Putting economic values on green infrastructure improvements

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Introduction

People with an interest in developing green infrastructure often need to assess the benefits that it provides to society. This can be to inform project design or to justify investment to others. Economic valuation is a very powerful method of assessing the benefits, because it provides an assessment of the size of benefit in monetary terms. This means that green infrastructure benefits can be easily compared to benefits produced by alternative investments. Indeed, only economic valuation can provide a value-for-money assessment.

This chapter was written to give green infrastructure practitioners the knowledge required to make well informed decisions about their engagement with economic valuation. Please note that economic valuation is a highly technical subject, and the chapter was seeking to help develop informed customers. You should seek expert help if you want to conduct an analysis. The note makes some comments about Economic Impact Assessment, which is related to, but different from, economic valuation. The differences will be explained.

The note includes the essential economic background. A glossary of terms is provided in Box 4.1 on page 19. Appropriate decision-making frameworks are explained and the valuation process provides details of some of the issues involved in practical assessments. There are also examples of the steps that need to be considered to successfully commission an economic analysis. The final section considers the limitations of the dominant approaches to economic analysis and demonstrates why alternative approaches may be required to fully make the case for green infrastructure. The conclusion draws together the information presented to explain how, and to what extent, valuation can improve decision making with regard to green infrastructure, and identifies some alternative approaches.

Background: Incorporating the environment into economics

Some essential background is required to make sense of this note. We start from the perspective of neo-classical economics. This is the dominant approach to economic analysis and will be referred to simply as economics unless otherwise specified.

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Markets, welfare and values

Economics is a social science focussing on the most efficient use of scarce resources to produce human welfare. Its originator, Adam Smith, observed that markets provided a very effective co-ordination mechanism for economic activity, even when each participant was acting only in their self-interest. He noted that interference in the market by government and guilds (traditional monopolies) could reduce public welfare. In the early twentieth century Pareto paved the way for mathematical formalization of this insight by showing that it could work without knowing how much benefit consumers gained form each good - they only had to be able to rank goods in order of preference. This formalization depended on some important assumptions about the agents in the model, specifically that they were individual, rational, maximisers of their own welfare. They would decide how to spend their limited income in the way which maximised their welfare. This meant that their purchasing decisions would express the relative value they place on different goods and services. Pareto's model showed that this willingness-to-pay would influence the profits available to manufacturers and alter production patterns to meet consumer demand. It must be remembered this is a model based on ideas, not a hypothesis verified through experiment. Nevertheless, since Pareto, this idea of a perfect market has dominated economics.

Governments aim to increase the welfare of the population. According to Pareto's model a central focus for increasing welfare should be to grow the size of the market, through increasing efficiency of production, through increased technology and improved skills. The size of the market is measured in Gross Domestic Product (GDP) and increasing GDP is the central target of most governments. Later in this note we shall consider Economic Impact Assessment which is a method of considering the effect of an intervention in increasing the size of the market.

Economic theory also recognises that there are imperfections in the market, known as market failures. Theory recognises five main types of market failure. These are: lack of perfect competition, lack of perfect knowledge, transaction costs, externalities and public goods.

Perfect competition assumes that none of the actors in the market are powerful enough to choose prices - that all must accept prices set by the market. Monopolies are the clearest example of an imperfection, because a lack of competition means that they can 'get away' with charging above the price a market would settle at. Externalities are impacts on third parties to the transaction. For example the buyer and seller of the cigarettes may agree a fair price which does not take into account the health impact on the passive smoker sitting next to them.

Public goods refer to things which, although they are important to welfare cannot be traded in markets. This is because they are non-excludable, meaning people can access them without paying, and non-rival meaning that more than one person can enjoy them. So national defence and clean air are non-excludable and non-rival and therefore public goods. Before we leave our explanation of market failures, it's important to note that the burden of proof is on those suggesting there is a market failure. In the absence of evidence the market is assumed to be functioning perfectly.

Green infrastructure offers its benefits, such as an attractive landscape or reduced air pollution, to everybody, whether or not they have contributed to it. Therefore it suffers from a public good market failure - the market will not deliver it alone, even though it is desirable, and so government must deliver it. Of course some green infrastructure is delivered privately because of the specific benefits it

offers to the individuals who own the land. Trees in private gardens and green roofs are examples. Even in these cases green infrastructure will tend to be delivered at lower levels than is economically optimal, because these pieces of green infrastructure offer positive externalities - that is they offer benefits to wider society, which the owners are not compensated for. So even in this case green infrastructure will tend to be underprovided without state action.

We have seen that at a strategic level policy focuses on growing the market and on addressing market failures. At project or programme level however decision makers need a method of making decisions which can handle more detail. They use Cost Benefit Analysis (CBA), which draws on the economic theory explained above, but also has some significant differences to Economic Impact Assessments. Most importantly, whereas EIAs include only goods and services delivered through the market, CBA includes market and non-market costs and benefits.

Cost Benefit Analysis works through comparing the costs and benefits of a project (PROJECT ON) compared to the situation without the project (PROJECT OFF). The costs and benefits are both valued and the project is considered desirable if the total benefits outweigh the total costs. Because the market is assumed to be working near perfectly, in most cases the price paid for a good and service in the market can be taken as its value and entered directly into the analysis. Where a change to non-market goods or services could be significant however, the analyst needs to find a method to place a value on the change in these. This is done through the creation of a hypothetical market which considers what would happen if these goods and services were traded.

How much would a member of the public on average be willing-to-pay for them? It is also possible to use willingness-to-accept compensation for a loss, which in economic theory should be equal to willingness-to-pay. However, research demonstrates people value losses much more highly than gains (Kahneman and Tversky, 1984). These willingness-to-pay values can be elicited from the public through carefully constructed interviews or can be inferred from market behaviour, such as the increment in house prices near attractive parks.

