3 Valuing the Environment: Concepts

In this chapter, we are going to consider:

- What 'economic value' means.
- In what ways the environment has economic value.
- How economic values might be measured.
- How measures of the economic value of the environment can help society make better decisions, particularly through cost–benefit analysis.

In the next chapter, empirical methods for measuring environmental values will be explained.

3.1 What Does Economic Value Mean?

Economics is often described as the study of how to allocate limited resources in the face of unlimited wants. The fact that resources are scarce means that using up resources in one way prevents us from using them in another way. The cost of these forgone uses is called an *opportunity cost*, defined as the best alternative use forgone. This concept is very relevant to the environment: using a river for waste disposal has an opportunity cost of lost recreation and wildlife benefits. Designating a mountain area as a national park means that we forgo mineral extraction opportunities. In other words, deciding to use the environment in one way entails a sacrifice, namely the benefits we could have gained by using it in another other way. Environmental policy may also imply non-environmental sacrifices: for example, the decision to impose an energy tax to reduce carbon dioxide emissions may mean that poor households forgo significant consumption possibilities (Sterner, 2011). However, if society decides to go ahead with the tax, then a judgement must have been made, either explicitly or implicitly, that the benefits of reduced emissions are 'worth it', in the sense that they justify the costs.

The idea that the value of something is dependent on what we are willing to give up to have it is a key economic principle. But how should we express what is being given up? In the preceding example, poor households could be giving up a significant proportion of their consumption goods. In the case of preserving a mountain area from mineral extraction, the profits from extraction could also have funded a wide variety of forms of consumption. One approach, therefore, is to take the most general measure of what is being sacrificed, namely *income*. The simplest way to see this is by considering an example. Suppose that poor households were asked whether they would support a local tax on petrol and diesel fuel used by cars and lorries, with the objective of improving air quality in their city. One way of putting this question would be to ask if their willingness to pay (to give up income) for the air quality improvement was higher than the cost to them of the tax.

An important point to note here is that a *change* in environmental quality is being valued, not the *total* environment. Economic value really only has any meaning when it is defined over a change; that is, when it is measured with regard to more or less of a good or service being provided. The change could be 'marginal', in the sense of a relatively small change in the amount or level of environmental service (e.g. a 5% reduction in current ambient particulate levels in a city), or 'non-marginal', such as the total loss of a forest or the draining of a wetland. Willingness to pay (WTP)—or, more exactly, *maximum* willingness to pay—would, in this case, measure the benefits to people of a beneficial change in environmental quality. For instance, for a prospective increase in air quality, the WTP is the most income that an individual would give up to have the improvement in air quality. The logic here revolves around rationality: no one would be willing to give up more for a change than it is worth to them, in whatever way they were to derive value (utility) from this change. An objection that could be made is that if WTP is used as a measure of value to an individual, then this measure depends not just on their preferences (how much they dislike air pollution, relative to their likes or dislikes of other things) but also on their income. A rich household, with the same preferences, could clearly afford to pay more than a poor household. Economic values based on WTP would therefore always be biased in favour of the rich. Economists usually answer 'Yes, that's right. But willingness to pay is a pretty useless concept unless backed up by ability to pay. At the level of the economy as a whole, we clearly cannot give up more than we actually have or expect to earn.' Economic value, as measured by WTP, is thus a function of the existing income distribution, and may change as this distribution changes. If preferences differ, then people with similar amounts of income will be willing to pay different amounts for the same change in environmental quality. For example, if Joe is more concerned about urban air pollution problems because his kids suffer from asthma, but Josephine has no kids, then if their incomes are equal, Joe's WTP for a given improvement in air quality may well be higher than Josephine's.

To recap, given that resources are scarce, using them in one way implies an opportunity cost. The value of a particular resource use can be measured in terms of the sacrifice that people are willing to make to have it. At the most general level, this sacrifice is in terms of income, so therefore WTP makes sense as a measure of economic value to the individual. However, we have to accept that this measure is sensitive to changes in the distribution of income.

