enHEALTH

Guidelines for Economic Evaluation of Environmental Health Planning and Assessment

Volume 1 – The Guidelines

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Preface

Launched in 1999, the National Environmental Health Strategy was developed to enhance national environmental health management through a framework drawn from the range of issues that encompass environmental health. The strategy identifies the following key areas for improving environmental health in Australia: strategic management, capacity building, and improving practice. Under the area of strategic management, the strategy identifies the need to bring together environmental and health economic techniques to develop a new paradigm for environmental health economics.

A workshop was convened on 10 April 2000 to investigate and discuss the application of economic evaluation methodologies to environmental health planning. Following the workshop, the enHealth Council agreed that development of guidelines for environmental health economic evaluation was a priority. These guidelines are the product of that initiative.

These *Guidelines for Economic Evaluation of Environmental Health Planning and Assessment* describe the method of economic evaluation and its application to environmental health policy issues. They consist of two volumes:

Volume 1 describes the major principles and practices of economic evaluation with special reference to environmental health issues.

Volume 2 describes four studies that illustrate the application of economic evaluation methods to environmental health issues:

- Safety fencing of swimming pools, NSW.
- Water quality in Wallis Lake, NSW.
- Control of Legionnaires' disease in Victoria.
- Control of sulfur dioxide emissions in Mount Isa, Queensland.

The *Guidelines for Economic Evaluation of Environmental Health Planning and Assessment* are prepared for environmental health policy makers and others who work with environmental health issues. This includes environmental policy makers, epidemiologists, urban planners, engineers and allied health professionals. Economists are expected to consult the Guidelines when they undertake environmental health economic evaluations.

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- Mr Jim Dodds
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- Ms Sophie Dwyer
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- Professor Brian Oldenburg
  Queensland University of Technology.
- Dr Thomas Tenkate
  Queensland Health (Project Manager).
- Mr Brian Harrison
  Commonwealth Department of Health and Ageing, provided substantial technical advice on health economics.

List of Abbreviations

CBA	Cost-benefit analysis
CEA	Cost-effectiveness analysis
COI	Cost of illness
CUA	Cost-utility analysis
CV	Contingent valuation
DALY	Disability adjusted life year
HRQL	Health related quality of life
NPV	Net present value
NSB	Net social benefit
QALY	Quality adjusted life year
QoL	Quality of life
SC	Stated choice
VOLY	Value of a life year
VOSL	Value of statistical life
WHO	World Health Organisation
WTA	Willingness to accept
WTP	Willingness to pay

Contents of Volume 1

Summary

The *Guidelines for Economic Evaluation of Environmental Health Planning and Assessment* describe the method of economic evaluation and its application to environmental health policy issues. A full economic evaluation compares the estimated benefits and costs of any action based on the principle that individual values matter and can be quantified. Economic evaluations are required because resources are scarce and choices have to be made about the use of resources.

Environmental health practice is concerned with all impacts of the environment on human health. The method of economic evaluation has general application and could be applied to many public policy decision questions. In deriving guidelines for the specific application to environmental health issues, the process of economic evaluation presented here draws also on environmental economics and health economics.

An economic evaluation has some core components. These include identifying the issues to be resolved, identifying the major options, expressing the costs and benefits as far as possible in monetary units, weighting these costs and benefits to allow for their timing, and estimating an overall net social benefit (which may be positive or negative). Economic evaluations should also assess the risks (that is, uncertainty of outcomes, or possible barriers to implementation) and the distributional impacts of policies (that is, the effects of policies on different groups in the community, eg, low/high income earners).

However, most policy issues have particular features and, as the case studies in Volume 2 illustrate, an economic evaluation has to be customised to meet particular policy development objectives. This means that the economic analyst should understand not only the method of economic evaluation, but also the reasons for it.

Other users of economic evaluations should be familiar with the core common concepts and be satisfied that these concepts have been followed.

Following the introductory chapter, the Guidelines contain six further chapters on:

- The process of economic evaluation;
- An overview of cost-benefit analysis;
- Alternative methods of economic evaluation;
- Estimating benefits;
- Estimating costs; and
- The relationship between economic analysis and policy making.

The main points from these chapters are summarised below.

Annexes discuss the nature of environmental health issues, briefly discuss some technical issues associated with discounting and valuation principles, and describe resources for use in economic evaluations.

The Process of Economic Evaluation

A full economic evaluation consists of the nine main steps shown in Box S.1. Some of these steps (identifying the issues and the policy options) are standard evaluation procedures and common to most evaluation techniques. Other steps, notably the valuation of costs and benefits, discounting to account for the timing of benefits and costs, and the estimate of the overall value of a policy or project, are particular to economic evaluation. The development of a baseline scenario is also important because all costs and benefits must be compared with a firm alternative. An economic evaluation should also assess the risk and equity implications of policies.

Box S.1 Main steps in a full economic evaluation

1. Identify the issues and objectives
2. Establish the baseline scenario
3. Develop policy, program and/or project options
4. Identify incremental impacts: costs and benefits
5. Quantify / value the costs and benefits
6. Estimate the overall value of project or policy
7. Test the effects of program risks
8. Consider equity and distributional issues
9. Prepare report

Cost-Benefit Analysis

A full economic evaluation is a cost-benefit analysis (CBA). CBA is the most comprehensive form of economic evaluation. In principle, all costs and benefits over the expected life of a project or policy are included in the evaluation. The project life is the period over which costs and benefits are expected to be significant.

Using CBA, if the estimated total benefit of a policy exceeds the total cost, there is said to be a *net social benefit*. The total value of goods and services in society, including the value of health and other non-market goods, increases.

In CBA, benefits and costs are valued as the individuals gaining the benefits or bearing the costs would themselves value the benefits and costs. To determine these values, the analyst estimates what people are willing to pay for goods, including non-market goods and health, and what firms would be willing to pay for the resources that are used to produce these goods.

Most people prefer present to future consumption, Also, if capital is spent for one purpose, the return in alternative use is foregone. To allow for timing, future costs and benefits are discounted. For environmental health policies, a discount rate of 5 per cent is used, with sensitivity tests ranging from 3 to 7 per cent.

Many costs and benefits are uncertain. In order to show policy makers the possible range of outcomes, the analyst should provide sensitivity tests that show how the estimated net social benefit changes with changes in key assumptions.

Other Methods of Economic Evaluation

Other methods of economic evaluation include cost-effective analysis, cost-utility analysis, and financial analysis.

Cost-effectiveness analysis (CEA) shows the cost of achieving a given output. This may show a policy maker the lowest cost way to achieve an objective. However, CEA does not show whether the output justifies the costs and it cannot deal with a policy that produces multiple effects.

Cost-utility attempts to overcome the limitations of a single output measure by valuing different health states in utility terms. This method avoids

the difficulties associated with putting money values directly on health. However this does not help policy makers when they have to trade off various costs and benefits as is often the case.

Financial analysis assesses the net revenues of particular parties, which is often a concern to government. However, this is not a complete social evaluation method.

CBA is recommended whenever possible. The other methods are essentially partial forms of CBA. However, one or other of these evaluation methods may be useful when a full CBA is difficult, notably when key benefits cannot be easily valued in monetary terms or health outcomes are the only relevant measure of benefit.

Estimating Benefits

The assessment of benefits is a multi-disciplinary process, which involves:

- Identifying potentially affected benefit categories;
- Quantifying the significant physical effects on the environment;
- Quantifying the health impacts of these changes;
- Estimating how these physical changes affect human production and consumption;
- Estimating the values of the effects on people.

Economists are responsible primarily for the fourth and fifth components, but should be involved in all parts of the process so as to ensure that data collection is well focussed.

An environmental improvement brings *health benefits* to four main groups:

- persons who would have been ill in the absence of the improvement;
- government, which saves health treatment costs;
- third parties, including employers, family and carers of patients; and
- third party payers, mainly insurance companies whose payouts are reduced.

These groups receive some or all of the following benefits:

- Cost savings;
- Gains in output and income;
- The value of health gains (life expectancy and quality of life);
- Quality of life gains for third parties.

Estimates of cost savings and estimates of the net revenue gains of increased output are fairly straightforward exercises. On the other hand, quality of life gains for third parties are difficult to estimate and often ignored.

There is a great deal of work on methods to value life and health. Because policies usually reduce the risk of death for many individuals, the value of life is generally described as the value of a statistical life (VOSL). The loss of health was measured traditionally with simple indicators such as restricted activity days. More recently it is measured in equivalent quality adjusted life years (QALYs) that take into account the various features of morbidities.

There has been little work on VOSL in Australia. Drawing mainly on international research, it is recommended that a value of $2.5 million be adopted for VOSL in environmental health studies in Australia. Development of an appropriate value for VOSL in Australia is now considered a priority.

Morbidity costs can be derived from the estimated value of a healthy life year (VOLY). With a discount rate of 5 per cent, a VOSL implies a VOLY of about $150,000. A quality of life index (QoL) for a health state then provides an estimate of morbidity. For example, a QoL of 0.8 (out of 1.0) would indicate a morbidity cost of $30,000 (equal to 0.2 x $150,000).

Alternatively, estimates of health costs can draw on international studies of the cost of various morbidities, based on stated preference surveys. When using transferred values, the values should be adjusted for income differences. There is a need to develop Australian values of health states.

Many policies or projects have several impacts, including *productivity* and *amenity* benefits as well as health benefits. There are several valuation

methods. For example, productivity gains can usually be estimated from market data on earnings. Valuation of amenity gains often requires an indirect market valuation or a non-market valuation technique. Valuing amenity from property prices is an indirect market valuation. Alternatively surveys may be used to elicit individual valuations of amenity.

Estimating Costs

Environmental regulations may impose costs on private firms, government, consumers and third parties.