For environmental valuation it is often necessary to construct a logic chain (see Chapter 22 of the *Green Infrastructure Handbook* for more information on logic models) which includes natural science and health evidence as well as willingness-to-pay. It is therefore possible to value non-market goods and services, but it can be time consuming and expensive to produce the necessary values.

Ecosystem services

To place a value on a green infrastructure improvement we need to build a logic chain which starts from the change in the natural environment and is convincingly linked through to a benefit for which people are willing-to-pay. Figure 4.1 shows the structure of such a logic chain, giving specific steps for the change in what the natural environment does (slow water) which provides a service (flood protection) which provides a benefit, such as health or safety, which can be valued by people's willingness-to-pay for it. The logic chain needs to have strong scientific evidence for the change and for each link in the chain.

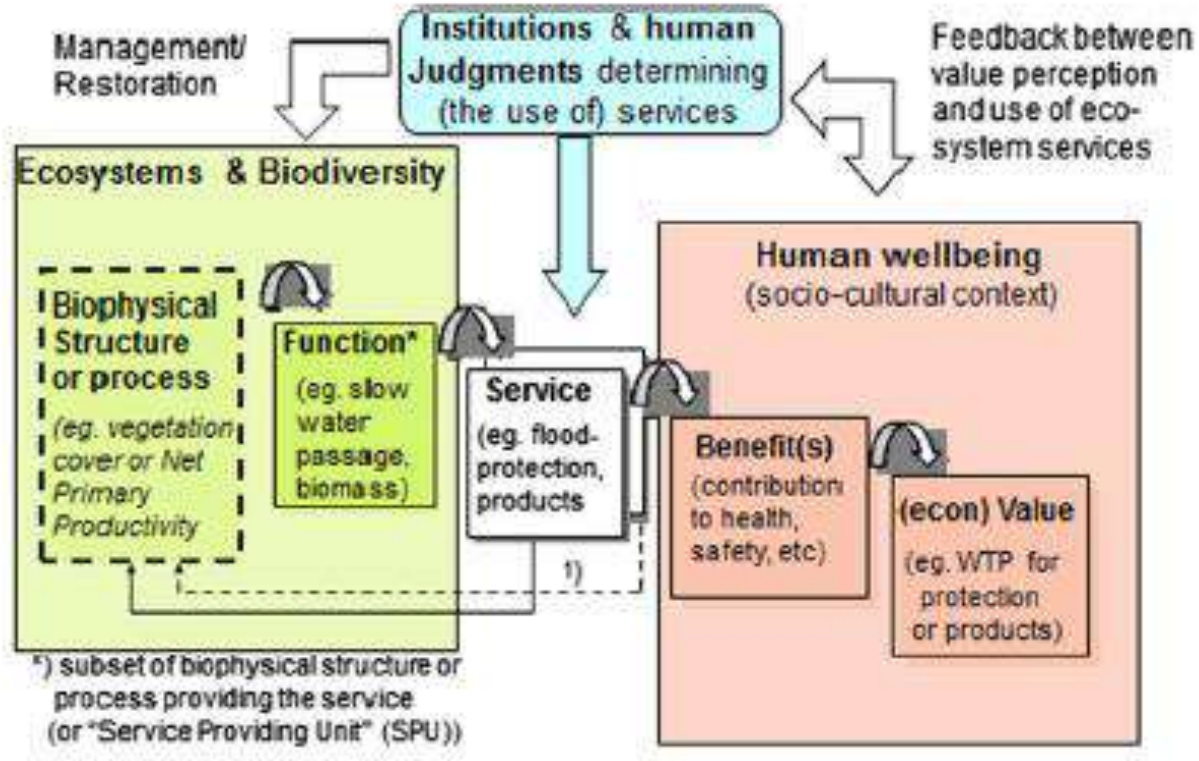

Figure 4.1 Ecosystem services cascade (Source: Braat and de Groot, 2012)

As we have seen, values due to environmental change in CBA are additions to an approach which starts from the market. There is therefore a danger that these additions are ad-hoc, or based on prior assumptions about which environmental changes will be of significant value. In order to address this problem, and support systematic decision making, it is best practice to use a check list of ecosystem services, to ensure none is accidentally omitted.

Major international research projects have developed their own classifications of ecosystem services. Table 4.1 shows a classification developed by the Department for Environment Food and Rural Affairs in the UK. The Ecosystem Services Framework (Table 4.1) divides the services provided by the environment into four categories: provisioning, regulating, cultural and supporting.

Provisioning services are the most straightforward to understand, they are products that are produced by ecosystems, such as food, timber and freshwater. Regulating services are somewhat more abstract, they describe the way in which ecosystems provide order and structure to the world in ways which are important, but that we often take for granted until they go wrong (DEFRA, 2007). To give two examples, trees help to regulate erosion and water absorption into soils - the loss of trees in upstream agricultural land has been connected to downstream flooding. Urban trees help to reduce air pollution and reduce temperature fluctuations. The list of services can vary from place to place. For example in South Africa regulatory services would include bush fire suppression.

The cultural services section captures the non-material importance of ecosystems to human beings, such as the importance of nature for tourism and recreation. The importance of nature to mental health fits in this section under aesthetic value (a cultural service).

Underpinning all of these are supporting services, which are things such as soil quality and the nitrogen cycle. These are not used by people directly, but are essential to delivering all the other ecosystem services.

Table 4.1 Ecosystem services typology (Source: DEFRA, 2007)

Provisioning services	Regulating services	Cultural services
Food	Air quality regulation	Cultural heritage
Fibre and fuel	Climate regulation	Recreation and tourism
Genetic resources	Water regulation	Aesthetic value
Biochemicals, natural	Natural hazard regulation	
Medicines, pharmaceuticals	Pest regulation	
Ornamental resources	Disease regulation	
Fresh water	Erosion regulation	
	Water purification and waste treatment	
	Pollination	
⬆	⬆ Supporting services	⬆
Soil formation, primary production, nutrient cycling, water cycling, photosynthesis		

A major consideration for all forms of CBA is to ensure that no benefits or costs are excluded, but also that none is counted more than once. This requires a clear list of benefit categories, which are distinct and do not overlap. For Ecosystem Service Valuation this requires careful working out of impact pathways - as demonstrated in Figure 4.2 that looks at ecosystem service changes and the resulting benefits from wetland improvements. It is these final benefits that we can value economically. For this reason supporting services are generally only taken into account as they relate to provisioning, regulating and cultural services, in order to avoid double counting.

