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Environmental valuation methods in SIDS

Chapter 9

Introduction

Clear and accurate valuation is fundamental to the design of economically efficient environmental policy. Around the world, environmental valuation is mainly used for:

- The preliminary investigation of environmental problems – getting a rough picture of policy options that might be worth exploring further.
- Cost-benefit analysis – detailed assessment of the benefits and costs of a particular policy option.
- Cost-efficiency analysis – finding the most efficient method for reaching a set target such as reducing flood risk or eliminating pesticide poisoning.
- Ex-post appraisal – examining whether, in retrospect the right decision was made and the correct values were estimated for costs and benefits.

In the last twenty years or so, economic valuation of the environment has become a small industry in its own right with a large number of associated texts and manuals. Bateman et al. (2002) offers an overview of stated preference methods in valuation, while van Breukering et al. (2007) shows how the methods can be applied in SIDS.

In this chapter we provide a brief overview of valuation techniques, provide case studies and examine some particular issues of concern to SIDS. Most of the basic principles of valuation apply to most economies, but there are three features that are especially pertinent for SIDS and we shall return to them in what follows:

1. Economic risk tends to be higher in SIDS compared to other kinds of economies.
2. Beneficiaries – for many SIDS tourists are an important source of income, but also important potential beneficiaries from environmental improvement.
3. Ecological risk, which as for economic risk is often higher in SIDS, compared to non-island states.

Certain kinds of environmental problems emerge more frequently on small islands. Compared to many larger countries, air quality tends to be less of a problem because of atmospheric mixing and prevailing winds. On the other hand, water quality may be particularly problematic, and, because island economies are often heavily dependent on the sea for livelihoods, the quality of surrounding water is important. Many low-lying SIDS are also at high risk from sea-level rise that is predicted to accompany global warming. Finally, the smallness of habitats may make the maintenance of biodiversity particularly difficult.

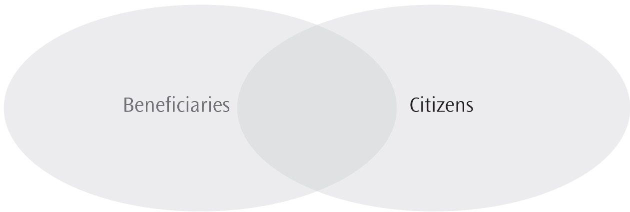
The special features of SIDS

There are some typical features of SIDS that are unusual in the context of valuation. These concern: the stakeholders, the economic risk and the ecological risk.

The Stakeholders

In a standard cost-benefit problem all the costs and benefits accumulate within one community. So the set of potential beneficiaries and the set of people who must bear the cost of a project are the same. With tourism projects the situation is slightly different. In Figure 9.1 we show the typical picture in SIDS, where the set of beneficiaries from a tourism-related project is not the same as the set of people who bear the costs (the citizens), although the sets overlap.