Typically a regulation requires firms to install and operate new pollution control equipment or to change their production process. Firms may also reduce output or relocate operations. The costs of complying with regulations are generally based on the assumption that output does not change. The cost to a firm of reduced output or relocated production is the loss of net revenue. Also, workers may lose wages and consumers lose some benefits when output falls.

Government may incur costs in providing public infrastructure or environmental protection services, for example waste treatment services. It may also incur regulatory costs in monitoring, administering and enforcing new regulations.

Both firms and government may pass on their increased costs to consumers. These costs should not be counted twice.

Some environmental regulations fall directly on consumers and require consumers to change their behaviour. The welfare cost of a regulation is the amount that people would pay to repeal the regulations.

Regulations may also affect third parties that are not directly involved in the production or consumption of the regulated activity. Firms may lose some producer surplus or individuals may lose some consumer surplus.

Economic Analysis in Policy Making

Economic evaluation is intended to assist decision making through the presentation and analysis of information. In order to be effective, economic analysis should be part of the whole policy development process.

A CBA seeks to find the policy that maximises net social benefit. This maximises the aggregate value of goods available to the community, including the value of non-marketed goods.

Although economic evaluations often focus on single number, such as net present value, to be credible and influential, reports should describe clearly and fully important data sources, references, assumptions used and their justifications.

As far as possible, an economic evaluation should value policy impacts in monetary terms and should describe the major components of total cost and benefit. This helps policy makers to compare the various elements of cost and benefit.

The economic evaluation should also present the non-quantified effects of policy options and an analysis of the sensitivity of the results to plausible variations in the variables.

However, policy changes nearly always have an adverse effect on some people, which is of concern to policy makers. Economic analysts should generally provide an analysis of the distributional effects of policy changes or, if it is the case, show that the policy change does not have an adverse impact on poorer groups in the community.

1

Introduction to Guidelines

1.1 Introduction

These *Guidelines for Economic Evaluation of Environmental Health Planning and Assessment* (hereafter referred to simply as the Guidelines) describe the method of economic evaluation and its application to environmental health policy issues.

Environmental health practice is that part of public health practice concerned with removing negative impacts and increasing the positive effects of the natural and man-made environments on human health. Much of the work is about environmental management where there are accepted links to human health and disease states. The method of economic evaluation has general application and could be applied to many public policy decision questions. In deriving guidelines for the specific application to environmental health issues, the process of economic evaluation presented here draws also on the specialised fields of environmental economics and health economics.

Environmental health economic evaluations are required because environmental conditions are critical to the health, well–being and sustainability of the community, and, while large amounts of public and private resources are used to create and maintain environment conducive to good human health it is important that these resources are used efficiently. The Guidelines are required because the method of economic evaluation is not widely understood, and, for environmental health applications, both health and environmental economics need to be integrated into the general method of economic evaluation.

The Guidelines are prepared for environmental health policy makers and others who work with environmental health issues so that they may engage constructively with economic analysts in planning and carrying out an economic evaluation. Those who may seek an economic evaluation include environmental policy makers, epidemiologists, urban planners, engineers and allied health professionals. Economists may consult the Guidelines when they undertake environmental health economic evaluations.

In this introduction, Section 1.2 outlines the nature of environmental health issues and some economic implications. Section 1.3 introduces the method of economic evaluation and alternative forms of an economic evaluation. Sections 1.4 and 1.5 describe the use of economic evaluation and the relationship between economic evaluation and environmental health assessment. The final section indicates how the Guidelines may be used.

1.2 The Nature of Environmental Health Problems

In the *National Environmental Health Strategy* (1999), the enHealth Council defines environmental health as ‘those aspects of human health determined by physical, chemical, biological and social factors in the environment’. The focus is generally on the impacts of the physical environment on health. However, it is not always easy or appropriate to separate the physical, social and psychological aspects of environmental conditions.

The World Health Organization (WHO, 2000) provides a useful framework for discussing environmental health issues, which these Guidelines follow.

- Water, hygiene and sanitation
- Air quality
- Food safety and food standards
- Climate change and ozone depletion
- Vector borne disease control
- Occupational safety and health
- Waste disposal and contaminated land
- Noise pollution
- Housing conditions and the built environment
- Ecosystems and other impacts

Annex A provides a fuller description of these environmental health issues. It lists the many ways in which a degraded environment can cause illness. Water and air pollution, inefficient waste disposal, poor food hygiene, vector borne disease and poor housing conditions are major causes of poor health.

A degraded environment can cause not only ill health, but also other major problems, notably losses of production and amenity. In order to evaluate a policy that improves or sustains the environment, all benefits of environmental improvements should be taken into account. Box 1.1 describes some of the benefits from improved water quality in Wallis Lake (NSW).

However, it is not sufficient to establish a general case for environmental improvement. To evaluate a proposed environmental health policy, the particular circumstances of each situation, the specific benefits to be achieved, and the specific costs incurred should be taken into account.

Box 1.1 Multiple impacts of environment: Wallis Lake case study

In early 1997, pollution of oysters in Wallis Lake resulted in 422 cases of hepatitis A. Many people were hospitalised and an elderly man died. The cause, which was the leakage of human sewage into the lake, had multiple impacts. In addition to the morbidity effects, the water pollution resulted in a loss of oyster production, loss of tourism, and some degradation of the ecosystem of the lake.

Wallis Lake water quality policies included investment in sewerage reticulation and treatment and many catchment management regulations. The benefits include health and safety, increased oyster production, increased tourist trade, residential amenity, increased development opportunities, and a sustainable ecosystem. These benefits are described in the case study in Chapter 3, Volume 2.

1.3 What is Economic Evaluation?

Economics is the study of the use of scarce resources to achieve individual or social goals. Economic evaluation compares the benefits gained by using resources in one way with the costs. The costs are the benefits that are foregone. In essence, therefore, an economic evaluation study compares the value of the benefits gained with the value of the benefits lost. In order to compare the benefits and costs of resource use, benefits and costs are expressed, wherever possible, in a common monetary unit (dollars).

If the estimated total benefit of a policy exceeds the total cost, there is a 'net social benefit'. This means that the estimated total value of goods enjoyed by the community, *including non-marketed goods*, will increase. If the benefits exceed the costs, the gains can be redistributed in such a way as to ensure that some people are made better off and no one is made worse off with the policy change. This economic evaluation method is known as cost-benefit analysis (CBA). It may also be thought of as a complete or full economic evaluation.

However, it is not always possible to quantify all impacts in dollar units. Impacts that are hard to quantify are described as 'intangibles'. They may be described qualitatively and presented alongside the cost–benefit result. This approach retains the CBA approach, but recognises that some potentially significant impacts are not quantified.

Alternatively, if a core benefit is hard to quantify, the analyst may employ cost–effectiveness analysis (CEA). CEA shows the cost of achieving a given output. Output is measured in a physical unit, such as lives saved. Costs are shown in dollars. CEA may be useful when there is only one major output (benefit), but is generally less practical when there are multiple outputs.

Cost–utility analysis (CUA) is a form of CEA, but attempts to deal with multiple health outputs of a policy by use of a health index, such as a quality adjusted health year. A health index enables the analyst to value different health states in utility terms. Thus, benefits are measured in terms of the health index. Costs are again measured in dollars.

Table 1.1 summarises these methods of economic evaluation. The most comprehensive method is CBA. CBA is the evaluation method recommended by the Commonwealth Department of Finance (1991) and most state governments, and adopted by most environment departments. CBA is the only evaluation method, described in the state of the art *Guidelines for Preparing Economic Analysis* (US EPA, 2000).

CBA is the recommended method of economic evaluation in these Guidelines and is the method demonstrated in the case studies. CEA and CUA are essentially partial economic evaluations rather than alternative methods of economic analysis. These methods are described further in Chapter 4.

1.4 Why Economic Evaluation is Useful

Policy evaluations are required because resources are scarce and choices have to be made about the use of resources. Resources used for one purpose cannot be used for another. Using resources for one purpose means foregoing the use of these resources for other purposes. Thus, as a community, we want to know what resource use will provide the highest benefit. Alternatively, if more resources are used for one purpose than another, we want to know whether the incremental benefits justify the additional resource use.

Economic evaluation provides a means to compare the benefits of any course of action with the costs, based on the principle that individual preferences matter and can be quantified. Economic analysis is based on the values that individuals place on health and the environment. They are essentially democratic values rather than values imposed by experts. Impacts are valued systematically and consistently. Indeed, benefits and costs are valued in a similar way, based on what individuals are willing to pay for goods gained or goods lost. This consistency minimises bias in decision making.

A full CBA provides a comprehensive framework for assessment of environmental health and other non-market goods. Such a CBA includes, and indeed quantifies, all costs and all health and other impacts of environmental policies. It also allows for the time dimension of environmental impacts. A full CBA also provides data and a framework for estimating the risks associated with environmental policies and for estimating the distribution of costs and benefits.

Economic evaluations can be made for projects, regulations or any kind of public policy initiative. Indeed, the guidelines for regulatory impact statements often require that a cost-benefit test of the public interest be made. The underlying process is the same for all economic evaluations regardless of the type of policy that is being examined: identify those who gain or lose from a

Table 1.1 Economic evaluation methods

Evaluation method	Summary	Measures	Comments
Full cost–benefit analysis	Benefits – costs	All major outputs and costs expressed in dollars	Includes all major impacts
CBA plus intangibles	Benefits – costs and intangibles	Most outputs and costs expressed in dollars; other items described	Often necessary to describe some impacts qualitatively
Cost–effectiveness analysis	Total costs / selected benefit	Costs expressed in dollars; benefit expressed as physical units, eg. life years saved	Output measured in a single common unit Often not practical.
Cost–utility analysis	Total costs / health index	Costs expressed in dollars; benefit expressed as a health index	Allows various health effects to be compared without full monetisation

project, regulation or policy change, and estimate how the persons affected value those gains and losses. In the case studies in Volume 2, the Guidelines illustrate how this process is worked through for regulations and policy changes for water quality protection, for swimming pool safety, and for protection from Legionnaires' disease.