Areas of green infrastructure are designed and managed to provide multiple ecosystem service benefits. For example Mayesbrook Park in London is designed to hold flood water, but also to support wildlife and provide an amenity space for local people (Everard et al., 2011). Careful planning is required to deliver these different benefits from the same site. It is important therefore that any economic analysis captures this full range of multifunctionality. If quantifying the benefit is not possible it should be described qualitatively.

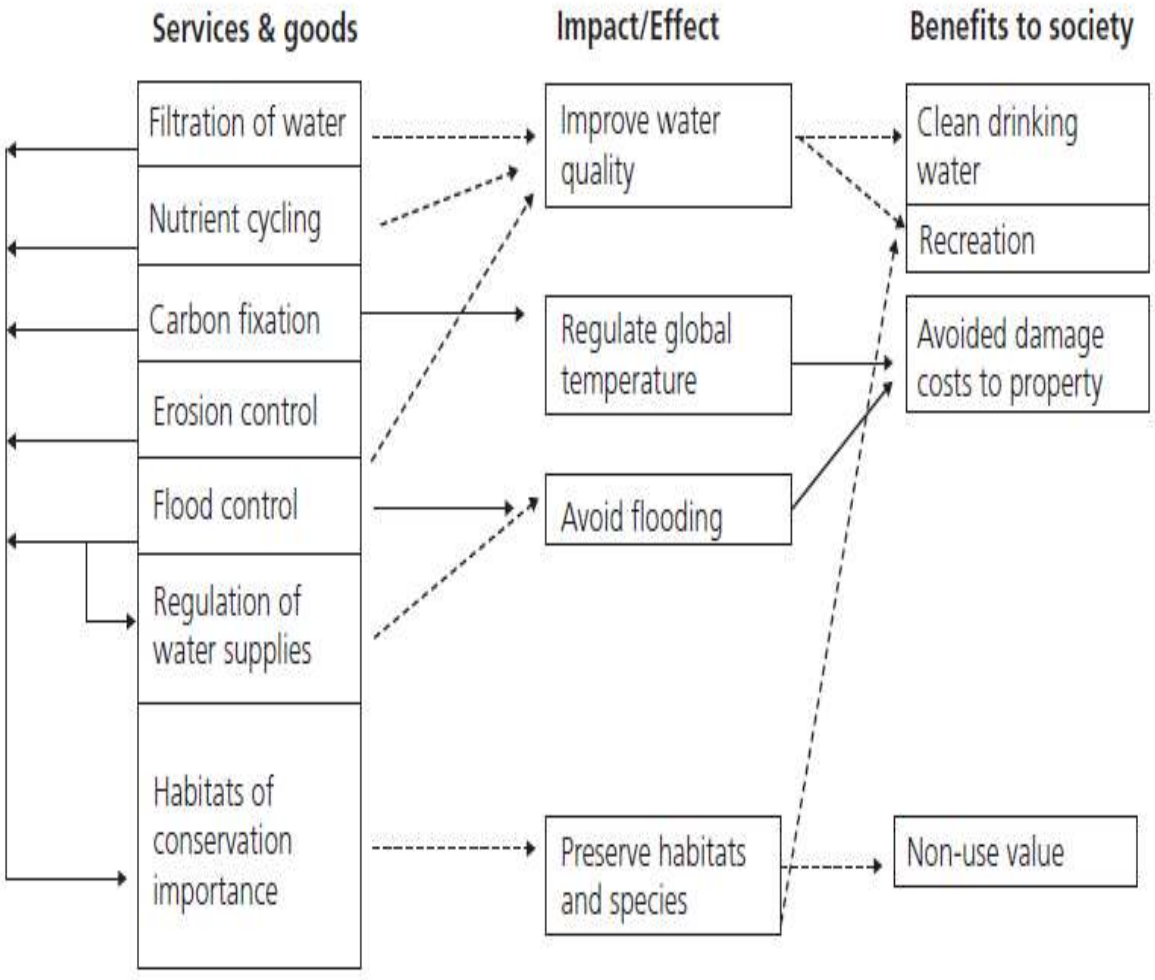

Figure 4.2 Impact pathways between environmental services and final benefits to society (Source: EFTEC et al., 2006)

Decision-making frameworks

Officials in public life face enormously complicated decisions. They not only need to come to a decision about the best use for their limited resources, but they need to be able to rationally justify this decision to others once made. Furthermore, senior management at organisational or national level want to be able to compare the results they are getting from a range of different projects or programmes. It is for this reason that society has developed standardised methodologies for making and justifying these decisions. These could be referred to as decision making tools, but this implies that these methodologies are objective and neutral with regard to the final decision. In reality many of these methodologies contain implicit value judgements and so we prefer to refer to them as decision making frameworks.

Selecting a decision making framework to apply to green infrastructure improvements

Status and use of decision making frameworks

Cost-Benefit Analysis is the theoretical gold standard for decision making in many governments, and formal CBAs are required for new legislation. However, a very large proportion of central government expenditure is driven by departmental targets, such as health outcomes or the proportion of people in employment. To some extent this is joined up at local authority level, but department specific targets are still common. This means as well as CBA you may need to consider evidence about relationship to specific targets, such as health or employment.

Cost Benefit Analysis

As described above, CBA is used to compare two scenarios, one with the project and the situation without the project, known as the counterfactual. It places values on the costs and benefits of the difference between the two scenarios, and compares the two to assess the desirability of the project. For example a cost: benefit ratio of 1:2 implies that the project offers benefits worth twice the costs of delivering it, and it is therefore desirable. Cost Benefit Analysis can and should include non-market costs and benefits, which makes it a useful tool for green infrastructure. Importantly, CBA is the only decision making framework which can assess the value for money from an investment in terms of increased welfare.

