events when they come. No engineering works have an infinite design standard, and we can expect them to be overtopped and possibly breached at some time in the future. This residual flooding must be planned for, with emergency response plans, probably tailored to local circumstances, and also plans to enhance the recovery of communities and individuals in such circumstances, after they have experienced flooding and the losses and disruption that it brings.

One of the problems of a portfolio approach to flood risk management is appraising these portfolios in a way that is sensible. A simple cost-benefit approach is not appropriate here, as that tends to focus on individual measures and the risk reduction that they achieve. No satisfactory method has yet been developed to appraise portfolios of flood risk reduction measurements, and further research is needed here.

# CHAPTER 3

# COSTS LINKED WITH THE IMPLEMENTATION OF FLOOD RISK MANAGEMENT MEASURES

The reliability of a benefit-cost comparison depends crucially on the accurate estimation of costs. All expected whole-life costs of works and management are required to be included in this (Table 2), including capital, maintenance and operating costs. Maintenance costs should include the expected value of the costs of repairs as a result of flood and storm damage and, where significant, decommissioning costs. If a national-level appraisal is the objective, as is usual, it will be necessary to strip out any taxation element of costs, because these are transfer payments within the economy. Such taxes will include those on fuel, labour and the purchase of materials, although it is unusual for taxation element of employment to be deducted from capital costs.

But some caution is needed here. First, we need to be clear what is meant by “national”. We are focusing here on the economic view in the sense of an overall view usually described as the “national economy” in contrast to a view via “business economics”. Nevertheless in the European context of our transnational FLOOD-CBA project the addressing of “national” losses might be introduced somehow between the transnational European (community / market) view and the smaller scales of federal states or even regions and municipalities. Much will depend here on who pays for flood risk management, rather than a rigid view as to what is “national” or not. If funds are raised at a regional level, then it is transfers as taxation at that level that are relevant, not the nation state.

Secondly, it is not entirely clear how we should deal with the taxes themselves. Unquestionably transfer payments (in the sense of a payment without any service in return) are not eligible for economic consideration, and therefore they have to be ignored in a pure economic analysis. Nevertheless it is clear that taxation is not simply always a pure transfer payment without any service in return and economic significance. To a certain extent taxation is necessary to run a society as the foundation for other economic activity (e.g. including promoting the health of the population, or ensuring that there are educational services). So we should perhaps allow the user to describe and/or define which elements of the relevant taxation, duties, etc. should be excluded and which parts should be included in the economic analysis: what is counted here, in this view, should not be determined without the acceptance of the relevant stakeholders.

## 3.1 Capital costs

The capital costs are generally the major costs of most structural engineering flood risk management works. They occur at the beginning of the project, but it is not usual for capital costs all to be spent in just one year, so for engineering works these need to be profiled over the construction period and discounted back to present values. These costs will include the cost of raw materials, labour, and interest charges if applicable. They can also include the cost of land purchase if this is relevant, and any management costs for the lifetime of the construction period

| Table 2 Typical costs of flood risk management, with examples | | |
|---|---|---|
| ***Cost element*** | ***Example: Structural flood risk management measure*** | ***Example: Non-structural flood risk management measure*** |
| Capital costs | Construction of culverts or raised flood defence walls | Telemetry system for flood forecasting and warning systems |
| Operating costs | Electricity to power moveable items such as flood sluices or gates | Staff for flood forecasting centres |
| Maintenance costs | Inspection and renewal of the bearings in a flood gate | Generally relatively insignificant |
| Decomissioning costs | Demolition of flood walls | Generally relatively insignificant |

## 3.2 Operating costs

The cost of operating a flood risk management scheme should not be overlooked. This will include management, staff time and any materials necessary to keep the measures in operating order. In a scheme that requires pumping, there will be fuel costs. For non-structural measures, operating costs can be the dominant cost element, so that, for example, flood forecasting and warning systems will require continuous staffing, and spatial planning will also require staff effort. Any private insurance arrangements must allow for the profit of insurance companies, as well as the staff to write policies and pay claims. Public education schemes will also require staff, as will any compensation scheme.