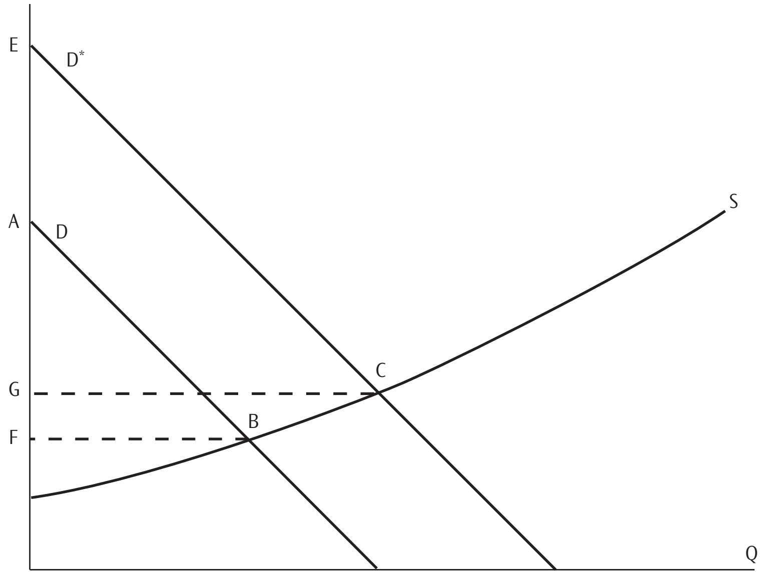
Figure 9.1. Beneficiaries and citizens



For example, the major beneficiaries of better coral reefs might well be visitors rather than citizens. If one was doing cost-benefit analysis from a global view point then the benefits to visitors would be included in the calculation of the project's viability. But typically that is not the case. Because cost-benefit analysis (CBA) is done from the perspective of the host nation, it is a local CBA. In these circumstances, benefits to visitors only count to the extent that these are captured by citizens. So, if the hotel facing the improved coral reef can raise its occupancy rate or increase room rates, then these benefits will accrue to the home nation and should be counted in. Additionally, some projects may generate non-use values for people who have no intention of visiting. Non-use values are derived from the pleasure individuals obtain simply by knowing something exists, even if they have no interest in visiting or experiencing it. There is plenty of evidence of non-use values both within and without countries. Citizens of the USA are apparently willing to pay to improve visibility around the Grand Canyon even if they will never visit it. It is conceivable that for rare and charismatic species, exotic habitats or unique environments many individuals around the world would be willing to pay something, but unless these payments can be collected by the state then they are irrelevant for the local CBA.

Figure 9.2 illustrates the situation where an improvement in environmental quality raises demand for visits to an island from D to D^*. We suppose that accommodation is supplied competitively and that S represents the appropriate supply curve. The total benefits from the improvement are ABCE, but only the increased profits to local suppliers – the area FBCG – can be included in a local CBA. This is potentially much smaller than ABCE.

Figure 9.2. Cost-benefit analysis with non-resident beneficiaries



It is worth adding an important point. Sometimes cost-benefit analysis is done as part of a case for development aid. In this situation it is appropriate to calculate the benefits to visitors and non-nationals that are not captured locally as these external benefits may be relevant to the funding agency. A topical example is that of Clean Development Mechanism (CDM) under the Kyoto protocol, which offers the opportunity for one of the richer countries that have signed up to the protocol to reduce their emissions by replacing carbon emissions in another country. Many SIDS are highly dependent on fossil fuels for their electricity generation and so projects of this kind represent opportunities for greater diversity in fuel sourcing as well as producing reductions in greenhouse gases. Table 9.1 illustrates this.

The final point concerns the dangers of double counting. Suppose we ask visitors their willingness to pay for improvements to water supply for an island where drinking water is sometimes risky or unreliable. We also find the extra profits local businesses would make from visitors if the supply improved. It is tempting to add these two sets of numbers, but some of the extra profits would come from the visitors' payments. Adding them would be counting the same benefits twice. There are a number of ways of dealing with the problem. The simplest is to subtract from the total the increased profits made.

Table 9.1. Inclusion of benefits in a SIDS valuation exercise

	Benefits to local citizens	**Benefits to visitors**	**Non-user benefits for non-citizens**
For Local CBA	Yes	The fraction that is captured locally	No
For development aid or global CBA	Yes	Yes	Yes

Note: Double counting needs to be avoided.

Economic risk

Although there is an extensive theoretical literature on cost-benefit analysis within a risky environment, in practice most valuation exercises concentrate on expected benefits and costs. The underlying justification for this approach is that projects are typically small compared to the size of the economy and their failure or success will not make a major dent in overall GDP. Yet, we noted in the introduction that the second potentially distinctive feature of SIDS is that their smallness often implies a lack of both ecological and economic robustness in the face of shocks. Markets may be thin; the economy may be overly reliable on a single crop or trade and its trade may be concentrated on only a few partners (Briguglio, 1995). In these circumstances, when a project is large compared to the size of the economy it can be appropriate to consider the consequences of failure (or indeed, success).

Failure may arise through two different sources:

- The anticipated benefits may fail to arise. For instance improvements to coastal water quality may fail to attract new tourist business if there is an economic downturn in key markets.
- Costs may be higher than anticipated, if, for instance, the project is financed through loans on the world market and global interest rates rise. If the project is financed through taxation, a drop in agricultural production (and associated taxes) may make the opportunity cost of funds higher.