Cost Benefit Analysis was designed to support decision-making and project design. If used at an early enough stage in the project design, CBA can support the design of a project which maximises benefits and minimises costs. However, fully worked through CBA can be a demanding and expensive piece of work, which means that in practice project appraisal (assessment of its desirability) using CBA is often only conducted when the project is finalised. This problem can be avoided by using the logic of CBA in a less refined, scoping manner, in the early stages of project design, as recommended by UK government guidance (HM Treasury, 2003). The Social Return on Investment (SROI) methodology offers a simplified version of CBA particularly suited to support project design and most relevant for projects of medium-scale, where partnerships are going to be important to the success of the project (Cabinet Office, 2009).

As well as supporting decision-making you may wish to value green infrastructure in order to justify your project to funders or to make the case in a more general way. Economic valuation is a very powerful tool for doing this because it values benefits in monetary terms, which allows both the public and government agencies to readily compare them with benefits offered through other sectors. In this ‘awareness raising’ context the values of changes to green infrastructure are of use outside the context of the project CBA, and can also be plugged into other CBAs. However, this is only true if the values are produced robustly and to recognised standards.

Economic Impact Assessment

Economic Impact Assessment is often confused with CBA. Economic Impact Assessment attempts to assess how much a particular investment will increase the size of the market within a particular area. This is different from CBA because non-market benefits are excluded from the calculation. Note that Economic Impact Assessment still has a counterfactual (the situation without the investment) and a project option. Some elements of an Economic Impact Assessment can count as benefits in a CBA,

but including any parts of Economic Impact Assessment in a CBA is technically quite complex. For example, work counts as a cost in CBA, but increased employment registers positively in Economic Impact Assessment. Because non-market benefits are excluded it is much harder to make the case for green infrastructure using Economic Impact Assessment. However if you feel that your project may contribute to the growth of the economy it may be worth conducting one instead of, or as well as, a CBA. Many influential partners are primarily concerned with economic growth, such as economic development authorities. For a review of the evidence about economic growth and environmental improvement see Gore et al. (2013).

Cost Effectiveness Analysis

Where you are trying to produce evidence to relate to particular departmental targets you will probably need to show how cost effectively you are contributing to meeting their target. This can often be accomplished with similar evidence to that required for a CBA, but it needs to be constructed differently. For example the health department may be looking for the most cost effective method of improving Quality Adjusted Life Years (QALYs). Projects which encourage people into regular patterns of physical activity can be very cost-effective in terms of QALYs (Rolls and Sunderland, 2014).

Selecting a framework

Cost Benefit Analysis is the most inclusive framework, the one with the highest status, and probably the easiest framework to use to make the case for environmental change. It should therefore be the first port of call for those interested in appraising or evaluating green infrastructure improvements. Cost Effectiveness Analysis will be most relevant when your project's benefits are focussed in a particular area or are relevant to particular stakeholders. In this case it may well make sense to focus on their targets. Health improvement is an example of a situation where this would make sense, and is probably easier than using CBA. Economic Impact Assessment should only be used if you have reason to suspect that your project is making a non-negligible difference to economic growth (at the local or national scale) and this sort of evidence is of particular interest to your stakeholders.

The valuation process: an example

This section seeks to make the theory offered so far more concrete by offering a real example of a valuation process and to explain some of the steps and challenges in valuation. We will use analysis of the ecosystem services offered by trees in Torbay, Devon, England, as an example (Sunderland et al., 2012).

Rationale

Street trees, and trees more generally in an urban environment, offer a wide range of ecosystem service benefits to people. Table 4.2 is an attempt to capture some of the main benefits. Unfortunately many of these benefits are difficult to quantify and value; and some are impossible. By contrast, the costs of planting and maintenance are easy to quantify, and feature on the local authority's accounts. There is therefore a significant danger that the local authority's decision making framework leads to an undervaluation and therefore under investment in urban trees.

An opportunity arose to use a computer programme called i-Tree Eco, developed in the USA, to place economic values on the health and climate change mitigation benefits provided by street trees through the carbon sequestration and air pollution removal services they offer (see Chapter 2 of the

Green infrastructure handbook for more information). This could lead to a wider appreciation of the benefits provided by the trees, and was the rationale for undertaking the project. This is a very common rationale for CBA; response to market signals only tends to lead to the under provision of non-market benefits, such as regulatory and cultural services. Cost Benefit Analysis is therefore used to make the case for government action to address this under-provision of street trees and increase welfare.

Table 4.2 Costs and benefits of urban trees (Source: Sunderland et al., 2012)

Costs		**Benefits**	
	Environmental	**Social**	**Ecological**
Planting (a)	Air Quality (a)	Aesthetic - including mental health/spiritual	Species habitat
Establishment (a)	Carbon storage and sequestration (a)	Increased attractiveness of streets for active travel and socialization	
Clearance of leaf litter (a)	Climate regulation/amelioration	Increased attractiveness of streets for socialization	
Damage to pavements and buildings	Erosion control	Education	
Removal of dead dying diseased trees (a)	Storm water attenuation	Attractiveness of locality for tourism and inward investment (b)	
Maintenance -trimming over carriageways (a)	Noise abatement		
Loss of light	Soil quality		
Release of Biogenic Volatile Organic Compounds	Water quality		

(a) These costs and benefits were included in this analysis, with the exception of the clearance of leaf litter which was only partially included.

(b) This benefit is a relative benefit; that is to say trees do not probably increase the level of tourism or inward investment in the UK, but may increase Torbay's attractiveness relative to other areas. For this reason it cannot be included in a cost-benefit analysis to national standards.