1.5 Economic Evaluation and Environmental Health Assessment

An economic evaluation generally requires forecasts or estimates of the effects of policies on the environment and on health. These estimates are made by technical experts. Valuations of benefits and costs are based on these estimates. An economic evaluation will therefore often draw on inputs from scientific, engineering and epidemiological expertise as well as economic expertise.

The development of an economic evaluation requires a team effort of relevant professionals. An economic evaluation does not contain only economic inputs. In principle, it contains all forms of impacts (material, health, social and environmental), both positive and negative.

However, it is rarely possible to identify or quantify all impacts. Moreover, other professionals often have a clearer idea of the nature of environmental health problems and of possible solutions than do economists. They may also be more aware of the risks associated with alternative policies. An economic evaluation may therefore be viewed as part of a wider evaluation process.

As shown in Figure 1.1, economic analysis is part of the overall process of risk assessment and risk management. A risk assessment typically identifies the nature and magnitude of all the major risks of actions and inaction, considers the technical and scientific issues, and examines the effectiveness of proposed interventions.

Risk assessment is described in more detail in a companion publication by the enHealth Council titled '*Environmental Health Risk Assessment: Guidelines for Assessing Human Health Risks from Environmental Hazards*' (enHealth, 2002).

1.6 Understanding and Using the Guidelines

The Guidelines are designed to explain *the method* of economic evaluation. Volume 1 describes the general method. Volume 2 describes four case studies that illustrate aspects of the Guidelines.

As Volume 1 describes, an economic evaluation has some core components. These include identifying the issues to be resolved, identifying the major option, expressing the costs and benefits as far as possible in monetary units, weighting these costs and benefits to allow for their timing, and estimating an overall net social benefit figure (which may be positive or negative). Many economic evaluations also provide an analysis of the risks and an analysis of distributional impacts. All evaluations should include these core components.

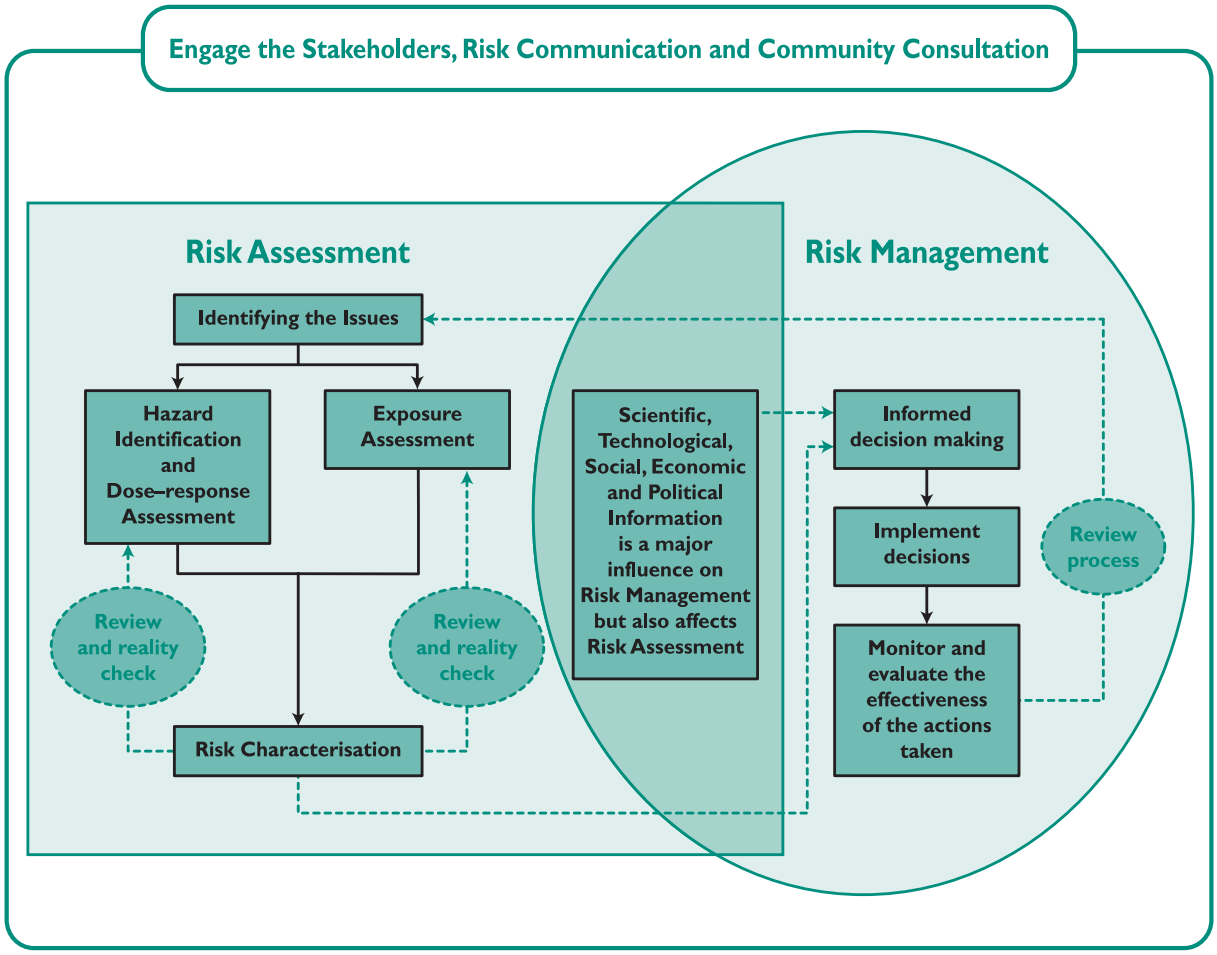
The Guidelines describe the essential features of economic evaluation and how an economic evaluation is made. However, most policy issues have some particular features and, as the four case studies in Volume 2 show, the economic evaluation has to be crafted to resolve these particular issues. Anyone carrying out an economic evaluation needs to understand not only the method of economic evaluation, but also the reasons for it.

Other users of economic evaluations should be familiar with the core common concepts and be satisfied that these concepts have been followed. Chapter 7 identifies some issues to look for in commissioning economic work.

Readers may wish to use the Guidelines in different ways. Readers with little familiarity with economics may find it useful to read the whole text. Readers who are familiar with economic evaluation methods may find it useful to refer to the text on an as needs basis.

Economic evaluation can be, and should be, used by all levels of government. In some cases, all levels of government are involved, as occurred with Wallis Lake. In the case studies of swimming pools safety and Mount Isa Mines, state and local governments were involved. This does not mean that officers from all levels of government or from different disciplinary backgrounds should or will

Figure 1.1 Relationship of risk assessment and risk management



Taken from *Environment Health Risk Assessment – Guidelines for assessing human health risks from environmental hazards* as adapted from P/CCRARM, 1997; Patton, 1998; NRC, 1983

be able to conduct economic evaluations. Where an environmental health policy maker or practitioner identifies the need for an economic evaluation, it is necessary that they work with a person skilled in undertaking them. With the help of these Guidelines policy makers and practitioners will understand the role, key elements of and major issues in economic evaluation.

Like other methods of evaluation, economic evaluation is intended to assist decision making through the presentation and analysis of information. In order to be effective, economic analysis should be an integral part of the whole policy development process. It is intended to inform political decision making, not to substitute for it.

2

The Process of Economic Evaluation

2.1 Overall Process

This chapter describes the process of economic evaluation. As shown in Box 2.1, the process consists of nine main steps, including the report phase. Some of these steps (identifying the problem and the policy options) are standard evaluation procedures and common to most evaluation techniques. Other steps (notably valuing costs and benefits and discounting for time impacts) are particular to economic evaluation.

The following three sections discuss the first three main steps. Section 2.4 briefly outlines the key steps 4 to 8. These tasks are described in more detail in the following chapters. The last two sections provide brief comments on the report and a short summary.

It is important that the process of the economic evaluation is transparent in the final report. This includes the provision of source data, assumptions made and analysis in such a form that results can be replicated, or re-evaluated if changes are considered necessary.

2.2 Identifying the Problem

The starting point of any evaluation should be a **clear statement of the problems** to be addressed and **the objectives** to be achieved.

Identification of the problem(s) to be addressed will generally include a review of:

- the human health problem to be addressed;
- the primary hazards causing the problem and their magnitude;
- the media through which exposures or damages take place;
- the sources responsible for creating the problem;

Box 2.1 Main steps in full economic evaluation

1. Identify the issues and objectives
2. Establish the baseline scenario
3. Develop policy, program and/or project options
4. Identify incremental impacts: costs and benefits
5. Quantify / value the costs and benefits
6. Estimate the overall value of project or policy
7. Test the effects of program risks
8. Consider equity and distributional issues
9. Prepare report

- other environmental impacts due to the degraded environment;
- the improvements that might be achieved by policy change.

Identification of the problem and its causes ensures that policies are properly targeted. Of course, this does not imply that a policy change will necessarily be the preferred outcome. This conclusion has to await a comparison of the expected benefits and costs of any policy change.

Objectives should be defined in terms of specific and measurable outcomes, such as water quality objectives or health status achievements. There should be a clear statement of the numbers of people who may benefit. Projects must be justified ultimately by the delivery of specific services to individuals.