An alternative measure of economic value exists, based on the same principles of scarcity. This involves asking what compensation an individual would accept to give something up. This is a very familiar idea in everyday life. For example, the value you place on your favourite guitar is equal to the *minimum* you would accept to go without it (to sell it), which we can call your minimum 'willingness to accept compensation' (WTA). For workers, the value of their working time is measurable by the minimum hourly wage they would accept to work. This compensation-for-loss concept of value can also be extended to environmental resources. The value you place on your garden could be estimated by the minimum compensation you would accept to sell it to your neighbour. Similarly, the value of peace and quiet could be thought of as the minimum compensation you would demand to agree to a new airport runway being constructed near to your house.

The question of whether we use WTP or WTA as the basis for valuation matters. According to a famous paper by Robert Willig (1976), the differences between WTP and WTA for most goods should be small, and should depend on the relationship between income and demand, and on how much of a person's income is spent on the good. However, experimental findings in economics have revealed quite large differences between WTP and WTA that seem to violate this finding. Competing explanations have emerged for this disparity. The first, based on work by Michael Hanemann (1991), shows that the difference is explicable in terms of how close a substitute exists for a commodity. For example, if we were to compare WTP with WTA for tickets for two ice hockey games, one of which was also being televised live, we might expect the difference between WTP and WTA to be smaller for the game that people could watch live on TV instead of only being able to watch it live at the stadium. If there are no close substitutes, then we could expect quite large differences between WTP and WTA, whereas if close substitutes exist, then WTP and WTA should not be that different. The second explanation is rooted in behavioural psychology, in the concept of loss aversion. This concept suggests that people systematically value what they already have more highly than that which they could acquire, so that losses are always valued more highly than equivalent gains. Experimental economics has also shown that differences between WTP and WTA can be much reduced as people gain experience in trading in a good, although such experience can be hard to gain for many environmental goods. This relates to a third possible explanation for the disparity, namely that people are unsure about their preferences (Loomes et al., 2003).

It seems likely, therefore, that important choices will often have to be made by economists between measuring WTP or WTA. Such choices can be based around the concept of property rights. If people have a moral, legal, or assumed right to a good, we would ask them about their WTA for a reduction in that good, not their WTP to prevent this reduction. If, instead, people have no right to an increase in a good, then it is reasonable to ask for their WTP for an increase, rather than their WTA to forgo such an increase.

To summarize, if an increase in an environmental good is being valued, we can try to measure either what people's maximum WTP is to have this increase, or what their minimum WTA is to forgo this increase. If a reduction in the same good is being valued, we can try to uncover either their maximum WTP to prevent such a reduction, or their minimum WTA to tolerate it. Either approach allows a monetary value to be placed on an environmental gain or loss, which is an estimate of the underlying utility gain or loss for an individual.

But how might WTP vary for that person for different amounts of an environmental good being offered? Imagine an experiment in which an individual is asked about his or her maximum WTP for a succession of increases in an environmental good. For one such person, Gavin, we might get results such as are shown in Figure 3.1(a). As the quantity of the

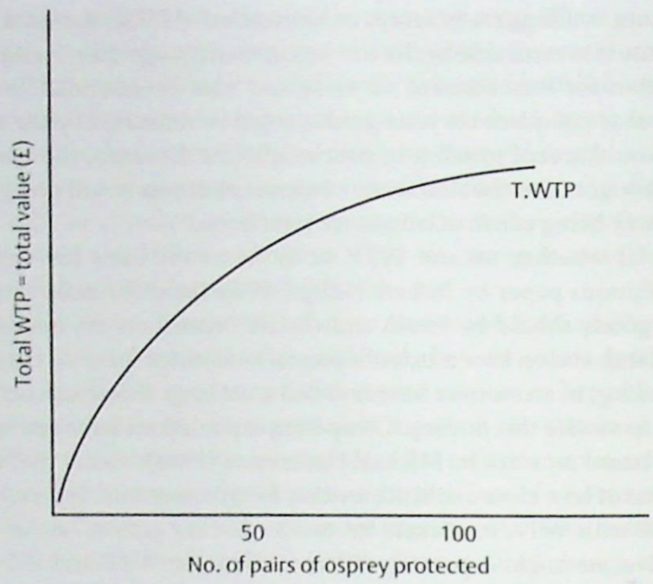

Figure 3.1(a) WTP for wildlife protection.