Steps in valuation: qualify, quantify and then value

As described in Figure 4.1, in order to value a benefit it is necessary to build a logic chain from the environmental feature, to a function of the feature, to a service and then a benefit which can be valued. There were two such logic chains in this example, air pollution removal (Figure 4.3a) and carbon sequestration (Figure 4.3b).

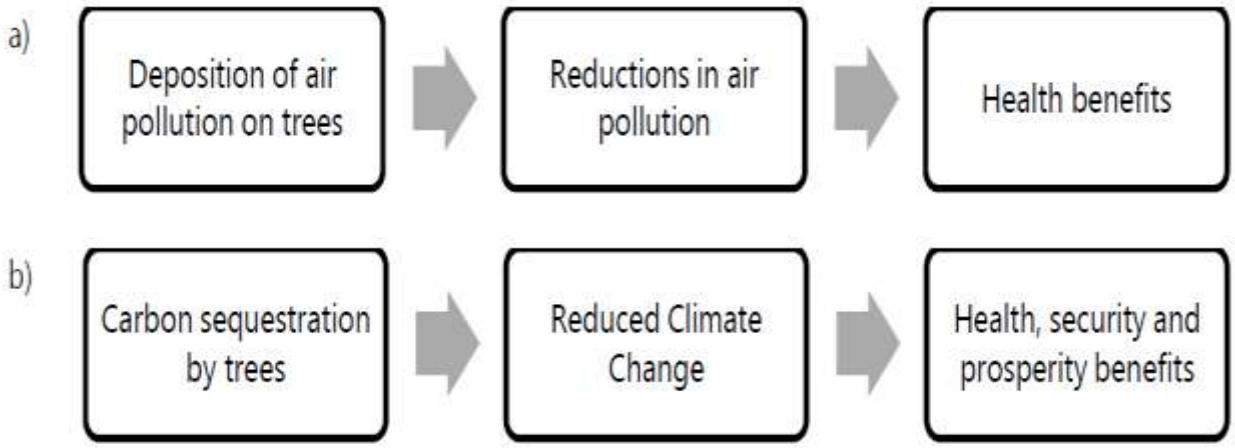

Fig. 4.3 Example logic chains for a) air pollution removal and b) carbon sequestration by Torbay's trees

For both these examples information was already available for the second half of the logic chain. Willingness-to-pay for avoided ill health data were available. Also available were estimates of the negative health impact of various air pollutants in cities. These two pieces of data had already been brought together to provide estimated costs for pollutants at different concentrations and with different population data. What was lacking was reliable quantification of the air pollution removal effects of trees. Similarly, estimates for the value of reducing carbon emissions were available but what was lacking was reliable quantification of carbon removal and sequestration.

It is important to note that whilst the two examples given above are positive it is also possible for natural features to cause ecosystem disservices, such as the emission of pollen (leading to hay fever) or biogenic volatile organic compounds (BVOC). These disservices lead to costs. In principle these costs should be added to the costs side of the cost benefit ratio, but we were unable to do so in this case due to lack of evidence to quantify them.

A review of the evidence for each ecosystem service can be found in MEBIE 2 (Rolls and Sunderland, 2014).

Ready-made tools

What made the analysis possible was the fact that a tool called i-Tree Eco had been developed which quantified these services based on sample surveys of the trees in the area. This first stage was to assess whether this tool was robust and appropriate. Fortunately the team's aboriculturalist knew the programme and was able to vouch for the natural science. The team had careful discussions, not just about the robustness of the approach, but also how transferable it was to a UK context. This led to us limiting the research to carbon sequestration and storage and air-quality services, because some of the other services offered by the programme were not transferable to the

UK context. For example calculations of reduced heating or cooling costs due to sheltering by trees relied on building type information which was US specific. The programme also contained some automatic economic calculations, which whilst providing some indication of value, would not have been appropriate for the UK and so these were not used.

There is a great demand for methods to place values on the environment, and this has led to the production of a large number of ready-made support tools. These vary from guidance documents, through to spreadsheets which purport to produce CBA based on the input of some key numbers, through to large and complex computer programmes which do biophysical modelling. Some of these tools are helpful and make valuing the environment quicker, cheaper or even feasible when it would have not been before. However, it is important to check that status of these tools with relevant experts. Be wary of tools which claim to make CBA an automatic data entry process, because this is not possible. In order to use these tools and pull together a reputable analysis you will need to employ an economist. Natural England has commissioned an assessment of some commonly cited tools (Gore et al., 2013).

The need for a discreet project and counterfactual

The example of i-Tree, from the United States, calculated the benefits offered by the trees within the target area in one year. This was then compared to the expenditure on maintaining the trees within the same year, in a ratio described as a 'snapshot analysis'. This snapshot analysis looked very favourable, but it didn't do what CBA should do, which is to compare the costs and the benefits of a specific and discreet project. To explain further, the benefits provided by the trees in any one year are due to investment over the last couple of hundred years. You could cease all investment in one year and still reap the vast majority of the benefits – the zero on the cost side would make investment in trees seem infinitely efficient. A CBA needs a discreet project, starting in the near future in which all the costs and benefits can be compared, and with a realistic 'project off' (or counterfactual) scenario to compare it to.

Ideally we would have liked to compare a scenario with 'business as usual' levels of investment in the area's tree stock with an 'enhanced investment scenario'. Unfortunately, this would have required tree stock modelling at a level which was not available at the time. Instead we addressed this problem by modelling the full life-time costs and benefits of four hypothetical trees of different species. This made it artificially easy for us to address stage one of an economic assessment of green infrastructure which is to have a clear, specific and quantifiable grasp of the change in green infrastructure that is due to your project. This change needs to be feasible for the values to be meaningful.

This was an illustrative valuation because there was no real decision being made and the longevity of the trees required the use of future values with very high levels of uncertainty attached to them. This was therefore clearly a case of using valuation to make a general point about the magnitude of the ecosystem service benefits trees provide, rather than to inform a real decision, but we took it as far in this direction as we could.