## 3.3 Maintenance costs

Maintenance costs and operating costs can often be synonymous, and it is not necessary always to separate the two. However maintenance should not be ignored in appraisal, because any scheme of works involving machinery or structures that are movable will require maintenance throughout their lives. Embankments will require maintenance in the form of grass cutting or routine inspections, in order to ensure that they remain effective. Flood walls may require routine maintenance for the same purpose. All these costs need to be included in a proper appraisal process, not least because there may be a trade-off between maintenance, operating costs, and the capital costs of any flood risk management measures. These trade-offs need to be explored in detail to ensure best value for money.

## 3.4 Decommissioning costs

The whole-life costs of any flood risk management measure will include the cost of decommissioning it at the end of its effective life. This is obviously important in the case of engineering works, where they may require demolition when they are effectively no longer required or have come to the end of their effective life. It is normal for such decommissioning costs to be incurred at the end of the life of the project, so that discounting means that these are relatively small sums when measured in terms of present values. Nevertheless they should not be ignored.

# CHAPTER 4

# 4. BENEFITS LINKED WITH THE IMPLEMENTATION OF FLOOD RISK MANAGEMENT MEASURES

## 4.1 Type of benefit: flood losses

The benefits of flood alleviation within flood risk management comprise the flood damage averted in the future as a result of plans and schemes to reduce the frequency of flooding or reduce the impact of that flooding on the property and economic activity affected, or a combination of both. Hence we need to understand the nature of flood damage losses, and also the impact of flood risk reduction and land drainage on agricultural productivity in areas liable to be affected.

It is customary to categorise flood damage and losses as direct or indirect, and by whether or not they are tangible or intangible (Parker et al., 1987, 2). Direct damages result from the physical contact of flood water with damageable property. The magnitude of the damage may be taken as the cost of restoration of the property to its condition before the flood event, or its loss in market value if restoration is not worthwhile. Indirect flood losses are losses caused by disruption of physical and economic linkages of the economy, and the extra costs of emergency and other actions taken to prevent flood damage and other losses. These indirect effects of floods can be suffered by productive activities and emergency services both within and beyond the area of immediate direct physical flood impact.

Many items of flood damage loss are a function of the nature and extent of the flooding, including its duration, velocity and the contamination of the flood waters by sewage and other contaminants. All these affect damages and losses, and the location of the flood will affect the networks and social activities disrupted causing indirect losses.

This situation is summarised in Table 3, and different appraisal techniques are necessary to gauge accurately the magnitude and extent of the flood losses categorised there. What is generally important, however, in each case is to ensure that for the purposes of benefit-cost analysis we assess only the national economic losses caused by floods and their indirect consequences, rather than the financial losses to the individuals and organisations which are affected (Table 4).

| Table 3 Direct, indirect, tangible and intangible flood impacts, with examples | | | |
|---|---|---|---|
| | | Measurement | |
| | | Tangible | Intangible |
| Form of Loss | Direct | Damage to building and contents | Loss of an archaeological site |
| | Indirect | Loss of industrial production | Inconvenience of post-flood recovery |

The exception is when the funders of flood risk reduction measures are restricted to local communities, or local communities make a significant contribution to total costs. Here it may be more important to look at the financial losses incurred in these communities, in order to gauge the financial worthwhileness of them making their contributions towards these costs. The policy move towards 'Partnership Funding' (Defra, 2011a) makes this approach more likely than has been the case in the past.

## 4.2 Flood losses and land use

The land use of a flood-prone area profoundly affects its likely damage characteristics. Houses are affected differently from offices and shops, which in turn suffer different kinds of damage from those experienced in industrial or commercial premises. Areas of recreational land use such as golf courses and playing fields are likely to suffer little damage, as are certain agricultural land uses.