good rises (as an example, we might consider pairs of ospreys protected in Scotland), Gavin's total WTP increases: for example, he is willing to pay more to protect 100 pairs than for fifty pairs, since, as a birdwatcher, his utility is higher for 100 pairs than for fifty. Note that as the number of pairs 'offered' continues to increase, his total WTP (the total value to him of ospreys) increases at a decreasing rate. Transforming Figure 3.1(a) into a marginal WTP curve—by measuring the increase in total WTP as the number of pairs, Q, rises—we get Figure 3.1(b), which shows marginal WTP decreasing but always positive[1] (no satiation is setting in, so that utility always goes up as consumption rises). Marginal WTP declines as *Q* rises due to diminishing marginal utility. Figure 3.1(c) shows Gavin's marginal WTP curve, which we now term a marginal value curve, MV^G, since it indeed shows the value at the margin to him of increasing numbers of ospreys. His friend Kitty is also a birdwatcher, who likes ospreys even more: her marginal value curve, MV^K, thus lies above Gavin's at every point (we assume, for simplicity, that Gavin and Kitty have equal incomes). Drawing MV curves as smooth and continuously decreasing is a theoretical assumption that makes the analysis easier, but that may not be borne out in reality. However, the assumption of declining marginal utility does seem to be well supported by a large amount of evidence from economic research.

Figure 3.2 shows the derivation of WTP and WTA for an individual who is offered an increase in environmental quality from Q_0 to Q_1. This diagram shows utility as being a function of two things: environmental quality, Q, and income, Y. The curves U_0 and U_1 are *indifference curves*. These have the property that along a given indifference curve, utility is constant. Indifference curves are shaped the way they are drawn as we assume diminishing

[1] Marginal WTP for any value of Q, say Q*, is equal to the slope of the total WTP curve at Q*. It is the partial derivative of total WTP with respect to Q, evaluated at Q*.

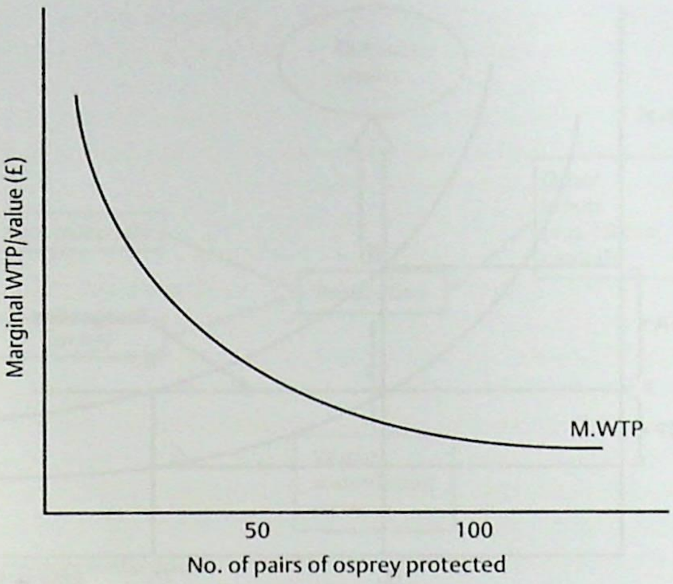

Figure 3.1(b) Marginal WTP for wildlife protection.

marginal utility, as in Figures 3.1: as we move along a particular indifference curve, the additional amount of one good we are willing to give up to have more and more of another good is falling, since the extra utility from having more of something declines as we consume more and more of that thing. The further an indifference curve is away from the origin, the higher is the level of utility, thus U_1 is greater than U_0. We start at point a, with an income of y and an environmental quality of Q_0. Now suppose that the environmental