Evidence, uncertainty and proportionality

The biggest challenge for economic analysis of green infrastructure is generating the scientific data to connect together the logic chain with enough confidence to derive values. In some cases no

quantification will be possible. In Torbay ground level ozone was a frustrating example of this. We had evidence that the level of ozone was above recommended levels and a quantified estimate of amount of ozone the trees were removing from the atmosphere. Unfortunately, however, there are significant uncertainties about the human health response to ozone and threshold effects. This meant that all we could do was to describe the effect qualitatively. This rather marginalizes it from the analysis, but we did highlight it as a key uncertainty which was positive with regard to the benefits of trees.

In some cases there is uncertainty, but the evidence is good enough to put some figures on the scale of this uncertainty. In our analysis this has been achieved with the official carbon and air quality values which both offered low, central and high estimates of value. In both cases the differences between the central and outlier values was high, indicating high uncertainty. We calculated values and cost benefit ratios at the different levels offered to illustrate the uncertainty in the analysis. This is called a sensitivity analysis. This approach can also be used when a piece of evidence is not available; where economists use an explicitly stated assumption to fill the gap. Where they do this they should also run the analysis with different assumptions to check the sensitivity of the results.

It is important to remember that the level of robustness required for a CBA depends on the magnitude of the decision it is informing. It would be possible, but not cost effective, to spend £1 million on improving the evidence to inform a £10 000 decision. Therefore proportionality should be considered in evidence gathering and analysis.

Timeframe

Cost Benefit Analysis adds up the benefits and costs from future years to produce total (net) costs and benefits for the cost benefit ratio. This means that the timeframe for the analysis needs to be considered and explicitly stated as part of the project. Economists use a mechanism called the discount rate to reduce the value of costs and benefits in future years by a percentage per year they are into the future. This process significantly reduces the influence of future costs and benefits on the final sum of costs and benefits. For example, using the UK government standard rate of 3.5 per cent reduces future costs and benefits to less than half their ‘raw’ value by year 21 and by year 100 only a tiny fraction of costs or benefits count. This is challenging for environmental projects because benefits may take several years or decades to emerge fully and may be sustained for a long period, whereas costs are more likely to be incurred within the first year or two.

For the analysis of Torbay’s trees the discount rate was critical. Most of the expenditure on trees is at the beginning of their life cycle, but the benefits of an oak may still be increasing at 200 years old. Accordingly we ran the analysis twice. Once with the standard Treasury discount rate for the UK. It is pragmatic to use the standard Treasury discount rate for your country, because this allows your cost to benefit ratio to be compared with other projects which are likely to use this rate. The second time we used a reduced discount rate based on an argument about inter-generational equity. This is called testing the sensitivity of the outcomes to the discount rate and is allowable under UK Treasury rules. As expected it showed that the results were extremely sensitive to the discount rate and that tree planting was more attractive with a lower discount rate. For practical assessments it is important to use the standard discount rate for your location (even if you do a sensitivity analysis around it) because analyses with different discount rates are not comparable.

Displacement

Good economic analysis will require evidence about displacement. Displacement occurs where a project or programme creates a benefit but at the expense of benefits elsewhere. Tourism and recreation are key areas where this occurs - if a new park is created, people may visit it instead of their usual park, rather than as well as their usual park. From a regional or local perspective this may be desirable if you attract visitors from elsewhere, but from a national perspective the net benefit may well be zero. This means that the spatial boundaries of your analysis need to be clearly defined. In our analysis it was also important that the spatial boundaries were clearly defined, so that we could be specific about our tree and human population, but displacement was not a significant issue because the analysis was focussed on benefits to a particular geographical area, and attracting new people to the area was not necessary for the benefits to be realised.

Steps for thinking through commissioning

If you are going to commission some economic analysis of your green infrastructure project it would be useful to think through the following steps.

Purpose

Be clear why you are commissioning the research. There may be a statutory or funder's requirement for a CBA. Alternatively their requirements may be less specific, but an economic assessment would be a good way to meet their needs. It may be that you want to generate an assessment to make the case for your project more generally.

Partnership

It may make more sense to conduct the analysis with a partnership, if the results will be of interest to all parties. This may help to spread the cost of the assessment, both in terms of finance, and in terms of gathering the relevant data and evidence. This however, needs to be carefully thought through so that responsibilities are clear and ways of dealing with differences of opinion and conflicts of interest are considered. It is particularly helpful to be clear about the split on a steering group between technical leadership (eg economics, data, ecology) and policy leadership.

Assessment type

You need to consider at this stage whether you require a CBA, an Economic Impact Assessment, or both. Social Return on Investment is a form of CBA used sometimes in the third sector. It has the advantage of explicitly identifying stakeholders and asking them what the major costs and benefits are. If the major benefits of your project are social it may be easier to use than standard costs-benefit analysis, but it doesn't make valuing ecosystem service change any easier. You will need at least an accredited SROI practitioner and may well need an economist - particularly if you are trying to value ecosystem service change. It is also worth considering whether other forms of evidence will meet your needs, such as a 'narrative of change'. Natural England's literature review provides the underlying evidence for the relevant theories of change (Rolls and Sunderland, 2014). In many cases reference to a previous assessment on a similar site elsewhere may be sufficient.

Budget

If you have no budget to spend on your assessment and some staff time available, the most appropriate response is to develop a plausible narrative of the change that your project will deliver, using generic evidence to justify the logical links between your project and the resulting benefits. You

could then show how the specific details of your project relate to this wider evidence base (see Rolls and Sunderland, 2014). If you have a small budget (for example £5000) for your assessment you may be able to employ an economist to produce an assessment based on already existing evidence. The economist will also be able to infer values for your project based on economic evidence from elsewhere, using an approach called value transfer. The more time you have put into thinking about your needs and gathering the available evidence before you commission an economist the better. Early effort will reduce the cost of the assessment and increase its usefulness to you. Only if you have a very substantial budget (£50 000 upwards) should you consider gathering new survey or monitoring evidence to support your assessment.