The effect of land use on flood damage and losses has determined the structure of all the Manuals that the Flood Hazard Research Centre at Middlesex University, UK, has produced since 1977 (for the latest, see: Penning-Rowsell et al, 2013). The rationale for this approach is that the type of use of a particular area of the floodplain affects both its likely direct damage potential and the magnitude of losses caused by an interruption of the economic activities that are carried out there (i.e. the indirect flood losses).

| Table 4 Financial and economic damages related to household flood losses |
|---|
| **Financial** |
| Takes the standpoint of the individual household involved |
| Uses the actual money transfer involved to evaluate the loss or gain (e.g. if a household has a new-for-old insurance policy and they claim for a ten year old television, the loss is counted as the market price of a new television) |
| VAT is included as are other indirect taxes as they affect the individual household involved |
| **Economic** |
| Takes the standpoint of the nation as a whole – one person's loss can be another person's gain |
| Corrects the actual money transfer in order to calculate the real opportunity cost (e.g. in the case of the ten year old television, the real loss to the country is a ten year old television; the depreciated value of that ten year old television is taken as the loss) |
| VAT is excluded, as are other indirect taxes, because they are money transfers within the economy rather than real losses or gains |

The type of land use also will affect the magnitude of any necessary emergency services and works required to protect or alleviate the damage to these areas during times of flooding. The type of land use on the floodplain will also determine to some extent its environmental value, which could be enhanced by flood risk management schemes or harmed if such schemes are implemented without due consideration for those environmental values. Hence the term "land use" encapsulates a number of characteristics of a floodplain area, and should not be confused with "property" or "urban development".

## 4.3 Type of benefit: Land value enhancement with flood risk reduction

Flood risk reduction may result in enhanced land values in both urban and rural areas and this can be a measure of the benefit of flood alleviation, although these values should not be added to flood losses that these areas may experience as this is double-counting the benefits.

In each case this enhancement of land values may result from the same land use becoming more profitable, as a result of the reduced hazard, measured either in terms of the greater production sustained or in terms of the rent that the land commands. Alternatively, a new land use may be possible, in the urban context perhaps allowing residential development where only recreational land existed before, and in agricultural areas allowing cereal or root crops where previously rough grazing predominated.

For example, in the UK and in the urban context, the UK Treasury has not allowed as a benefit of flood risk management the enhanced value of land which could be converted to more productive economic activity (i.e. the move from recreational land to residential development, indicated above). This is because to do so would provide a subsidy to that development, through flood risk management being provided by the state, based on counting the private gain to the developer from the protection thus afforded. However, once a flood risk management scheme has been constructed an ‘escalator effect’ may occur whereby further flood management may be required - and can be justified under the Treasury rules - to protect against increasing flood damage potential owing to post-scheme development (Parker, 1995).

In the agricultural context, and again the in the UK, however, the opposite has been the case. Here the calculation of the benefits of flood risk reduction (and land drainage) may include the enhanced future productivity of the land in terms of its production of crops of higher value or greater volume. Although the costs of agricultural land drainage and agricultural flood risk management have, in the past, been substantially met from the public purse in the UK (and elsewhere), the gains in producing more crops have been interpreted as benefits to the nation as a whole, particularly at times when national self-sufficiency in food was a primary agricultural objective (Tunstall et al., 2004).

Nevertheless those appraising flood risk management schemes across both the rural and the urban sectors should note the potential for the different treatments.

# CHAPTER 5

# ASSIGNMENT OF THE VALUES OF ITEMS IN A COST BENEFIT ANALYSIS

In conventional economics, the individual is assumed to be the best judge of his/her own interests and so the value of any action is the contribution that action makes towards achieving their personal objectives. Thus economic value is ultimately subjective, reflecting individual preferences; the problem for the economist is to measure it rigorously, a problem which economics seeks to resolve by using money as a yardstick.

| Table 5 The four general strategies for deriving values for use in benefit-costs analysis |
|---|
| Using market prices |
| Using 'inferential' methods |
| Using 'expressed preference' methods |
| Benefit (or value) transfer |

Deriving values for use in benefit-costs analysis uses four approaches (Table 5):these are generally used in different circumstances, such that 'inferential' and 'expressed preference' methods are reserved for detailed appraisals rather than initial investigations, given that they tend to be somewhat expensive, and benefit transfer is used in both but is particularly useful for initial studies.