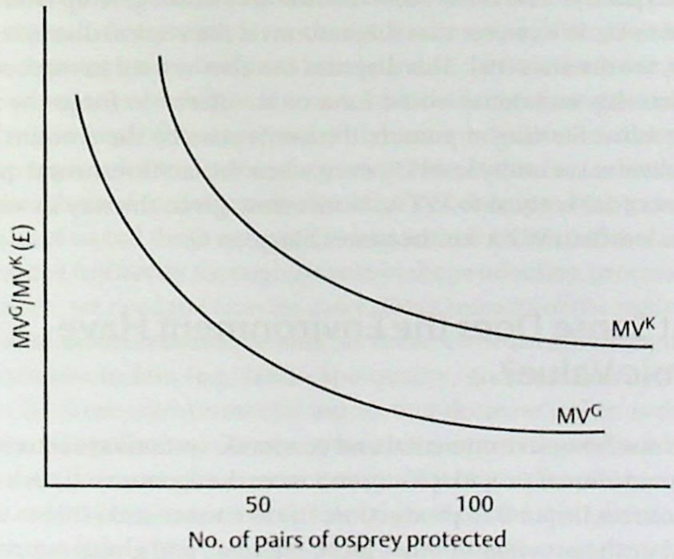

Figure 3.1(c) Marginal WTP for two people.

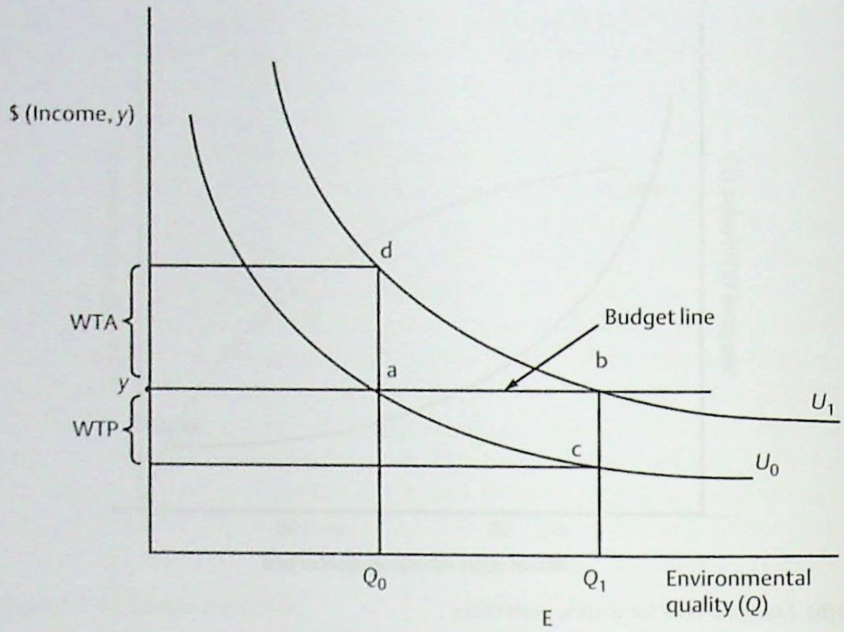

Figure 3.2 Indifference curves and the value of an increase in environmental quality.

Note. Environmental quality increases from Q_0 to Q_1. This increases consumer utility from U_0 to U_1 along their fixed budget line, moving the consumer from point a to point b. This also implies that consumers have a maximum willingness to pay of WTP. Alternatively, they would be willing to accept compensation of WTA to forgo an improvement in environmental benefits. Note that WTA is greater than WTP.

quality increases to Q_1. With the same income, the individual moves to point b, on a higher indifference curve. They are thus better off. What is their maximum WTP for this increase in environmental quality? This is the most income they could give up from point a and still have utility equal to U_0. We can see that this amount is the vertical distance labelled WTP in the figure; that is, the distance (bc). This diagram can also be used to work out the minimum compensation that this individual would have to be offered to forgo the improvement in environmental quality. Starting at point b, if income rises by the amount shown as WTA, this keeps the individual at utility level U_1, even when the environmental quality stays at Q_0. Thus the difference (da) is equal to WTA. Notice that, given the way in which the diagram is drawn, WTP is less than WTA for the same change in Q.