Against this, the benefits may be higher than anticipated and the costs may be lower. This potential variability in outcomes represents economic risk[1].

Risk can be incorporated into a valuation in two stages. In the descriptive part of the enterprise, the possible outcomes can be identified and the benefits and costs in each outcome assessed. Incorporating risk into the actual valuation is more problematic. Van Breukering et al., 2007, note that 'The main approach to dealing with risk in a decision framework is to consider the expected value of alternative options'. But this can be inappropriate when the risk is high. The traditional alternative is to raise the discount rate used for the project appraisal. In this way future benefits are discounted more heavily, because they are less than certain to occur and the reasonable assumption is made that individuals are averse to risk. One problem with this method is that it also discounts future costs more heavily, when their riskiness means that we may wish to attach a greater weight to them. An alternative approach is to use explicitly a utility function for the assessment of benefits and costs that reflects aversion to risk. For instance in the Stern Report (2007) on climate change, the authors use the following function:

$$U = \frac{c^{1-\eta}}{1-\eta}$$

In this expression, U is utility, c is per capita consumption and η (the Greek letter, 'eta') is a measure of aversion to risk. Larger values of η represent greater aversion to risk. When $\eta = 1$, we have a special case in which $U = \ln(c)$, where ln is the natural log. The Stern report argues that $\eta = 1$ is in fact a reasonable value.

Ecological risk

Ecological risk matters for valuation because variance and uncertainty in the performance of the environment can affect the economy and the well-being of citizens. As with economic risk, ecological risk tends to be higher in small islands primarily because of their size, which can make the various habitats less resilient in the face of shocks. Also, there is a high proportion of endemism – species found only in one location. According to the FAO See: http://www.fao.org/forestry/sids/4786/en/, in Mauritius, Haiti, and Jamaica over 30 per cent of higher plant species are endemic, while over 25 per cent of mammals are endemic in the Solomon Islands, Fiji and Mauritius. Ecological sites are also likely to be linked, so that for instance poor solid waste management may damage river courses and onshore fisheries and reefs. The small size of islands also means that they face risks from being overrun by invasive species.

When there is ecological or economic risk to which individuals are averse, then they will be willing to sacrifice some resources in order to reduce such risk. For instance, suppose on an island subject to the risk of hurricanes, mangroves are removed in order to establish prawn farms and beach amenities. There is a 50 per cent chance of a storm year. In a storm-free year the value of these activities is US$1m, but damage and disruption means that in a storm year the benefits are only $0.4m. It is proposed to rebuild the mangroves and also provide coastal forests to reduce the damage from storms. Some inshore fisheries are then more productive and the forest will yield crops. Overall, the forest and mangroves reduce storm damage but also eliminate the benefits of storm-free year, so that the benefits are always $0.7m per year. If one just considers the expected outcome of the two options, they are the same: $0.7m, but the afforestation and re-establishment of the mangrove involves lower risk, so a risk-averse person will be willing to pay something to achieve it.

To sum up, risk reduction projects can be important in SIDS, so it is equally important to treat risk and changes in risk in any economic valuation. Using expected values is common but it can ignore a significant rationale for a project that is being considered.

Valuation methods in practice

Valuation methods in practice include the following:

1. Pricing methods
2. Revealed preference methods
3. Stated preference methods

Pricing methods

The primary advantages of pricing methods are that they:

- **i** often are more comprehensible to policy-makers, compared to stated preference;
- **ii** frequently use existing data; and
- **iii** they are possibly more robust than some valuation methods, if only because they are the result of actual choices, often made repeatedly by experienced consumers.

The major disadvantages are that:

i typically, they provide only incomplete measures of value;
ii more specifically, they typically underestimate values; and
iii they are poor at estimating the benefits of innovations and of completely new goods or programmes.

The main pricing methods are as follows.

- **Opportunity costs**

In the opportunity cost approach we examine what value would have to be foregone in order to, say, create or enhance a particular environmental asset.