2.3 Establishing the Baseline Scenario

Secondly, the baseline scenario (or base case) must be established. The base case is the existing policies, including control and mitigation measures, and the likely evolution of the environmental problem affecting health without any policy change. This should generally include any changes to which the government is committed. It will also be necessary to forecast the impacts that are likely to occur in the base case.

Establishing the base case and alternative cases is an essential part of evaluation. Each policy option should be evaluated against the same standard, usually the base case or status quo.

Specification of the base case can have a critical impact on the outcome of the evaluation, especially if it represents poor policy and few options are considered for the evaluation. The evaluation project manager has to be wary because when the baseline case is highly unsatisfactory, nearly any policy change is likely to be preferred. A common way to justify a major policy change is to assume the worst about the present. If the base case is clearly unsatisfactory, it is particularly important to generate a range of options, including low cost options.

A broad range of interventions is possible in the practice of environmental health.

Each intervention type may have its own issues in establishing the baseline scenario. For example, work on environmental health infrastructure can be dependent of multiple funders, have multiple service providers and be linked to multiple health outcomes.

For interventions based on legislation, environmental health problems may arise because of weak monitoring and compliance rather than weak environmental regulations. The US EPA (2000) recommends that most analyses of regulations 'should develop baseline and policy scenarios that assume full compliance with existing and newly enacted regulations', because the analysis will then focus directly on the impact of the policy change.

However, this approach assumes that extent of compliance is independent of the regulation or policy change. Also, assuming that the baseline exists with complete compliance may be unrealistic. If an existing baseline with weak compliance or other unsatisfactory attributes is adopted, it is important to generate options that allow for incremental improvements, such as improved compliance, as well as options which represent major policy shifts.

Box 2.2 Establishing the base case

To establish the base case, it is necessary to:

- Identify existing policies (and regulations)
- Identify committed changes in these policies
- Forecast environmental impacts given actual and committed policies
- Forecast impacts on health, economy and amenity
- Review the effects of varying degrees of compliance with policies.

2.4 Establishing Policy Options

A range of options for solving the problem(s) and meeting objectives should be developed early in the evaluation process. These options should generally include low as well as high cost policies.

The easiest, but least robust, way to make the case that a policy or project is desirable is to evaluate only one policy against an inefficient base case and to ignore better options.

There are four main strategies employed in environmental public health programs:

- Investment in public infrastructure and services
- Regulations to prevent specific degradation or behaviour harmful to others
- Incentive, market-oriented, programs
- Public education and community based programs

A more complete description of the range of intervention types in public health (including environmental health) is provided in *A Planning Framework for Public Health Practice* which is available on the National Public Health Partnership website www.nphp.gov.au.

Investment in environmental health infrastructure and services, that is, in engineering and technical interventions, may include refurbishing existing assets, variations in staging investment, demand management, and minor and major capital expenditure options.

Public investment also has many applications. These include protection of water catchments, expenditure on water treatment and reticulation, investment in sewerage reticulation and treatment, the creation of shade areas, investment in drainage systems, the treatment of mosquito breeding on wetlands, investment in waste disposal sites, cleaning up contaminated land, construction of public housing, and slum improvement.

Recently there has been a move towards private provision of public infrastructure services. In Victoria, local governments were required to put environmental health services out to tender under a previous government initiative. However, this has now been modified to a 'best value' approach. As such, much provision of waste removal services has been privatised under contract to local governments.

Regulations take two main forms.[1] Many regulations are *command and control* instruments, prescribing particular design features. Such regulations generally specify through a legal standard the form of technologies or designs, such as the treatment of coal or the height of chimneys. They often impose similar technical requirements on all sources, except for new sources that are subject to higher standards. Standardisation simplifies compliance monitoring. However, it is often a costly way to achieve a desired level of environmental quality. As systems deteriorate and are not maintained, emission standards decline. The design feature may be present but the desired outcome might not be achieved. Also, regulations must be enforced by penalties, usually fines, for breaches of regulations.

Performance-based regulations specify a source's maximum level of emission and allow the source to meet this target in whatever way it chooses. Generally the regulator specifies similar emission standards for all sources, although this is not necessary. This approach allows sources to tailor their methods of production to meet emission control targets in a flexible and least costly way. However, monitoring costs may be higher for firms, which usually have little incentive to reduce emissions below the stated performance target.

Performance-based regulations may also specify certain organisational procedures, often requiring the assessment of public health risk, and establishment and documentation of procedures to mitigate that risk. Examples include food safety programs and radiation safety protection plans.

Environmental health interventions may also include non-regulatory forms of public policy, for examples, guidelines or facilitation of self-regulatory systems.

Incentive, market-oriented approaches to environmental protection use the price system to provide incentives to firms or households to act in an environmentally supportive way. The aim is to ensure that private incentives are aligned with social benefit. Examples follow.

Taxes, fees and charges put a price on pollution and allow each source of pollution (or each firm) to determine its level of emissions. Firms decide the quantity of emissions based on the costs of pollution control on the one hand and the charges from not controlling their emissions on the other. They can choose the least costly method of production and have an incentive to reduce their emissions at all levels of output of emissions.

1 The discussion of regulations and market instruments draws on US EPA (2000).

Subsidies also provide a financial incentive. In this case, firms are rewarded for reducing emissions. This can produce the same outcome as taxes or fees. However, this approach is generally not politically acceptable in a developed country.

With a *tradeable permits system*, government sets the total quantity of emissions allowed and allocates this total among various firms, possibly by auction. Firms can trade permits. Firms with high emissions per unit of output can buy emission permits from firms with low emissions. The trade sets the price.

With *deposit refund schemes*, households pay a deposit when they acquire a good and receive a refund when they return it. Actually, any scheme with a refund is effectively a deposit refund scheme. Such schemes have been applied to tyres, newspapers, plastic and bottles.

Liability rules allow government or victims of pollution to force polluters to pay for the damages that they impose. They are often applied to clean up of hazardous waste sites. Such rules work only if the legal system can deal with disputes in a relatively low cost and expeditious manner.

Community education programs are a fourth environmental health strategy. Public health programs adopt an exhortatory or persuasive approach aimed at creating a social climate to support behavioural and community change, such as not drinking and driving, using sun protection cream, stopping smoking and so on, some with a regulatory component. For example, mass media campaigns promoting good food safety practices to the community have been effective in generating change at the individual level, and raising the profile amongst community organisations. They also have the added benefit of promoting the food safety issue to employers, employees and decision makers in the home, as members of the public.

Food labelling is an example of a public health policy based on informing the public of the contents of various foods. Another example is information about dangerous snakes and insects. Programs to prevent Ross River Virus disease transmitted through mosquito bites may include public information advising people to cover up in various ways or to adopt other prevention policies, as a complementary strategy to mosquito control programs.

Community based health promotion programs have also been effective in achieving environmental health outcomes. Local, multi-strategy community action, as part of a comprehensive Dengue Fever Management Plan (for further information, see WHO Dengue Bulletin, 2002, vol. 26) has been effective in addressing outbreaks of dengue fever in North Queensland. Processes of community engagement have complemented strategies of community education, disease surveillance and house-to-house mosquito control by local and state government environmental health and vector control officers.

Other things being equal, policies that support voluntary behaviour change and competitive markets are generally preferred to regulations that force individuals or firms to change their behaviour involuntarily. However, these policies maybe less effective than more stringent regulatory policies.

Examples of Policy Options

Environmental health interventions that may deal with a range of environmental conditions are shown in Box 2.3. The case studies in Volume 2 also illustrate the range of policies available for some conditions. There are, for instance, numerous possible interventions to improve water quality and ensure fish and oyster safety in Wallis Lake.

In developing policy options, analysts should consider the major features that might affect their costs and effectiveness. Potentially significant features are:

- The standards required – the level of stringency to be applied;
- Tailoring pollution control requirements to allow for geographical differences in environmental effects or source differences in pollution control costs;
- Phasing in policies or expenditures in over time;
- Risk management features.

These key features of policy design may affect the viability of an option relative to the baseline scenario and its ranking relative to other policy options.

Box 2.3 Examples of environmental (and other) health interventions

Type	Environmental health interventions	Other health interventions
Water, hygiene and sanitation	Improve water quality Improve water supply Reduce use of polluted waters Improve sewerage facilities Hygiene education (e.g. hand washing)	Oral rehydration therapy Antibiotics Breastfeeding Safe weaning practices
Food safety and Contents	Improve food production Improve storage and packaging Reduce harmful substances Adequate cooking Hand and surface area washing Increase access to treatment of poisoning	Antibiotics Special diet
Vector-borne Disease control	Environmental manipulation Environmental modification Personal protection Biological control Chemical control	Chemoprophylaxis Vaccination Bed nets Case detection Health education
Waste disposal	Appropriate storage before collection Regular and safe collection Appropriate storage in dump Safe incineration (smoke/water hazards) Well managed landfill	Treatment of ill effects of contact with waste using antibiotics or emergency treatment
Housing Conditions	Safe building materials Ventilation Adequate size	Treatment of ill effects of poor housing, such as mental stress
Air pollution	Reduce use of fuel Reduce harmful substances in human environment Reduce human exposure to harmful air	Emergency treatment Asthma inhalers
Climate change	Reduce emission of greenhouse gases Preventive measures to reduce harmful effects of climate change	Emergency relief
Stratospheric Ozone depletion	Reduce emissions of harmful gases Reduce human exposure to radiation	Treat cancers
Occupational Safety	Reduce harmful exposures and mental stress Improve social environment and job security	Treat illnesses and injuries
Noise pollution	Noise laws and law enforcement Exhaust silencers on cars	Treat illnesses and injuries

Source: WHO, 2000.