3.2 In What Sense Does the Environment Have Economic Value?

In Chapter 1, we saw how environmental and economic systems are interlinked. Figure 1.1 shows that the environment provides four services to the economy: (i) as a source of energy and material resources (inputs) to production; (ii) as a waste sink; (iii) as a direct source of amenity; and (iv) as the provider of other local, regional, and global support services, such as nutrient cycling and climate regulation. Services (i), (ii), and (iv) can be grouped together

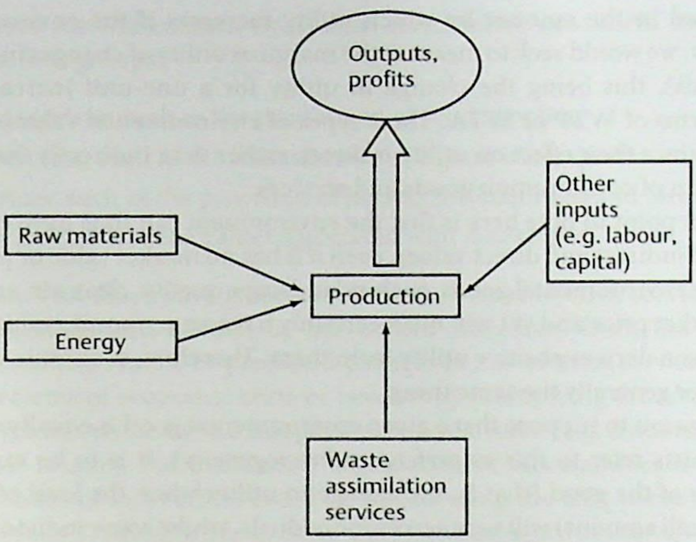

Figure 3.3 Indirect environmental values.

as they both provide inputs to the production process, of raw materials, energy, nutrients, and waste disposal services. Climate change may also impact on production; for example, in agriculture. Figure 3.3 shows these inputs, combined with other inputs such as labour and capital, producing goods and services for sale in markets. For example, inputs of bauxite, energy, and waste assimilation capabilities allow the production of aluminium. One monetary value of each unit of output is its price. The value of a *change* in the level of environmental and resource inputs to the production of any good might thus be approximated by the value of the change in profits due to this change in environmental service flows or inputs. The values of the environment in roles (i) or (ii) or (iv) above can thus be partly determined as the change in the value of profits for a change in the value of environmental inputs: in other words, if bauxite inputs are reduced by one tonne, what is the value of the associated profit decrease? For waste assimilation services, essentially the same question could again be asked: What is the loss in profits associated with a unit reduction in emissions? This marginal productivity approach for determining environmental values is essentially no different from the approach used to determine the value of other inputs to production, such as labour and capital. Let us call these types of environmental values *indirect benefits*, since the environment is valued indirectly through its role in the production process.

For amenity values, we need to consider more direct impacts of the environment on utility. We can speak of environmental 'goods' as those environmental inputs of which the individual prefers more to less (e.g. landscape quality, good air quality). Environmental 'bads' would then be those environmental inputs that decrease utility as they increase: for example, noise or water pollution. Clearly, some environmental goods and bads are mirror images of each other; for example, river water quality (a good) and river water pollution (a bad). The economic value of any environmental good can be thought of as the increase in utility if that environmental input is increased by a given amount; or the reduction in utility if the quantity and/or quality of that good is decreased. Similarly, for an environmental bad, we are interested in the amount by which utility increases if the environmental bad is reduced. Ideally, we would seek to measure the marginal utility of changes in environmental goods (and bads), this being the change in utility for a one-unit increase in the good expressed in terms of WTP or WTA. These types of environmental values could be called *direct* benefits, since their effect on utility is direct, rather than indirectly through their role in the production of consumption goods and services.

An important point to note here is that the environment can thus have economic value, in terms of both indirect and direct values, even if it has no market value or price. For example, many of the environmental goods, such as landscape quality, clean air, and wildlife, may have a zero market price and yet will most certainly have an economic value, provided that at least one person derives positive utility from them. Therefore, economic values and market prices are *not* generally the same thing.