- **Costs of alternatives**

One evaluation strategy is to calculate the cost of using some alternative resource. For instance, Costanza et al., (1989) undertake an assessment of the economic use value of a coastal wetland in Louisiana (see Table 9.2). To do this, they first identify the flow of ecological services from the wetland. For some of these services, such as commercial fishing, there is information available on the value-added of the existing industry. For storm protection, there is no such market information, so they consider instead the costs of building an equally effective man-made defence system. They argue that this underestimates the true value of storm protection, though it is the nature of the cost-of-alternatives approach that in practice a man-made barrier might well be an overestimate of the value. As can be seen from Table 9.2, storm protection is the largest contributor to the value of the wetland.

Table 9.2. Economic use values for the functions of a Louisiana wetland

Source of value	Valuation ($/acre)
Commercial fishery	400
Fur trapping	190
Recreation	57
Storm protection	2,400
Total	3,047

Source: Costanza et al. (1989)

- **Mitigation costs**

Mitigation costs are the prices which individuals pay in order to avoid or reduce environmental impacts. A family might buy bottled water or use a purifier when tap water is potentially harmful due to contamination. It is well known that the value to the family of safe water is less than the cost of mitigation (if it were not, then they would not be buying the bottled water or the purifier). We do not know what they would be willing to pay. So as with the costs of alternatives we can take it that the mitigation costs underestimate values. When mitigation is partial – for instance double glazing that lowers noise from a nearby airfield, but does not eliminate the nuisance – then we can conclude that the marginal value of the mitigation is equal to its marginal cost, but we still do not know the total value of the amenity.

- **Shadow project costs**

Another 'pricing' option is to look at the costs of providing an equal alternative environmental good elsewhere. For instance, suppose a new airport access road and runway extension destroys a wetland. One way to price the lost resource is to calculate the costs of building a new wetland elsewhere. This is often difficult to do because mangroves take years to grow and so the ecological value of the new site will not be realised for some time.

- **The Dose-response method**

The dose-response or production-function method is popular for evaluating health impacts of poor quality air and water and for assessing the benefits of policies to improve public health. In its most common form there are two parts to the method:

a linking differing levels of pollution (the 'dose') to differing levels of damage (the 'response'); and
b giving a monetary evaluation by multiplying this damage by the market price per unit.

For example, consider a study of the benefits of improving air quality in several large Brazilian cities conducted by Seroa da Motta and Mendes (1993). The study begins with an econometric analysis of the relationship between air pollution and mortality rates in Sao Paulo. In the first stage of the analysis, regression analyses were conducted relating death rates from respiratory diseases to air quality, social and economic, and meteorological variables. The relationship is then used in an analysis of the health care costs associated with air pollution in Sao Paulo and in two other major Brazilian cities (Rio de Janeiro and Cubatao). Five pollutants are included in the analysis: inhalable particulate matter (PM_{10}), carbon monoxide (CO), Ozone (O^3), Sulphur dioxide (SO^2), and nitrogen dioxide (NO^2). The main results suggest:

- an increase of 10 $\mu g/m^3$ of inhalable particulate matter implies an average increase in the mortality rate from respiratory diseases of 1.6 per cent;
- a drop in the PM_{10} concentration from 89 $\mu g/m^3$ to the primary standard of 50 $\mu g/m^3$ would reduce the mortality rate from respiratory disease by about 6 per cent; and
- mortality rates from respiratory diseases were related to concentrations of carbon monoxide, ozone and nitrogen and dioxide.

In the second part of the analysis, values were estimated for deaths and illnesses associated with poor quality air. The authors used health costs as a measure of costs. As with the other pricing methods, the assumption is that this is an underestimate – that these costs were incurred because the anticipated benefits were as least as large. Table 9.3 summarises some of the estimates.

Table 9.3. Hospital costs per death and total hospital costs due to air pollution, by city

City (year)	Deaths associated with air pollution	Hospital costs per death	Total
Sao Paulo (1989)	139	5,647	785,000
Rio de Janeiro (1984)	40	3,775	151,000
Cubatao (1988)	139	4,896	142,000

Source: Seroa and Mendes. (1993)

A key problem with this approach is that values that are elicited can be highly sensitive to the pricing measure. Moreover, these prices can be highly inaccurate. Suppose for instance that sufferers from air pollution died quickly without receiving much medical care. Then the method would suggest that costs of pollution are low.