2.5 The Process of Economic Evaluation Continued

Identifying and forecasting incremental impacts: After policy options have been established, the main impacts of each option must be identified, forecast and quantified where possible. Note that evaluations of any kind should always deal with marginal or *incremental* impacts. These are the new or additional impacts that occur as a result of a policy change.

Valuing costs and benefits: Policy costs include all incremental capital and operating costs over the life of an option. The costs include adverse impacts on third parties (externalities), for example air pollution or noise effects of road developments. The costs of a policy are the *incremental* costs compared with the base case. Sunk costs should be ignored. Sunk costs are fixed costs that do not vary with a policy or project.

Benefits may accrue to various parties, namely producers, consumers, third parties, or government.

- Producers may obtain increased revenues or lower costs as a result of the project.
- Consumers may receive more or better quality goods or pay lower prices for goods.
- Third parties may gain from an external effect, such as an environmental improvement.
- Government may gain increased operating revenues or increased tax revenues.

Assessing overall project value: After the costs and benefits of a policy have been identified and quantified over the life of the project, they must be compared. A project or policy has life so long as it is causing significant positive or negative impacts. As a matter of convenience, evaluations often assume an end-point beyond which impacts are expected to be insignificant. However, they may also allow for a residual value at that point, which is in effect the value at that point of any future costs and benefits.

In the first case study in Volume 2, dealing with the evaluation of mandatory fencing for swimming pools, the economic evaluation assesses the impacts of fencing swimming pools between 1990 and 2100 as a result of NSW policy on pool fencing. Costs and benefits are estimated in the central case to 2015. The assumption here is that fences have an effective life of about 15 years. However this is a conservative assumption and the evaluation also considered the effects of benefits occurring up to 2030.

When costs and benefits occur at different points in time, they are generally weighted to reflect the preference of individuals for present goods rather than future goods. This means that future costs and benefits are discounted to obtain an equivalent present value.

Dealing with uncertainty and risk: It may not be possible to quantify accurately all impacts of a policy in money terms. For example, some environmental impacts are difficult to quantify. In such cases, a CBA should not only provide the estimated quantified net benefits but also describe the unquantified impacts. Policy makers can then decide how the unquantified factors should be taken into account. In addition, the economic evaluation should show how various risks might affect the overall project value.

Considering distributional implications: The estimated aggregate value of a policy or project shows its value across all individuals without regard to the distribution of costs and benefits. If a policy has adverse equity impacts and compensation is not provided, policy makers are likely to want to consider the distribution of impacts along with the overall benefit. A distributional analysis shows how the costs and benefits are borne by different groups in the community and can complement the aggregate form of analysis.

2.6 Preparation of Report

Preparation of a clear and succinct report is an essential part of an effective evaluation of any kind. If the project is complex and a lengthy report is unavoidable, it should be divided into sections that allow readers to obtain the main points quickly.

The report should contain sufficient information to allow the reader to understand the main arguments, data sources and the data themselves. Thus the basic raw data for the results should be presented in natural (undiscounted) form or be readily available in electronic form.

2.7 Summary

At the start of any evaluation of an environmental health policy, it is necessary to:

- Define the problem and the need in principle for a policy change;
- Establish the baseline scenario;
- Identify the main policy options.

It is important that the proposed policy options deal with the subject issue and that an adequate number of options be considered, especially if the baseline scenario represents a poor outcome.

The four main kinds of strategies for improving environmental health are:

- Investment in public infrastructure and services;
- Regulations to prevent specific degradation or behaviour harmful to others;
- Incentive, market oriented strategies;
- Public education and community based programs.

Within each of these categories, there are usually several main options. Moreover, within these options, there are often important design sub-options with respect to stringency, geographical and point source coverage, timing and risk management features.

As a practical matter, an evaluation must focus on key options. In a complex case, it may be necessary to generate a long list of options, to filter this into a medium list, and to filter this medium list in turn into a short list of options for detailed analysis. At each stage of the process, selection of options should be based on estimated costs and benefits. Initially, these will be order-of-magnitude estimates. As the list of options shortens, the assessment will be based on more accurate estimates of costs and benefits and more detailed analysis.

After policy options have been established, the incremental impacts and the costs and benefits and overall value of each option must be estimated. In addition, risk should be assessed and the distributional implications analysed. These tasks are described in the following chapters.

3

Cost–Benefit Analysis: Core Principles

3.1 Introduction

This chapter outlines the core principles of cost–benefit analysis (CBA). These principles include the concept of net social benefit, the basic principles of valuation, the valuation of benefits and costs arising at different points in time, and the management of risk and uncertainty. Chapters 4, 5 and 6 cover alternative methods of estimating benefits and estimating costs, respectively. The treatment of distributional issues is discussed in Chapter 7. These core principles apply to all forms of cost–benefit analysis. Some limitations of cost-benefit analysis are also described in Chapter 7.

3.2 Net Social Benefit

As described above, a CBA attempts to estimate the overall value, or net social benefit (NSB), of a policy. The NSB is the difference between total benefit and total cost.

Formally a net social benefit exists when, for all impacts (i), the sum of benefits (B) exceed the sum of the costs (C).

$$NSB = \Sigma B_i - \Sigma C_i > 0 \qquad (3.1)$$

A benefit is anything that makes someone better off than in the base case. A cost is anything that makes someone less well off.

Benefits and costs are estimated for all individuals who may be affected by a policy change. As a practical method of estimation, four main social groups can usefully be identified: producers and consumers of the directly affected products, third parties who are not producing or consuming the directly affected service, and government. Thus, Equation (3.1) can be expressed as:

$$NSB = \Sigma(PS + CS + TPE + GR)_i \qquad (3.2)$$

where PS and CS are producer and consumer surpluses respectively (which may be positive of negative), TPE are third party effects, and GR is (the change in) government revenue. If NSB is positive, the aggregate value of goods and services enjoyed by the community will increase.

The NSB can also be reported as a benefit-cost ratio (BCR).[2]

$$BCR = \Sigma B_i / \Sigma C_i \qquad (3.3)$$

In this case, NSB is positive if the BCR > 1. Clearly, if NSB is > 0, the BCR is > 1, and conversely, if NSB < 0, BCR < 1. It might be concluded that the NSB and BCR measures give equivalent results and can be used interchangeably. However, the NSB is an absolute number and the BCR is a ratio and the two measures may rank policies differently. The NSB measure is generally the preferred ranking criterion. However, when an agency has a significant capital budget constraint (more viable projects than it can fund), the BCR is the relevant ranking criterion (Abelson, 2003).

3.3 Basic Principles of Valuation

An important principle of CBA is that benefits and costs are valued as the individuals gaining the benefits or bearing the costs would themselves value the benefits and costs. Economic evaluation uses these individual values, not values imposed by economists or other experts.

2 In many versions of the benefit-cost ratio, the numerator equals net recurrent benefits (benefits less recurrent costs) and the denominator contains only capital costs. This is appropriate if the purpose is to estimate the return to capital expenditure. Because the results are sensitive to the way recurrent costs are dealt with, a consistent approach is important.

In order to estimate the values that people attach to goods, economists rely on the twin concepts of **willingness to pay** and **opportunity cost**.

The value of a good is the maximum amount that someone is willing to pay for it. What someone is willing to pay for a good is a measure of its value to that person because it is a measure of what that person is willing to give up to obtain that good. For example, if a person is willing to give up two apples to gain a peach, the value of the peach to that person is at least two apples. Likewise if a person were to give up $1 for the peach, we would conclude that the value of the peach to that person was at least $1. Note that what someone is willing to pay for a good may be higher than the price he actually pays.

Benefits and costs are symmetrical. The true cost of using a resource is the value of the goods foregone. This is the opportunity cost. For example, the cost of public expenditure on water supply is the value of electricity or roads foregone. The value of resources used to produce some good or service is the maximum amount that firms are willing to pay for these resources in alternative use.

Thus willingness to pay for goods or resources is the central measure of value for both goods obtained and resources used (or goods foregone).[3] Benefits are worth what people are willing to pay for them. The cost of resources used to produce these benefits is measured by what people would be willing to pay for those resources (or the goods they would produce) in alternative use.

Box 3.1 Key valuation principles

- The value of a good is the maximum amount that someone is willing to pay for it. This represents what someone is willing to give up for that good. i.e. it is the opportunity cost.
- The true cost of using a resource is the opportunity cost. The opportunity cost of a resource is its highest value in alternative use. This is the maximum amount that someone else is willing to pay for the resource.

3.4 Discounting: the Value of Costs and Benefits over Time

The impacts of policies occur at different points in time. Generally costs are incurred before benefits are gained. In some cases benefits occur many years later. This raises the issue of whether the timing of benefits and costs matters or not.

Generally, people attach more importance to present benefits and costs than to future ones. Most people prefer an immediate benefit to a deferred one. They also prefer to defer expenditure when they can. These preferences can be allowed for by weighting the benefits and costs, or technically by using a discount rate, that allows for time preferences. The discount rate gives less weight to future costs and benefits than to present ones.

The technique of discounting reduces the flow of benefits and costs to give a **net present value** (NPV). This simply redefines the NSB to allow for the timing of benefits and costs. The NPV is the sum of discounted benefits less discounted costs over the life of the relevant project or program. Because costs reflect the value of whatever benefits the relevant resources could yield in other uses, a positive NPV would justify the program and the larger the NPV the more desirable it would be (ignoring distributional impacts).