There is no reason to suppose that a given environmental good is equally valuable to everyone (economists refer to this as *preference heterogeneity*). It is to be expected that the marginal utility of the good (that is, the change in utility when the level of the good itself changes by a small amount) will vary across individuals, whilst some individuals may derive no utility at all from some environmental resources. For example, if Joe is completely uninterested in birdwatching, then an increase in his local population of curlews may well have zero value to him. If his neighbour Jane is a keen ornithologist, then her marginal utility for this same increase may be very high. This means that these two people would have different WTP amounts for a given change in bird populations.

As shown in Figure 1.1, the economic process benefits from the many support services provided by the natural environment, such as global climate regulation, the maintenance of a global atmospheric chemistry suitable for sustaining life, the stratospheric ozone layer, and local nutrient and hydrological cycles. It is possible to think about the value of preventing changes in these services. For example, the value of preventing further changes in the global climate through enhanced warming could be measured by looking at the costs (and benefits) that would result from a given change in greenhouse gas emissions. Chapter 9 considers this in detail. As another example, reductions in the stratospheric ozone layer could be valued by estimating the economic costs of an increased incidence of skin cancer.

A recent way of thinking about these links between the environment and the economy is the idea of *ecosystem services*. This conceptualization of the value of conserving or enhancing ecosystems is most associated with the Millennium Ecosystem Assessment.[2] More recently, the National Ecosystem Assessment (NEA) exercise in the United Kingdom[3] has shown the links between the state of different ecosystems (in the UK) and the economic values that flow from the services generated by these ecosystems (see the UK NEA). In this world view, ecosystems are thought of as capital assets (Barbier, 2009) generating a flow of valuable services (economic goods). The conservation of ecosystems can then be described as investment, since it enables the flow of ecosystem services and their associated goods to be protected into the future. Ecosystems depreciate when their ability to supply people with useful services is reduced; for example, if a wetland is drained, or a coastal mangrove forest converted into a shrimp farm.

[2] See http://www.millenniumassessment.org/en/index.aspx.

[3] See http://uknea.unep-wcmc.org.

Following from the Millennium Ecosystem Assessment, ecosystem services are often categorized into four groups:

- Provisioning services, such as the production of food supplies
- Regulating services, such as the maintenance of a good water quality
- Support services, such as the provision of habitat for mammals and birds
- Cultural services, such as the values associated with landscapes

Table 3.1 shows an illustrative categorization of some ecosystem service flows for one ecosystem (moorlands and heaths) in the United Kingdom, from the UK's National Ecosystem Assessment. Actual or predicted changes in any of these service flows can then be expressed in terms of economic costs or benefits by multiplying the actual or predicted change in ecosystem service by the marginal economic value (e.g. from market prices, or from some other source). For instance, if degradation of moorland leads to a net loss of carbon, these tonnes of lost carbon could be valued using the CO_2 permit price from the European Emissions Trading Scheme, since this is one measure of the value of each tonne of carbon sequestered. If moorland loss also means a decline in water quality downstream

Table 3.1 Some of the ecosystem service flows from moorlands and heaths

Provisioning services	Food provision—livestock and crops:
	• Livestock products from sheep and some beef cattle
	Food provision—deer and game birds:
	• Wild harvest products, including venison and grouse meat
	Fibre from sheep wool
	Traditional lifestyle products, including honey and whisky
	Peat extraction for fuel and horticultural use
	Freshwater provision for domestic and industrial use
	Alternative energy provision:
	• Opportunity for wind energy schemes
	• Generation of water flows for hydro-energy in freshwater habitats
Regulating services	Climate regulation:
	• Carbon storage; maintenance of plant and soil C stores
	• Carbon sequestration potential
	Natural hazard regulation:
	• Potential for flood risk mitigation
	• Opportunities for wildfire risk mitigation
	Pollution mitigation:
	• Interception and retention of airborne pollutants by plants and soil
	• Regulation of particulate matter and pH buffering
	• Dilution by water from uplands of pollutants in downstream locations
	Disease regulation:
	• Disease transmission through ticks
	• Disease regulation of waterborne bacteria (e.g. *Cryptosporidia*)

Source: Van der Wal et al. (2011).