## 5.1 Market prices

For a priced good sold in a **perfectly competitive market**, the prevailing **price** would exactly equal both the marginal value and the marginal cost (Samuelson, 1970). However, the conditions that define a perfectly competitive market are so restrictive (Henderson and Quandt, 1971), that this only provides a starting point for estimating the value or cost of anything. In addition, even if a market were to be perfectly competitive, it has shown (Coase, 1991; Stiglitz, 2008; Williamson, 1981) to mean that the result may not be the optimal allocation of resources.

In the real world, markets are commonly imperfect or distorted in some way. Hence, it is often necessary to make some corrections to the observed market price – to derive its **shadow price** - in order to estimate the economic value or opportunity cost of the good or service in question.

In assessing the benefits of flood risk management schemes, one important correction is that for second-hand goods, the prices of which are depressed below their true value for many reasons (Akerlof, 1970). Therefore, in evaluating the loss in a flood of, say, a five year old television, the economic value of that television before the flood is *greater* than the market price of an apparently identical second hand television. Equally, the economic value of the television is clearly *lower* than the cost of a replacement new television, since that new television would have a longer expected life. Therefore, the pre-flood values given in Penning-Rowsell et al (2013, Chapter 4), as the baseline for assessing the flood losses to building contents, are based upon the use of straight-line depreciation, rather than second hand values.

It is also necessary to remove direct and indirect subsidies within prices. For example, in much of the world, irrigation water is heavily subsidised either directly or indirectly (Garrido, 1999). If an irrigated crop is lost as a result of a flood, the real loss is given by calculating the market value of the crop less the costs of the inputs, including the real costs of providing the irrigation water. Again, agricultural outputs are commonly either subsidised or supported. Here, too, the value of a lost crop needs to be adjusted downwards by removing the subsidy or price support element.

In turn, where inputs or outputs are subsidised in this way, the capital value of the asset that produces the outputs can also be artificially inflated. Thus, when assessing the value of agricultural land that may be lost to erosion, the market price of that land must also be corrected downwards to the level which would exist were there no subsidies on inputs or outputs (MAFF, 1999). There is, however, an exception to the general rule for subsidy removal; where a subsidy is intended to represent a positive externality. Some agricultural subsidies are in this form, for example, those intended to promote environmentally friendly farming.

Indirect taxes must also be removed as they are simply a tax intended to generate revenue rather than a real opportunity cost. However, 'green taxes', those that are intended to reflect the externalities caused by the use of a particular good, are real economic costs and for that reason they should not be removed. For example, any tax on pesticides intended to reflect the damage caused to the environment, or the costs of removing pesticide residues from potable water, is a real economic cost.

The practical problem in any analysis is that it is necessary to determine whether any indirect tax is solely for revenue raising purposes or if it is designed to incorporate the costs of externalities into the cost of using the product (many so-called ‘green taxes’ combine both functions).

Where a resource would be put to no other use if it were not applied to the project then its opportunity cost is zero, whatever the price actually paid for it. This situation is most likely to be found when looking at labour inputs; where there is a high level of unemployment or under-employment, the wage rates paid to those building an engineering scheme to reduce flood probabilities will overstate the opportunity costs of that labour and a **shadow wage rate** needs to be estimated (Squire and van der Tak, 1975).

At times, where something is not priced, there may exist a near-perfect substitute that is priced, and this can then be used to set an upper bound on the value of the good we need evaluate. However, the value of the good in question can be no greater than the cost of this **least cost alternative**. Thus, for example, the contribution to the benefits of a flood storage reservoir, in terms of reducing the losses when the local telephone exchange floods, can be no greater than the cost of flood-proofing that exchange.