Evidence assembly

Initially at least, this is not about generating new evidence, but about assessing what evidence you already have. This includes specific evidence about your project and the more general environmental and economic evidence you want to connect it to. Evidence on any change in land use, should be as specific as possible, for example new planting, change in river function etc. You also need evidence about change in use of your new area. If it is a new park how many people use it? Why do they use it? What did they used to do before coming to your park?

Commission

When commissioning economics research think carefully about the brief and the skills you need to ensure you are getting value for money. In particular, you need an environmental economist, who specialises in this area, for the best outcome. If you can, pull in a supportive economist from government, academia, or business to help draft the tender and assess the bids.

Analyse

The process of analysis should be iterative, and the quality of the product will depend on the quality of the conversation between the customer and the economist. Therefore be prepared to think through issues yourself and express your views and concerns.

Reconsider

Economic analysis should ideally be conducted at the stage where there is still room to change a project or stop it completely. So if you are at the early stages of developing a project the analysis may give you ideas for things to do differently, may point out barriers or opportunities, or may even suggest new partners you should be working with. More often economic analysis is conducted when the plan for the project is already fixed, in order to justify the project or to demonstrate its attractiveness to funders. Even at this point it is still worth considering whether the analysis points to any desirable and viable changes. Lastly, the analysis may be conducted as an evaluation, in which case it should provide learning for other projects or the next phase.

There is an important caveat here however, which is that if your project doesn't look as good in the economic analysis as you hoped this could be as much to do with the analysis as your project. One problem might be that it is disproportionately difficult or expensive to get hold of evidence which is certain enough. Another might be that the form of analysis you are using either has a different value set to that of your organisation (see Limitations of economic valuation of the environment section) or is just not very sensitive to the changes you are delivering. This may be partly methodological - Economic Impact Assessment is insensitive to changes in welfare which do not impact on the size of

the economy. It often seems logical that these benefits should in time help the economy, for example health improvements helping productivity, but this can be very hard to demonstrate. Similarly CBA is restricted to markets or hypothetical markets and so will not pick up on outcomes for which it is difficult to imagine a market. An example might be group walks reducing people's isolation in their community. Lastly the Economic Impact Assessment and CBA methodologies have a high burden of proof and will omit changes which many people would accept, but can't be proven.

Communicate

Once an assessment has been completed see whether it is worth communicating, before you set about sending it to people. Does the piece of research do what you set out to do? Are the evidence, numbers and findings robust enough? Does the piece of research itself communicate clearly if people go beyond the press release to the original analysis?

Particular care needs to be taken with the use of values and cost to benefit ratios. If these are robust they can be powerful communication tools, but they are most powerful when they are placed in context of the project under discussion, the theory of change and the evidence. The numbers will need to be carefully integrated into a meaningful story if your audience is to connect with them. Communication should focus on the things in your analysis you are reasonably confident of, but the summary needs to be an accurate reflection of the analysis so careful writing is required.

Limitations of economic valuation of the environment

The economy is a subset of the environment

Up until this point this note has been written from the point of view of neo-classical economics. This sees the market as the starting point and the environment as important additional detail which needs to be built into a market dominated view of the world. This however, is entirely back-to-front. It is the economy which embedded in, and dependent upon, the environment.

It is quite common in academic and policy circles to see sustainable development conceptualized as economy, society and environment drawn as three, equal interrelated parts in a Venn diagram as shown in Figure 4.4a.

This approach implies economy, society and environment are co-equal and mutually interdependent. This suggests an approach to sustainable development in which all that is required is for each to be considered properly. At its worst this can treat the environment as a nice-to-have, rather than a necessity. It is of course clear from natural science that instead the human economy and society are embedded in, and totally dependent, upon the environment, as shown in Figure 4.4b.

Figure 4.4a

Figure 4.4b

Figure 4.4a Conceptual models of sustainable development showing the Venn diagram model

Figure 4.4b Conceptual models of sustainable development showing the embedded economy

There is therefore a clash between neo-classical economics, which implicitly treats the environment as an additional source of costs and benefits, and the reality of the economy's dependence on the environment. This means that neo-classical economics is a very difficult vehicle with which to conduct analyses on environmental sustainability. The problems are less acute with marginal changes, which is what CBA is designed for. This is because if changes are marginal they will not lead to system-wide shifts in either the environment or the markets from which prices are taken. By contrast non-marginal changes would radically change the market from which its values are derived. So you can sensibly value the natural flood defence offered by the delta-wetland in the New Orleans delta, but the valuation of large-scale system changes are much more difficult.

Attempts to value unrealistically large changes tend to be driven by the aim of drawing attention to the value of the environment, rather than informing specific decisions. A famous example is the Costanza et al. (1997) valuation of global ecosystem services at $33 trillion a year, which was criticised by Toman (1998) as a 'serious underestimate of infinity'. The global environment is infinitely valuable: there is no life without it. This leads to a second problem which is that a series of non-marginal decisions can have cumulative consequences (good or bad) far greater than the addition of the individual values. This is particularly the case when dealing with complex systems, such as ecosystems or human societies, which are subject to threshold effects or 'tipping points' where a small change can set off a large chain reaction. For this reason CBA is best used as a guide to inform decisions within a wider strategic assessment which is sophisticated enough to include environment, society, economy and the relationships between them. This form of analysis is very challenging and attempts are being made to move this direction in the UK through the Natural Capital Committee and National Ecosystems Assessment Follow-On Asset Check.

Because CBA is based on values which occur in markets (or hypothetical markets) it does not have any method of informing decisions for changes which a market cannot value. This means that irreversible loss of unique ancient forest (for example) requires engagement with decision making approaches, and ethical discussion, outside of CBA.