The NPV of a projected stream of benefits and costs is found by multiplying the benefits and costs in each year by a time-dependent weight, d_t, and adding the weighted values as follows:

$$NSB = NPV = NB_0 + d_1NB_1 + d_2NB_2 \ldots + d_nNB_n \quad (3.4)$$

where NB is the difference between the benefits and costs (B – C) that accrues in the period t = 1… n years over which the policy effects are felt, and the discounting weights are given by:

$$d_t = 1/(1+r)^t \quad (3.5)$$

where r is the discount rate. Note that the net benefits in Equation (3.4) are assumed to arise at the start of each period, so that the net benefits in the first period are not discounted. Equivalently,

3 When someone loses a good that she previously enjoyed, it may be argued that 'willingness-to-accept' (compensation) values should be instead of 'willingness-to-pay' values. Because the issues are complex, these terms are defined and the issues are discussed in **Annex B**.

$$NSB = NPV = NB_0 + NB_1/(1+r) + NB_2/(1+r)^2 \ldots + NB_n/(1+r)^n \quad (3.6)$$

Again if NSB > 0, the expected total benefit exceeds the total cost.

Note also that the discount rate used is a real discount rate. It does not include any element of inflation. Thus it is different from market interest rates that allow for expected inflation. In CBA, costs and benefits are generally measured in the prices applying at the time of the analysis. This makes it easier to compare costs and benefits that occur at different points in time.

The Choice of Discount Rate

The choice of discount rate can affect the desirability of a policy or project. Suppose that government invests $50 million today for an expected benefit of $100 million in 20 years time. With a discount rate of 3 per cent per annum, the present value of the $100 million is $55 million and the project is worthwhile. With a discount rate of 7 per cent, the present value of $100 million is only $26 million and the project is not worthwhile.

Given that the aim of CBA is to value future consequences of policies as affected persons would, the rate at which individuals are willing to exchange present for future benefits (**the consumer rate of discount**) is often considered the appropriate discount rate. However, to determine this rate, adjustments need to be made for inflation and taxes. Suppose that the market rate of interest is 5 per cent and that the marginal tax rate is 40 per cent, the consumer rate of discount is 3 per cent.[4] This is the rate at which people are willing to defer a marginal amount of present consumption in order to obtain a marginal increase in future consumption.

However a problem arises because the consumer rate of discount is generally lower than the gross pre-tax rate of return on capital. The latter rate is known as the **opportunity cost of capital** or the **producer rate of discount**. In the example above, firms are willing to borrow at a 5 per cent real interest rate because they expect to achieve at least this rate of return before tax. This return is shared between the lender, who receives 3 per cent, and the government, which receives the other 2 per cent. Now, if a private firm invests in any project, society loses the *total pre-tax return* from other investments that are foregone. The real cost of investment is the loss of the 5 per cent return that is available on alternative investments. If government can obtain a 5 per cent return from an investment in transport capacity, this is what it foregoes with an environmental health project.

The technically correct way to deal with the difference between the producer and consumer rates of discount is the shadow price of capital method. The analyst applies a premium to capital expenditure to reflect its opportunity cost and then discounts all future benefits and costs with the consumer rate of discount. However this method is complex, generally unnecessary, and rarely employed.

The most common discount rate used is the producer rate of discount. This ensures that efficient projects are adopted and produces a similar result to the shadow price of capital method when one capital investment replaces another. However, this assumes that all capital is funded from investment funds and none from consumption. Because of concerns that using the producer rate of discounting may overstate the appropriate discount rate, sensitivity tests using a consumer rate of discount, or a weighted average of some kind, are often employed as well. **Annex C** provides further technical explanation of these issues.

Commonwealth and state governments recommend and use a variety of real discount rates. For example, the Commonwealth Department of Finance (1991) recommends that costs and benefits be discounted with a real (inflation free) producer rate of discount of 8 per cent. This is higher than the discount rates recommended by most other Australian government authorities, which centre on about 7 per cent. For example, NSW Treasury (1997) recommends using a 7 per cent discount rate. Queensland Treasury recommends using a 6 per cent discount rate. On the other hand, the Commonwealth Department of Health, Housing, Local Government and Community Services (1993) recommended that a 5 per cent rate of

4 This ignores inflation and the interaction between inflation, taxation and the producer and consumer rates of discount.

discount be used in assessing pharmaceutical products for inclusion in the Pharmaceutical Benefits Scheme. Given recent trends in the returns to capital, a marginal real rate of return of about 5-6 per cent seems more generally applicable than the earlier higher rates.

In order to ensure a sustainable environment and so as not to disadvantage future generations, health and environmental authorities often use lower discount rates, which more accurately reflect consumer rates of discount. The Commonwealth Department of Health and Ageing currently recommends using a 5 per cent discount rate. This rate was endorsed by enHealth Council Steering Committee for this report. Accordingly, a 5 per cent discount rate is used in the case studies in Volume 2, along with sensitivity rates ranging from 3 to 7 per cent. Consistent with these practices, the use of a 5 per cent discount rate is recomended for environmental health programs along with sensitivity rates ranging from 3 to 7 per cent. However, where an environmental health project competes for investment funds with other economic sectors, the economic analyst should take into account any official discount rates that could apply to the project and test whether use of these rates affect the estimated result.

3.5 Managing Risk and Uncertainty

Inevitably many estimated costs and benefits are uncertain. The issue is how to treat these costs and benefits.

Some costs and benefits may be so uncertain that they are not even quantified. It is a matter of judgment when to quantify and include an uncertain factor in the cost-benefit results or to omit it. Some analysts prefer to try to quantify as many costs and benefits as possible in monetary terms so that they can be compared with other costs and benefits using a comparable unit. Others prefer not to quantify when data are very limited. Whichever view is taken, when factors are omitted from the CBA results, they should be described explicitly and transparently.

Turning to the included variables, a single estimated NPV may not do justice to the range of possible outcomes. Policy makers often want a broader picture of possible outcomes. Sensitivity analysis is the main method used to show these outcomes.

Sensitivity tests show how the estimated NPV alters with changes in key assumptions. A full sensitivity analysis involving all variables is usually impractical and could confuse policy makers rather than inform them. Thus the analyst must select those input parameters that have a major

Box 3.2 Discounting: key concepts

There are two key discount rates:

- The producer rate of discount: what firms are willing to pay for capital
- The consumer rate of discount: the rate at which individuals are willing to lend.

The producer rate is usually higher than the consumer rate because government gets some of the return through taxation.

When an investment in a program represents an investment foregone in something else, the producer rate of return is the appropriate rate of discount. When an investment is funded from foregone consumption, the consumer rate of discount is the appropriate rate of discount.

The producer rate of discount is generally the recommended discount rate. However, for environmental health projects, where sustainability and inter-generational equity are major concerns, the lower consumer discount rate may be more appropriate.

Drawing on national recommendations, practice and recent trends in real discount rates, this report recommends the use of 5 per cent discount rates for environmental health projects along with sensitivity analysis using 3 and 7 per cent rates.

Box 3.3 Dealing with uncertainty

In order to provide a broader picture that covers the range of possibilities, the analyst should:

- Present expected outcomes or conclusions based on the expected mean values of variables;
- Provide descriptions of major assumptions;
- Perform realistic sensitivity tests on key assumptions;
- Justify the assumptions used in the sensitivity analysis.

This analysis provides useful information to policy makers. The policy maker may then decide how to use this information.

impact and that may be subject to a significant value range. The range of values tested should be plausible. It is common practice to vary the value of one parameter at a time. However, inter-relationships should be considered (for example price and output vary inversely) and it may be appropriate to vary more than one parameter value simultaneously.

Sensitivity analysis provides useful information to policy makers. However, it does not provide a decision rule. The policy maker can now decide how to use this information. This may involve project redesign. When a project shows substantial variance in outcome, risk may be managed by redesigning the project. When a project has an expected high NPV with a high variance, redesign may be preferred to abandoning the project.

Other important methods of risk analysis are threshold analysis and Monte Carlo analysis. A threshold analysis examines the key break-even points for the project. These points may be costs, but are more likely to be the benefits required for a project or policy to be worthwhile. Monte Carlo analysis requires estimated distributions for each variable and a computer program that takes a random draw from these distributions to arrive at a set of estimated net social benefits with a mean and a variance. The latter approach is comprehensive but rarely used.

3.6 Summary

Economic evaluation usually means cost-benefit analysis. If the estimated total benefit of a policy or project exceeds the total cost, there is said to be a net social gain. The total value of goods and services in society, including non-market services, increases.

In CBA, benefits and costs are valued as the individuals gaining the benefits or bearing the costs would themselves value the benefits and costs. To determine these values, the analyst estimates what people would be willing to pay for the goods and services provided and what firms would be willing to pay for the resources that are used to produce these goods.

The timing of costs and benefits is important. To allow for the opportunity cost of capital and consumer preferences, CBA uses weights to discount future costs and benefits. It is proposed that a discount rate of 5 per cent be used for environmental health policies, with sensitivity tests ranging from 3 to 7 per cent. Evaluations should also take notice of any official discount rates in relevant jurisdictions.

Many estimated costs and benefits are uncertain. In order to provide the range of possible outcomes, the CBA should generally provide sensitivity tests that show how the estimated NPV changes with changes in key assumptions.

For readers who wish to follow up the discussion in this chapter, recommended readings are:

Boardman A.E., Greenberg, D.H., Vining, A.R., and D.L. Weimer, 2001, *Cost-Benefit Analysis: Concepts and Practice*, Prentice Hall, New Jersey.

United States Environmental Protection Agency, 2000, *Guidelines for Preparing Economic Analyses*, US EPA, Washington, D.C. This can be found on www.epa.gov

Both readings carry extensive references.

4

Alternative Methods of Economic Evaluation

4.1 Introduction

Cost-benefit analysis is the most comprehensive form of economic evaluation. It is also based on a firm theory of values of benefits and costs. It is therefore generally the preferred method of economic evaluation.

However, it may be difficult to do a full CBA when quantification of key benefits in monetary terms is difficult. Or it may be considered too expensive to conduct.