One limitation of this approach is that the alternative must either not yet have been undertaken or all the costs can be recovered if it has already been adopted. Any irreversible expenditure is termed a **sunk cost**. For example, where the occupiers of a floodplain have flood-proofed their property, in estimating the benefits of constructing a flood risk management scheme for the whole town, the costs of these walls or stop-gates must be ignored since the costs of their construction are irrecoverable in the project appraisal. This said, the benefits that are gained from their construction should be included: we should not assume that they are not there when assessing flood extent or depth.

## 5.2 Inferential Methods

The use of market prices is often referred to as the **revealed preference** technique but, as can be seen from the above discussion, it is often necessary to make quite a large number of corrections to the observed prices in order to calculate economic values and costs. The second group of techniques may be termed **inferential methods** and these use statistical techniques to infer the value of something that does not have an observable price.

The **Travel Cost Method** (Clawson, 1959) is a way of putting a value on a recreational resource by determining the distances that different visitors have travelled to a site and the costs they have thereby incurred. By regression analysis, a relationship between the distance travelled and the probability of making a visit is deduced and the resulting function is then used to estimate the value of a visit to the site.

One problem is that any function can be fitted more or less badly to any set of data and we have no theoretical reason for expecting one functional relationship rather than another. Depending upon what relationship is actually applied, the values derived may then vary by a factor of perhaps ten. A second problem is that the assumptions about recreational choices made in the model seem to be inconsistent with recreational behaviour (Green et al., 1990). We therefore do not recommend this technique.

The **Hedonic Price** technique (Rosen, 1974) is intended to determine the influence of the area's characteristics in question, such as a sea view, on the market price of the land or, more usually, houses. A number of studies have been undertaken of the effects of flood risks on house prices (e.g. Donnelly, 1989). Using this technique, the reasonable assumption is made that the market price of a particular house is the result of a series of parameters, including flooding or erosion threat, that make the house more or less desirable/valuable.

In practice, we do not know exactly which are the parameters that most influence house prices. We cannot measure all of these parameters but have to use surrogate variables in some cases, and we do not know what is the functional relationship between them but have to infer this relationship in order to undertake the statistical analysis.

Ducci (quoted in Ardila et al., 1998) refers rather despairingly to the practical problems of obtaining results of any real value from this method, referring to the time spent on 'torturing the data to provide a decent coefficient' and the hedonic price method being as '… more unreliable (than the Contingent Valuation method) with respect to whether you will be able to get a usable result' (Ardila et al., 1998). Again, therefore, we do not recommend this technique.

## 5.3 Expressed preference methods

Neo-classical economists long resisted the use of the remaining approach, **expressed preference techniques** (Conjoint Analysis and the Contingent Valuation), which employ social survey techniques, because these involve asking people what choices they would make. The basis of the criticism is that what people say they will do in a situation is not necessarily as reliable as observing what they actually do in such situations, were we able to observe their behaviour. Likewise, there is a problem in that people are being asked to respond to hypothetical circumstances.

**Conjoint Analysis** was developed in market research (Green and Srinivasan, 1978) and then adopted in transport research under the name of Stated Preference (Hensher, 1994). Using this method, respondents are asked to make a series of choices between different combinations and different levels of those characteristics believed to be most important, including the characteristic in which we are interested (e.g. flood or erosion risk).

For example, if we were interested in how flood risk affected house prices, we would first determine what are the critical parameters that determine the amounts individual households are prepared to pay for dwellings. One of the characteristics then included in the study is price. By statistical analysis it is hoped to determine how changes in the quantity of the characteristic of interest affects the amount people are prepared to pay for the good. Conjoint Analysis is thus the Expressed Preference equivalent of the Hedonic Price method, and is subject to some of the same problems but its merits are demonstrated by its widespread use by consumer companies when seeking to determine whether there is a market for a potential new product, and to identify who will buy it and at what price.