In most studies involving health risks, different types of measures are used. A common approach is the human capital approach which estimates the earnings lost as a consequence of poor health. By the standards of the human capital measure, medical costs are usually a poor measure of the value of life. Krupnick, (1991), for instance, shows that the human capital cost of chronic bronchitis is around 40 times the estimated medical cost. In passing, it is also worth noting that the human capital approach is often criticised. For instance, it places a zero price on the life of someone who is retired. More generally, it fails to include all the benefits from health that are not picked up through higher earnings and for many individuals these benefits are significant. Many societies therefore use contingent valuation to estimate the benefits from reductions in health risk.

Usefulness of revealed preference methods

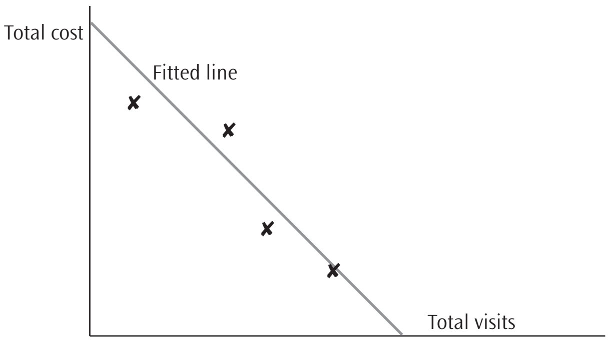
Revealed preference methods value environmental assets by observing purchases of market-priced goods, which are necessary to enjoy the environmental good in question.

- **Travel cost**

Individuals can reveal the value they place upon a good by the amount of time and other resources they are willing to devote to its consumption. For instance, Susie takes a trip to Mauritius. If the cost of her flight is £1,000 then we know she is willing to pay at least that amount to see Mauritius. This is the basis of the travel cost method. Suppose there were four equal-sized countries that supply tourists. The total cost for someone visiting from country i would be the monetary costs of the visit (m_i) plus the time costs (expressed in £) or, $m_i + t_i w$

where t_i is the time spent travelling from the ith country and w represents the opportunity cost of time. Let us imagine that for the four countries, the percentage of the population and total costs visiting Mauritius are (0.1, 1000), (0.06, 1500), (0.04, 2000) and (0.02, 3000). Note that as the costs rise, the number of visitors dwindle. Essentially, these are observations on a demand curve and we can plot them then use regression to discover a line of best fit (see Figure 9.3 where the crosses represent observations).

Figure 9.3. Estimating demand from travel cost data



If country sizes differ then adjustments must be made and we would also want to gather data on the age, sex, and income of all visitors to control for these variables in the estimation procedure. In the absence of individual-level data we might have to use country-level data, though that would limit the information that is obtained from the regression.

The method yields an estimate of consumer surplus, but it omits non-use benefits. For instance, many people might have no intention of visiting Mauritius, but they might place some value on the existence of high quality coral reefs. A second major problem with the travel cost method is that we need to have an estimate of the opportunity cost of time. We might argue that most visitors are on annual holiday so that the time spent in travelling would not normally be used for work. In this case we would still need to have some estimate of the value of the leisure time lost by sitting for many hours in a plane.

A third problem is that typically individuals travel for more than one reason. For some, the coral reefs are the only reason for their visit. For others who like sun, but not the sea, the quality of sea water may play only a small part in their decision. So, the analysis has to apportion the benefits of the trip between its different purposes, only some of which will be relevant to the project or problem being valued. For instance, in a study by Cesar et al. (2002) of the value of reefs around Hawaii, the authors obtain travel cost data for visitors coming from mainland USA. By using economy-class air ticket prices they estimate the basic travel costs for each group. To get an estimate of the total travel costs they assume that the opportunity cost of time equals 1/3 of the wage rate for visitors. To get a feel for the importance of the reefs to the visitors they include a question about its relative importance compared to the other reasons for visiting and attribute costs on that basis.