Cities are dependent upon, and embedded in their environment

In cities green infrastructure is often seen as useful additional infrastructure. This sees the city as the whole and green infrastructure as some natural or semi-natural spaces that supply valuable, but not essential additional benefits. Just like the economic assumptions, this is backwards. Cities are embedded in, and dependent upon the wider environment. Energy is produced outside the city and brought in. Food, timber and other materials are brought in and wastes discharged. The ecosystem services outside the city control its temperature and risk of flooding. People travel out regularly to experience more natural environments. Understood properly therefore green infrastructure planning is about the relationship of cities to the environment the city sits within.

Much of the focus on green infrastructure is on ecosystem services which cannot easily be provided at a distance. Shade, wind speed reduction, noise reduction, local flood risk reduction and the attractiveness of the local area all need to be provided at point of consumption. But well-planned green infrastructure can also go a long way to reducing the cities' demand on the external environment. To give some examples, naturally cooled buildings reduce energy demand and the amount of heat dissipated into the city, urban parks reduce the need for people to travel to the countryside, and natural water filtration can reduce the amount of urban pollutants entering the watercourses. These properties of green infrastructure will be important for the twenty-first century as a rapidly urbanizing world tries to reduce its carbon emissions and deal with rising energy costs and climate change.

Some features of green infrastructure can be understood and managed effectively as individual assets. For example, individual green roofs and street trees, although obviously their context is important to their effectiveness. Other aspects of green infrastructure however, such as its impact on water, active travel routes and wildlife habitat, require it to be understood as a network. This network of green infrastructure can provide services significantly greater than individual patches. For example New York has strategically purchased land in its watershed to ensure a supply of clean water to the city. The integrity and spatial configuration of the green infrastructure around its source rivers are crucial to the outcome. Successful green infrastructure planning means connecting our green and blue spaces into networks and increasing the complexity of the ecosystems they hold. This 'systems approach' to green infrastructure poses significant challenges to economic analysis, which has a tendency to reductionism. This makes very careful consideration of the green infrastructure change under discussion important.

Conclusion

Gross Domestic Product growth or maximising the size of the market is the dominant decision making framework in many countries. This leads to the prioritisation of market benefits over non-market benefits. In urban areas this could mean the prioritisation of housing, leisure or office development over green infrastructure. In rural areas it can mean the prioritisation of provisioning services, such as food or timber production, over regulating and cultural services. Government and

the third sector take action to deliver welfare improvements which will not be delivered by the market alone. In urban areas this might be the delivery of green infrastructure, in rural areas it might be protecting land for its natural beauty or managing to reduce flood risk.

Sometimes this action, which would not have been delivered by the market, can nevertheless be justified in terms of making the market more secure or growing it. For example flood management which reduces the flood risk in a town centre. In these cases green infrastructure can be justified using Economic Impact Assessment. There are other examples, however, where action by government and the third sector is welfare increasing, but precisely because the benefit is not delivered through the market, it cannot be justified using Economic Impact Assessment, but can be justified using CBA. The effective use of Economic Impact Assessment and CBA is therefore important to improve decision making and lead to better welfare outcomes. The ability to include the benefits provided by the environment in both decision making frameworks has increased dramatically in recent years, and is likely to continue to do so. This improved evidence provides an opportunity for improved decision making.

However, there is a significant academic literature of the weaknesses of both Economic Impact Assessment and CBA. Three major limitations need highlighting here. First, because CBA can include benefits only if people can imagine them being delivered by the market, some of the more subtle benefits about mental health or relationships with others are very difficult to capture. Second, because neo-classical economics treats the environment as specific elements of detail to be included into a market based analysis it cannot express the dependency of the market on the environment and therefore capture the 'sustainability value' of environmental improvements. Third, Economic Impact Assessment and CBA are inherently conservative tools. They implicitly assume that the status quo is either good or inevitable and seek to make the case for marginal changes. However, the current situation in terms of the growing negative human impact on the planet requires non-marginal changes in how cities are built and function. Green infrastructure improvements may in some cases be better justified by this broader systems perspective than by Economic Impact Assessment and CBA.

Further information

Natural England evidence publications can be downloaded from the publications and products catalogue: **http://publications.naturalengland.org.uk/**. For information on Natural England evidence publications contact the Natural England Enquiry Service on 0845 600 3078 or e-mail **enquiries@naturalengland.org.uk**.

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Box 4.1 Glossary

- **Benefit:** Something beneficial to welfare, which features on the positive side of a cost: benefit analysis.
- **Cost:** Something detrimental to welfare, which features on the negative side of a cost: benefit analysis.
- **Cost Benefit Analysis (CBA):** A formal method of assessing the desirability of a project, routed in neo-classical economic theory.
- **Cost Effectiveness Analysis:** An assessment of the cost of meeting a pre-determined target through a particular project or programme.
- **Economic Impact Assessment (EIA**): An assessment of the impact of a project on the size of the economy in a spatial area.
- **Externalities:** Effects of a transaction on a third party (someone not buying or selling). These can be positive, in the case of garden trees, and negative, in the case of air pollution.
- **Market:** The system of free exchange - providing goods, services and labour in exchange for currency.
- **Market Failure:** The failure of a market to deliver the optimal outcome, with income distribution as a given.
- **Non-market goods and services:** Goods and services which are of value to people, but which are provided outside the market. This may be by the state, by community, by family or by nature directly.
- **Public Goods:** Goods that everyone can benefit from, and therefore for which it is impossible to charge. These will not be provided by the market and so must be delivered by other actors - primarily the state
- **Valuation:** The process of eliciting the value placed by the public on particular goods and services and/or the process of applying the public's values to particular projects and programmes.
- **Value:** The importance of a good or service to someone, relative to other goods and services, as a proportion of the income. Normally expressed in currency.
- **Value Transfer:** The inference of the value of a cost or benefit at a policy site based on studies done on another site previously.
- **Welfare:** The level of utility (happiness or contentment) achieved through the consumption of market and non-market goods and services.
- **Willingness-to-pay:** The amount of money someone would be willing to pay to receive a new or improved good or service.
- **Willingness-to-accept:** The amount of compensation someone would be willing to accept to forgo a good or service or to receive one of lower quality

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