The **Contingent Valuation Method** (CVM) is a rather simpler technique. Respondents to the interview survey are asked directly how much they are prepared to pay for a change in the availability of the good in question (e.g. coast protection of beaches: see Penning-Rowsell, et al, 2013, Chapter 8).

As this is essentially a social survey approach, it is a virtue of the CVM, as opposed to the Travel Cost and Hedonic Price Methods, that validity and reliability tests can be applied. As with Conjoint Analysis, it is essential to follow good social survey practice in terms of question design, sampling and fieldwork (Mitchell and Carson, 1989).

Unfortunately, the influential NOAA Panel (1993) recommended that CVM studies should be conducted using the 'referendum' format: each respondent is asked whether or not they would be prepared to pay a fixed amount, this amount varying between respondents.

Using this approach, we would not know precisely what any respondent would be prepared to pay and can only estimate, by fitting a statistical relationship to the data, the sample mean. As with the Hedonic Price and Travel Cost methods, the resulting estimate then depends upon what functional form is fitted to the data. Ardila et al. (1998) have, therefore, argued that the approach of simply asking respondents how much they would be prepared to pay should be reassessed.

But both techniques have a number of virtues:

1. The first is that they are experimental techniques. Hence, we can test whether or not there is a particular relationship rather than being forced to assume it.
2. A second is that they involve listening to the public, both through the exploratory qualitative studies (Krueger, 1988) that invariably should precede the quantitative interview survey, and in the quantitative study itself.

We would argue that one primary goal of using project appraisal methods is to understand what the choice involves. The use of social survey techniques, therefore, is potentially a good way of learning how members of the public, or of more specialised groups, interpret the choice and the issues it raises.

## 5.4 Benefit transfer

Benefit transfer (Podar et al., 2000; Rosenberger and Loomis, 2001) – usually now termed 'value transfer (Eftec, 2010a, 6 (Footnote)) - is simply the use of an estimate of the unit value of some benefit (or cost) derived in one context within a specific and different benefit-cost analysis. All benefit-cost analyses use some form of benefit transfer: an obvious example is the use of unit rates in estimating the capital costs of any engineering works or flood warning system. The alternative is to develop estimates of every stream of benefit or cost that are specific to the site and scheme in question.

There are four basic methods of benefit transfer:

1. Using a specific value derived in another context
2. Using standard or average values
3. Using site specific values within a predictive equation derived in other conditions
4. Meta-analyses: the statistical analysis of values derived for different sites and the use of site specific values within that equation.

In the initial stages of the iterative project appraisal process, it is appropriate to make use of whatever information is available: benefit transfer data is therefore useful. Only if that particular parameter proves to be critical is it logical to seek to improve estimates of that parameter's value.

The central issues in benefit transfer are:

- What is the variance in the value between apparently similar contexts?
- What are the causes of that variance?

This something of a chicken-and-egg situation because until we know how much variance there is, we are unlikely to have a good idea of the causes of that variance. For standard or average values to be appropriate, we have to have good knowledge of the causes of variance and also its extent. If we use a predictive equation derived in one condition for another context (e.g. an equation which predicts the number of visits to a site as a function of the nature of the population and the costs of visiting a site) then we are assuming that the pattern of visiting between sites is determined by the same factors as explain visits to the single site.

Meta-analyses (Smith, 1992) are a means of evaluating those types of benefits and costs which are otherwise expensive to measure for a particular scheme. A meta-analysis is a statistical analysis of the results obtained of the estimates of the value of a particular good in a large number of different studies in different contexts of different sites. The obvious advantage of such an approach is that we can make the best use of what we have learnt.

Such meta-analyses have been carried out for the value of wetlands (Brouwer et al., 1999) and the recreational value of coastal sites (Polome, 2003). It is hoped that the explanatory variables included in the statistical analysis will provide a valid explanation of the differences in the values obtained in the different studies. If this is the case, then the value of that good for a new and different site can be simply derived by inserting the site specific values in each of the explanatory variables. That value should be expected to some function of site characteristics and population characteristics.