- **Hedonic pricing**

Rooms with a sea view cost more per night than those without; detached bungalows cost more than semi-detached or hotel rooms; and rooms with a balcony fetch a higher price than those without. In each case, the value placed on the amenity (a sea view, no shared walls, a balcony) is revealed by supply and demand. The method can sometimes be extended to deal with environmental amenities such as noise and air pollution. Rooms in hotels neighbouring an airport generally rent at a discount to identical buildings away from the flight path. The value that people place on quiet can be revealed by the choices they make. Hedonic pricing can therefore be used to value resources and features appreciated by visitors. By using house prices or house rents, it can also be used to value environmental features appreciated by the local population.

The problem with the hedonic pricing method is that other factors affect land prices, including many that are not environmental. Disentangling factors like this is difficult when the sample size is small in comparison to the number of factors, and in particular when factors are correlated across the sample[2]. For instance houses close to the shore face a higher risk of flood damage, but at the same time often benefit from a better view compared to houses inland. Hedonic pricing may be used in this instance to place a value on living close to the sea, but not its separate components, higher flood risk and a better view.

Applications of stated preference approaches

As we have just stressed, with many amenities it is not possible to use revealed preference methods. Instead, we have to rely on individuals answering hypothetical questions designed to reveal the value they would place on the good if it was marketed. In environmental economics in particular, this *contingent valuation* (CV) technique, though controversial, is widely employed. Similar methods are employed to evaluate safety improvements and in healthcare. There are a variety of difficulties with the CV technique, which call for caution in using its results. Nevertheless, its use is spreading and manuals for its use by government officials are now widely available (e.g. Bateman et al., 2002). One reason it is used is because non-use aspects of valuation cannot be estimated in any other way. Because there is no behaviour associated with non-use value, its level cannot be estimated using revealed preference methods. Often charismatic species or famous world monuments have this feature, so stated preference can be particularly important for rare or precious environmental features such as coral reefs or, for example, the Easter Island statues.

With stated preference methods, individuals may often have incentives to misrepresent their preferences for collective goods. Someone who is asked: 'what are you willing to pay for cleaner beaches?', but who is then told that they would not actually have to pay anything would have an incentive to overstate their valuation. Similarly, if asked the same question, but told that they would have to pay, then there would be an incentive to free-ride on other people. The problem is known as *strategic bias*.

The most commonly used method of eliciting values is an alternative technique known as *dichotomous choice*. Respondents are simply asked 'are you willing to pay x?', with x varied over the sample, and a bid curve[3] is estimated. The procedure is similar to that employed in the travel cost method, though the demand curve estimated is compensated rather than Marshallian.

While the dichotomous choice technique overcomes the problems of strategic bias in CV responses, a number of other problems remain, two of which we will consider here. The first is the tendency for individuals to give similar willingness to pay (WTP) figures for a large project (e.g. 'save endangered species') and its component parts (e.g. 'save the whale'). Known as part–whole bias or the embedding problem, its presence in a survey may require careful interpretation:

- It may be that the marginal utility of the amenity declines rapidly, so that it truly is the case that the value of the larger project is only slightly higher than that for its components.
- It may be that the survey does not actually elicit the values of the parts and the whole. Instead, the people doing the survey treat it as a hypothetical exercise where they are given the opportunity to advertise their altruism. They may then feel a 'warm glow' from saying 'yes' to the key questions. Since answering 'yes' to any bid value would yield the same 'glow', then the aggregate results suggest that the component and the whole are valued more or less equally.
- It may be that individuals truly do not have coherent preferences for the good in question and are guided by the suggestions of value embedded in the questionnaire.

It is important to be able to distinguish between these answers. Good surveys test subjects' understanding of the problem and probe their ability to formulate realistic answers. Some surveys therefore include 'cheap talk' reminders to participants of the possibility of 'warm glow' answers. It is also common to ask the same individual to value both the smaller good and the larger good and it is also common to split the sample so that the order in which the two are presented varies randomly. In this way, we can see both if the values for the part and whole differ for each individual, but also we can check to see if it is the first bid value that determines subjects' answers.