This chapter discusses three alternative methods of economic evaluation: cost-effectiveness analysis, cost-utility analysis, and financial analysis. Each of these evaluation methods may be useful at times.

Public administrators sometimes use other non-economic methods to develop resource allocation frameworks or to evaluate performance. The main difference between economic evaluation methods and other methods of evaluation lies in the valuation principles (or the lack of them). In Chapter 7 we briefly discuss the relationship between economic and other evaluation methods.

4.2 Cost-Effectiveness Analysis

Cost-effectiveness analysis (CEA) shows the cost of achieving a given output. CEA measures outputs in physical units rather than in monetary terms. Costs are still measured in dollars.

Ideally CEA measures outputs in terms of final health gain (lives saved, disability avoided, incidence of disease reduced). If direct measures of health gain are not available, CEA may measure intermediate outcomes which are associated with health improvement, for example cases of disease detected, immunisation levels achieved, or identifiable risk factors reduced, such as blood pressure or cholesterol levels.

Results are generally expressed as net dollar costs per unit of output.

$$\text{Costs of intervention / physical health benefits} = \text{cost per unit of output} \qquad (4.1)$$

Following Weinstein et al. (1996), the numerator should capture all changes in resource use associated with an intervention, including costs of health services, costs of patient time expended for the intervention, the costs of care, costs borne by employers and so on. The denominator should capture the physical health benefits of the intervention.[5]

Like CBA, CEA takes into account expenditure savings, for example costs of treatment avoided. These savings are deducted from other program costs. Also like CBA, costs and benefits should be discounted for time-preference, although this is sometimes not done.

CEA avoids valuing benefits in monetary terms, but at the expense of greatly reducing the range of problems that it can address. CEA is typically based on the objective of meeting a given objective, such as ambient air quality or lives saved, at lowest cost. For limited and specified purposes, CEA can be useful.

As shown, CEA presents the results of an analysis in the form of a ratio, whereas CBA describes the net value of a project in absolute terms. Ratios must be treated with caution as the results can be manipulated by placing different numbers in the numerator or the denominator. To illustrate the dangers of ratios, consider a project that costs $10 and that produces $20 in health benefits and

5 The CEA ratio can also be expressed as output per unit of cost (say $ million) with output as the numerator and costs as the denominator. The choice of denominator (and numerator) is a matter of convenience.

$10 in health care savings. The benefit to cost (20 + 10) / 10 = 3:1 or 20 / (10 –10) = ∞ !

More fundamental differences between CBA and CEA are that:

(i) CEA does not place a value on the benefits of outputs or outcomes, and

(ii) CEA does not provide a test of the value of intervention.

It follows from (i) that CEA cannot deal adequately with a policy that produces multiple effects. It follows from (ii) that the policy maker has to decide if the cost per unit of output is acceptable. Generally it is necessary to show that a program is not only the most cost-effective but also that is has a net social benefit. These are significant disadvantages for general use of CEA.

In summary, CEA shows the cost of achieving a given output. This is sometimes useful. However, CEA does not provide guidance as to whether the cost per unit of output is acceptable and it cannot deal with a policy that produces multiple effects.

4.3 Cost-Utility Analysis

Cost-utility analysis (CUA) may be viewed as a compromise between CBA and CEA. CUA attempts to overcome the limitations of a single output measure by valuing different health outcomes in utility terms.

Costs of intervention / utility index of health benefits = cost per unit of health benefit (4.2)

To develop a utility index of health benefits, a quality of life (QoL) index is required which can compare the health states of different individuals. Typically a QoL value of 1.0 represents a state of perfect health; a QoL value of zero corresponds to an impaired state of health judged to be equivalent to death. To estimate social health values, the time in various health states must also be allowed for. A year in full health is often referred to as a QALY; a quality adjusted life year. Given information on QoL states and times, the number of equivalent QALYs can be estimated. One QALY would be the unit of health. For example, 10 individuals enjoying a QoL health state of 0.8 for five years would experience the equivalent of 40 QALYS (10 x 0.8 x 5). Another program might produce say 30 or 50 QALYs.

CUA does not attempt to estimate the monetary value of QALYs or other indexes of health states. If it did do so, the evaluation would become a CBA (at least in benefit-cost ratio terms).

In its purest form, CUA can reflect the requirements of economic theory by eliciting from individuals the satisfaction or 'utility' which they attach to different states of health and hence the strength of their preferences for them.

Because QALYs incorporate length and quality of life, in principle the value of all health outcomes of a policy intervention can be compressed into a single non-monetary measure, which is comparable across programs and services. Programs can then be ranked according to costs per QALY gained.

However, there is often only a weak connection between QALYs and the economic measure of willingness to pay. If willingness-to-pay amounts are known, or can be estimated, little is achieved by a CUA. If they cannot be measured, a CUA may give limited information about the overall worth of a program.

4.4 Financial Analysis

Financial analysis deals with revenues and expenditures affecting a specific party, usually the main proponent of a project, rather than with social welfare benefits and costs. As its name implies, financial analysis is concerned only with financial flows.

Government agencies are often concerned about the financial implications of projects for government. In so far as environmental regulations are designed to change the behaviour of private firms or consumers, the financial implications for government may be minor in the short term. The financial implications are more significant for major public infrastructure projects designed to protect the environment.

Government may require a financial analysis for two reasons. First, financial analysis ensures that projects undertaken by either the private or public sector are economically sustainable.

Second, it ensures that government agencies do not lose revenues and so have to cut other services or seek increased income from consolidated revenue.

However, a financial analysis picks up only some of the costs of a project, namely the financial impacts associated with the main proponent of the project. It excludes non-financial impacts on the proponent and excludes all impacts on all other parties (externalities). Accordingly, a financial analysis may complement a full economic evaluation. It does not provide a substitute method of evaluation.

4.5 Conclusions

When possible, an economic evaluation should be a full evaluation. This is a cost-benefit analysis. If it is not possible to conduct a full CBA, a simplified version is generally preferable to any other method of evaluation as it maintains the underlying integrity and principles of the full approach.

The other main methods of economic evaluation are cost-effectiveness analysis, cost-utility analysis, and financial analysis. Each of these evaluation methods may be useful when preparing a CBA is difficult, notably when quantification of key benefits in monetary terms is difficult, or too expensive to conduct.

Cost-effectiveness analysis (CEA) shows the minimum cost of achieving a given output. This is sometimes useful, for example to determine how to achieve a given environmental target. However, CEA does not show whether the output justifies the costs and it cannot deal with a policy that produces multiple effects.

Cost-utility attempts to overcome the limitations of a single output measure by valuing different health states in utility terms. This method avoids the difficulties associated with putting money values directly on health. However this does not help policy makers when they have to trade off various costs and benefits as is often the case.

Financial analysis assesses the net revenues of particular parties, which may often be of concern to government. However, this is not a complete social evaluation method.

Box 4.1 Choosing the economic evaluation method

- Always start by preferring the best and fullest evaluation method: cost-benefit analysis.
- If a full CBA is not practical, generally prepare a simplified cost-benefit analysis.
- If a CBA is not practical because output cannot be valued in dollars, or because the data requirements are too costly, consider doing a CEA. Interpret the results cautiously.
- When the outputs are mainly health benefits, a CUA may be preferred to a CEA.
- Consider whether a financial analysis is required to complement a CBA or CEA. It is rarely a substitute for CBA.

5

Estimating Benefits of Environmental Health Policies

5.1 Introduction

Most environmental health interventions produce several benefits. While these benefits may sometimes be valued as a whole, it is more common to value them separately and to aggregate the benefits. Adopting this effect-by-effect approach, it is important to avoid double counting any effect, for example by valuing both improved water quality and the services resulting from it.

The assessment of benefits from environmental health policies has five main components:

- Identifying potentially affected benefit categories by developing an inventory of the physical effects that may be averted by the policies;
- Quantifying the significant physical effects on the environment as far as possible, working in particular with physical scientists, engineers and ecologists;
- Quantifying the health impacts of these changes, drawing in particular on epidemiological studies;
- Estimating how these physical changes affect human production and consumption;
- Estimating the values of the effects on people either by a study of relevant individual valuations or by transferring estimates from other studies.

Scientists in one or other discipline are likely to be responsible for the first three steps. However, although economists may not contribute technically to these components, they should be involved in the process for three reasons. First, environmental interventions typically have a wide range of impacts. It is neither sensible nor feasible to identify and quantify all these impacts. Studies must focus on those impacts that are likely to be significant. Second, the effects of change must be evaluated against a baseline scenario. This should be established at an early stage of the analysis. Third, data should be collected in a form that can be input into the CBA.

Economists are likely to be closely involved with the fourth stage, for example in forecasting the impacts of environmental change on agriculture, fishing or forestry, or in forecasting the location and behaviour of industry. Above all, economists are primarily responsible for valuations of effects. This chapter discusses the valuation methods, especially the valuation of health effects.

However, two caveats should be noted. First, economic valuations are only as good as the foundations on which they rest. There often are significant uncertainties about the physical impacts of environmental interventions. Second, although methods for valuing most effects on humans exist, application of these methods is often complex and data and time intensive. Original valuation research for a particular CBA is often not feasible. The analyst must then draw on existing valuation estimates for use in the benefits analysis (a process described as 'benefits transfer'). This point is discussed further in the last section of this chapter.

Box 5.1 Key activities in benefit valuation

- Identify potentially affected benefit categories
- Quantify the significant physical effects on the environment as far as possible
- Quantify the health impacts of these changes
- Estimate how these physical changes affect human production and consumption
- Estimate the values of the effects on people

5.2 Health Benefits: Evaluation Framework

In Australia, where government is the main funder of health services, an environmental improvement brings benefits to four main groups:

- persons who would have been ill in the absence of the improvement;
- government, which saves health treatment costs;
- third parties, including family and carers of patients; and
- third party payers, mainly insurance companies whose payouts are reduced (leading ultimately to lower insurance premiums).