How valid and reliable those estimates are then depend upon:

- The degree to which the individual studies are a random and representative sample of the population of all possible sites of that nature.
- The size of that sample of sites.
- The inclusion of the relevant explanatory variables (site characteristics and population characteristics).
- The quality of the original studies.

For example, there is a wide variety of different types of wetland (Mitsch and Gosselink, 2000) and the value of a specific form of wetland should be expected to vary according to its relation to wider systems. Thus, the value of a wetland for flood risk management purposes will depend upon whether it is groundwater or surface water fed, and its location within the catchment.

We need to have a good theoretical understanding of the relevant variables that should be expected to explain differences between sites, and data as to the value for each parameter at each site.

The original studies have to be of adequate quality and ideally each should have adopted exactly the same methodological approach. Unfortunately, meta-analyses tend to discover that a major form of explained variance is a result of methodological differences (e.g. Brouwer et al., 1999).

Whilst meta-analyses are promising in the longer run, they remain somewhat experimental at present. But certainly for the initial stages of an analysis, some form of benefit transfer should be used as it is the only method of trying to assess at an early stage in an investigation whether or not that parameter is critical to the choice between options.

# CHAPTER 6

# INCORPORATION OF FACTORS THAT ARE NOT FULLY TAKEN INTO ACCOUNT IN THE ECONOMIC ANALYSIS

It is inevitable that some factors will not be able to be included in a traditional economic analysis of flood risk management measures (and the stakeholders surveyed in Task B3 were most concerned with these matters (see the B3 report, Table 1). The strategy to be adopted in the appraisal process here should be described these factors in as much detail as possible, so that those making the decision can take these into consideration.

- Many so-called "intangible" effects can be taken into consideration using a multi-criteria approach. This can involve scoring each element that is to be taken into consideration, and then weighting the elements within the calculus to arrive at the multi-criteria result. In effect, this involves converting these "intangible" effects into monetary values using as a benchmark one of the factors that has been quantified in money terms during the economic analysis.
- Other factors are even more difficult to quantify, such as the disruption, inconvenience and noise created during construction of major engineering works.
- The loss of life floods is often an important consideration, yet there is disquiet about quantify this in monetary terms, despite this being quite normal by life insurance companies.
- Certain environmental aspects are also difficult to quantify in economic terms, and they have to be left with detailed descriptions. Particularly difficult is the complete elimination of sites of scientific value, species, or particular a vegetation assemblages. This can be valued at the cost of replacing them either at the site or in an alternative location, but this is controversial and such transfer values are often distrusted as a true measure of the effect of the flood risk management measures on environment values.

As indicated above, the best approach here is to describe in full the potential effects of the flood risk management scheme – positive or negative – and leave it to the decision-makers to make the decision, guided by those descriptions and by the economic analysis provided. In this respect technologies such as Appraisal Summary Tables can be useful in standardising the approach to these descriptions, but this is no panacea.

There is, of course, the danger that the most important considerations are those that have to be described in this way, and the economic analysis simply considers those matters which are simple to quantify. There is no easy way round this dilemma, except to stress again that economic analysis is a guide to decision making, rather than a system that decides "by itself".

As reinforced by the stakeholders surveyed in Task B3 (see the B3 report, Table 7) it also needs to be remembered that proper stakeholder engagement will be an important mechanism whereby these considerations are foregrounded, rather than left to specialist analysts and decision-makers. Thus one important part of the role of stakeholders in this respect is to bring forward considerations that cannot easily be quantified, so that the appraisal team can discuss these and review them comprehensively.