The possibility that the first bid value determines subsequent figures is known as 'starting point bias' – an example of *anchoring*, where subjects with uncertain values for the good respond to the numbers given to them. Anchoring has been demonstrated in a variety of circumstances, many of them quite unrelated to valuation. The many settings where anchoring has been found include guessing solutions to multiplication problems and the estimation of the number of African countries in the United Nations. In these tasks, subjects have to say whether the correct answer is above or below a value suggested by the experimenter. A classic example is provided Ariely et al., (2003), who asked students for the last two digits of their US social security number and discovered that it was correlated with their reservation prices for a number of unfamiliar goods. In other words, the higher the person's social security number, the bigger the value they tended to attached to the goods. When anchoring occurs in valuation, it calls into question the validity of the whole contingent valuation exercise because it suggests that individuals do not have well-formulated preferences. Instead, it suggests that they construct values and valuations based on the information they encounter – even if that information is actually irrelevant.

So, as with part–whole bias, it is important for researchers to test for anchoring in the data. And, if the data does show evidence of anchoring, then it must be viewed as less reliable for potential decision-makers.

Recently, economists have realised the value of having more structural data about preferences including, for example, whether people are willing to pay for better waste management. Methods from marketing and consumer psychology have been adopted resulting in what are known as *choice experiments*. In a choice experiment the attributes of the good are varied. Consider, for instance, possible improvement to a town's waste management scheme. Perhaps currently there is a problem with run off from a land fill site into a river after heavy rains and problems of flies and vermin during hot weather and smell when the wind is in a certain direction. We can assume different levels of investment into reducing the problem and different ways of tackling the issue. We can also assume that people in the town may have different priorities for the different aspects of the scheme. Subjects would face a series of questions like the one shown in Table 9.4, which just happens to have three alternatives. The values of the attributes would change between questions and a discrete choice model used to estimate the utility function for participants.

As an example, Beharry and Scarpa (2007) used a choice experiment to examine preferences for coastal management amongst visitors in Tobago. Among the attributes included

Table 9.4. A choice of experiment question

	Option A (no change)	Option B	Option C
Local tax, per month per household	No change	$1 more	$2 more
Days of run off into local river, per year	30	20	20
Days of flies per year	25	20	25
Days of smell per year	50	50	25
Choose one	☐	☐	☐

in the design were: visibility, probability of gaining infection during swimming, numbers of fish and the establishment of a marine park. They found that visitors were willing to pay a small sum (around US$1) towards the establishment of a park that restricted fishing rights, but twice this amount for improvements to water visibility and $6 per visitor for reductions in the probability of an ear infection.

To sum up, choice experiments therefore provide more information about the shape of the utility function. As such, compared to traditional contingent valuation techniques, the decision-maker can evaluate more options at once using the same survey. However, it can be easy to overwhelm subjects with information. Moreover, issues of part–whole bias and anchoring do not disappear when choice experiments are used. Though these new methods have been tested much less than traditional methods of estimating benefits, there is no particular reason why they should not have many of the same defects.

Conclusion

Fundamentally, economic valuation of the environment in SIDS involves the same kinds of techniques are as used in other countries. However, risk is probably more important in SIDS than in many other countries. In addition, the high dependence of many SIDS on tourism means that the pool of beneficiaries from an environmental management initiative needs to be examined carefully before a valuation study is undertaken.

Further reading

Hanley and Spash (1993) is slightly old but is still a good introduction to valuation of the environment. For an up-to-date manual on stated preference techniques, Bateman et al. (2002) is recommended and widely used. Brander et al. (2007), applies many of the ideas to SIDS and has many interesting examples.

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Notes

1 In everyday life, risk usually means the risk of the downside, of failure or disaster. In economics, risk means variability. For instance consider the possibility of a volcanic eruption, like the one which devastated much of Montserrat in 1995. This is undoubtedly a negative event. As the probability of an eruption rises from zero, the expected impact rises. The riskiness of the event can be measured here by its variance, which rises until the probability equals 0.5 then falls again. When volcanic eruption is certain, there is no risk.

2 The market for land used for hotels and that used for other purposes will typically be closely linked. Thus a comprehensive hedonic price analysis of an environmental amenity in an area where there are many tourist developments can be potentially complex.

3 A bid curve shows the proportion of the population who state they are willing to pay x for different levels of y. The area under the bid curve is then the mean willingness to pay. See Hanley and Spash (1993) for more details.