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# TERMINOLOGY[3]

- **Design standard.** A performance indicator that is specific to the engineering of a particular defence to meet a particular objective under a given loading condition. Note: the design standard will vary with load, for example there may be different performance requirements under different loading conditions.
- **Direct, tangible damages.** Direct damages are those where the loss is due to direct contact with flood water, such as damage to buildings and their contents. These are tangible when they can be easily specified in monetary terms.
- **Efficiency.** The ratio of outputs to inputs.
- **Exposure.** Quantification of the receptors that may be influenced by a hazard (flood), for example, number of people and their demographics, number and type of properties etc. Exposure is a measure of the total number of receptors in a given area and the proportion of these that will be exposed to the flood water.
- **Flood.** The temporary covering by water of land not normally covered by water [Definition from the European Directive on the assessment and management of floods (Directive 2007/60/EC); the "Floods Directive"]
- **Flood Hazard**. Flooding that has the potential to result in harm; the description of flood hazard may include the physical characteristics of a flood at a given point; including depth, duration and velocity. Sometimes flood hazard also includes an assessment of the probability of occurrence, but this is excluded from the definition used here.
- **Flood management measures**. Actions that are taken to reduce either the probability of flooding or the consequences of flooding or some combination of the two.
- **Indirect, tangible damages.** Indirect damages are losses that occur due to the interruption of some activity by the flood, e.g. the loss of production due to business interruption in and outside the affected area or traffic disruption. These also include the extra costs of emergency and other actions taken to prevent flood damage and other losses. These are tangible when they can be specified in monetary terms.

[3] Selected from: Samuels, P. and Gouldby, B. (2009) Language of Risk – Project Definitions (Second Edition). Wallingford, UK: HR Wallingford (the definition of 'non-structural' has been amended to match current thinking)

- **Intangible damages.** Casualties, health effects or damages to ecological goods and to all kind of goods and services which are not traded in a market are far more difficult to assess in monetary terms. They are therefore indicated as “intangibles”.
- **Measures.** Measures are direct physical interventions that are usually implemented by flood risk managing authorities. Measures can be divided between control measures (such as flood defences), retreat measures (i.e. moving receptors out of flood hazard areas) and adaptation measures (such as compatible land management). Alternatively, measures are often described as structural or non-structural:
    - Structural measures are engineering works, intended to reduce the frequency of flooding. Examples include dams, flood walls, embankments, tidal barriers, etc.
    - Non-structural measures are generally not physical interventions but measures to reduce or modify hazard impacts. Examples of these types of interventions include flood warning systems, insurance, emergency response, spatial planning, public education, etc. Sometimes flood resistant construction techniques or flood proofing, etc. can also be termed non-structural. As can be spatial planning be seen as ‘structural’ in that it deals with buildings.
- **Pathway**. Route that a hazard takes to reach Receptors. A pathway must exist for a Hazard to be realised.
- **Proportionate methods**. Provide a level of assessment and analysis appropriate to the importance of the decision being made.
- **Receptor .** Receptor refers to the entity that may be harmed (a person, property, habitat etc.). For example, in the event of heavy rainfall (the source) flood water may propagate across the flood plain (the pathway) and inundate housing (the receptor) that may suffer material damage (the harm or consequence). The vulnerability of a receptor can be modified by increasing its resilience to flooding.
- **Return period.** The expected (mean) time (usually in years) between the exceedance of a particular extreme threshold. Return period is traditionally used to express the frequency of occurrence of an event, although it is often misunderstood as being a probability of occurrence.
- **Risk.** Risk is a function of probability, exposure and vulnerability. Often, in practice, exposure is incorporated in the assessment of consequences, therefore risk can be considered as having two components — the probability that an event will occur and the impact (or consequence) associated with that event. Often this is abbreviated as Risk = Probability multiplied by consequence;
- **Risk management**. The complete process of risk analysis, risk assessment, options appraisal and implementation of risk management measures

- **Sensitivity Analysis.** The identification at the beginning of the appraisal of those parameters which critically affect the choice between the identified alternative courses of action.
- **Source.** The origin of a hazard (for example, heavy rainfall, strong winds, surge etc).
- **Sustainable Development.** Development that meets the needs of the present without compromising the ability of future generations to meet their own needs
- **Susceptibility.** The propensity of the people, property or other receptors to experience harm.
- **Vulnerability.** Characteristic of a system that describes its potential to be harmed. This can be considered as a combination of susceptibility and value.