Table 5.1 shows the main types of benefit for each of these four groups and the main measures of these benefits. In total, ten types of benefit are noted. However, these ten benefit types can be valued using **four main measures**: savings in health treatment costs, gains in productive output, the value of health gains, and quality of life gains for third parties.

In each case, these benefits must be measured relative to the baseline scenario. Thus, *incremental benefits* must be identified.

Savings in Health Treatment Costs

Health treatment costs are the medical costs of treating morbidity. In principle, estimating savings in these costs due to reduced morbidity is straightforward. In practice, there are three main problems: (i) It is important to estimate the incremental or variable costs of health treatments that are avoided as a result of health improvements. However, (ii), if the scale of savings is large, it may be necessary to allow also for some savings in capital expenditure. (iii) Data on operating savings, for example related to fewer cancer or coronary patients, may not be readily available. Fortunately, in Australia, the Australian Institute of Health and Welfare (AIHW) has made detailed estimates of the costs of medical and hospital services for a wide range of morbidities (see Mathers et al., 1998, and related studies).

Box 5.2 Major benefits of environmental health programs

- Savings in health care costs,
- Gains in the quantity and value of economic output,
- The value of health gains (life expectancy and quality of life),
- Quality of life gains for third parties.

Table 5.1 Main benefits of health improvements

Benefit enjoyed by	Type of benefit	Benefit measure
Patients[a]	Increased life expectancy	Health gain
	Increased health-related quality of life	Health gain
	Reduced medical costs	Cost savings
	Increased productivity	Output gain
	Reduced avertive expenditures	Cost savings
Government	Reduced hospital and medical costs	Cost savings
	Reduced ancillary costs (ambulance, admin. costs etc)	Cost savings
Third party payers	Reductions in payouts to health care providers	Cost savings
Family or carers of patient	Reduced time in caring	Output gain or cost savings
	Reduced grief and anxiety	Quality of life gain

[a] A patient is a person who would have been ill in absence of environmental health intervention.

Gains in Productivity

Productivity gains occur in both the market economy and in the household. Output gains in the market place are generally measured by increases in wages or salaries. Thus the gain is the product of the days or months of work gained and the wage rate. Of course productivity gains in the household also enhance welfare. If these gains are large it may be appropriate to estimate the value of the increase in productivity using proxy market wages for the type of household work done. However, such estimates should be made cautiously as they are easy to exaggerate and may discredit the evaluation.

Measuring Personal Health Gains

Health gains comprise longer life expectancy and improved health-related quality of life. There are of course many dimensions to both longevity and quality. Life expectancy may be increased by as little as one or as much as seventy years. Quality of life may be improved marginally or greatly. Non-fatal illnesses range from mild nuisances like headaches to severe illnesses like cancer.

In practice, environmental interventions generally do not save particular lives. Rather they provide marginal changes in small risks for a large number of people. Consequently, reduced mortality risks are generally measured in terms of *statistical lives* saved. Suppose that an intervention reduces the risk of premature death for 1000 people by one in a 1000, the intervention is said to save one statistical life.

Statistical lives saved can be converted to *statistical life years* saved by multiplying expected lives saved by the average number of years saved. Measuring mortality risk reduction in terms of life years saved, rather than by lives saved, provides more information about the benefits of an intervention, but requires risk estimates for specific aged groups that may not be available.

Morbidity can generally be characterised by duration and severity. Traditionally, morbidity effects were measured by such concepts as restricted activity days, lost workdays, or bed disability days. However these are crude indices of health quality. In recent years, health status or quality of life (QoL) indices have been developed in an attempt to capture the multiple dimensions of health (pain, mobility, need for care and so on) in a single index number. The difference in the index value is intended to reflect the relative disutility associated with the morbidity.

Typically QoL indices measure health status on a scale of 1 to 0 where 1 represents a healthy life year and 0 represents death. They may of course also be measured on a sale of 100 to 0 or any other scale. With a 1–0 scale, a death prevented without residual illness represents a change in health quality from 0 to 1.

However, it is not sufficient to measure the change in health status, we also want to know the period applicable. Here the concept of a quality adjusted life year (QALY) is useful. A QALY is one year of perfect health. If someone improves their QoL health status from say 0.6 to 0.8 for a full year, the benefit is equal to 0.2 QALY. Of course, to achieve a monetary valuation, it is necessary to estimate the value of a QALY. This is discussed in Section 5.5.

Various methods have been used to estimate QoLs. Traditionally QoLs were based on expert rating of health states. However, these ratings may not reflect the views of patients about health states. To obtain these views, many surveys have now asked people to rate health conditions. A common survey approach is the 'time trade-off' where people are asked to compare time in perfect health with a greater length of time in imperfect health. The comparison is intended to incorporate all facets of an illness. Again, it is not possible to undertake research into QoLs as part of a CBA study. However, Mathers et al. (1999) estimate QoLs for a wide range of morbidities in Australian conditions.[6] These values can be applied with caution in CBA studies (see the Wallis Lake study in Volume 2).

Of course, in order to estimate the total *improvements* in health, the total expected cases of morbidity and the associated QoLs must be estimated in the baseline scenario as well as with the policy intervention.

Although QoLs and their related measure QALYs are the most common indicators of

6 Actually Mathers et al (1999) estimate a disability index, which runs from 0 for zero disability to 1 for a state of health equal to death. However, the results are easily converted into a QoL index.

health status, several other indicators are also used. These include traditional indicators such as 'symptom days' or 'restricted activity days' as well as close substitutes for QALY such as Disability Adjusted Life Years (DALYs, see footnote 6) and other health-related quality indices. In Australia, the Centre for Health Program Evaluation (Monash University) has been developing an Assessment of Quality of Life index (AqoL) for several years (Hawthorne et al., 1998 and 1999). However the program has not produced an operational index for morbidity disutility.

Accordingly, it is recommended that analysts measure morbidity effects by using either the well-understood simple traditional measures, such as symptom days or restricted activity days or the health indices developed by AIHW (Mathers et al., 1999).

Other Quality of Life Gains

It is difficult to measure the grief and pain of family and friends or the relief of such suffering. It is sometimes argued that an individual's assessment of the disutility of a morbid condition includes an allowance for the suffering of others and that health status indices implicitly allow for this. However, this is not very convincing.

Another approach is to allow for this suffering by adding some amount, say 20 or 30 per cent, to the estimated cost of individual's illness. The Bureau of Transport Economics (2000) adopted this approach in its estimate of the costs of road crashes in Australia. This approach has the advantage of dealing explicitly with this real cost. However, in the absence of adequate research on the topic or government guidance on the values to be applied, measures of the cost of family pain and grief are likely to be arbitrary and inconsistent.

The third approach is simply to note that the suffering of family and friends is an important issue but not quantified in the CBA.

Australian health authorities should consider how the grief and pain of family and friends might be formally allowed for in cost-benefit studies. In the absence of any direction from government agencies, this suffering should generally not be quantified in CBA studies.

5.3 Methods for Valuing Health: Life, Life Years and Quality of Life

Basically, monetary values are required for:

- The value of a statistical life (VOSL),
- The value of a healthy life year (VOLY), and
- The value of a partly healthy life year or the value of a symptom day.

VOSL and VOLY are related. The higher the value of one, the higher is the value of the other. Generally, a VOLY is derived from an estimated VOSL rather than the other way around. The value of a life year (VOLY) is usually taken as 'the constant annual sum which, taken over an average remaining life span, has a discounted present value equal to a pre-specified VOSL' (NERA, 1998).

Suppose for example that the value of a statistical life is $1.0 million and that this is based, as is the case for road accidents, on a life expectancy of 39 years. If the discount rate is 5 per cent, the constant value of a life year is approximately $60,000.

Suppose further that an environmental intervention increased the lives of potential cancer patients by 10 years, the value of life saved would be the present value of $60,000 for 10 years discounted by 5 per cent, which would be $463,000.

Now suppose that an environmental health improvement would prevent the loss of 10 years of life expectancy for someone who is already suffering from impaired health with a QoL value of 0.8 (where 1.0 corresponds to perfect health). The value of each year of life expectancy gained would be $48,000 (i.e. 0.8 x $60,000) and the present value of life saved would be $370,000.

Alternatively if an environmental improvement lifts someone's health status from 0.8 to 1.0, this would be valued at $12,000 (i.e. 0.2 x $60,000).

This approach presumes that a standard value for life can be reliably estimated, or at least agreed for the purpose of economic evaluation and policy making, and that QoL indices are meaningful measures of health well-being.

The approach also assumes more contentiously that the value of a healthy statistical life year

(VOLY) is constant and independent of factors like age and income. This implies that the value of a statistical life is proportional to life years gained and falls linearly with age. Several experts have questioned these assumptions on theoretical and empirical grounds (Jones-Lee, 1985: NERA, 1998; Maddison and Pearce, 1999). Ostro et al. (1999) follow Jones-Lee in allowing the VOSL of persons over 65 to equal 0.75 of the average VOSL, rather than a lower proportion as would be implied by a constant VOLY.

In the absence of formal Australian guidelines on these issues, these Guidelines are based on the reasonable assumption of a constant VOLY. This ensures that resources will be applied to producing the maximum number of life years (holding health states constant). This is a safer strategy than allowing an equal VOSL for all persons regardless of age, which would risk a serious misallocation of resources. However, as discussed below, Australian health authorities should consider these issues further with the aim of developing informed values for life and life years.

There is also a fair presumption that the consumer rate of discount is the appropriate rate of discount to apply to derive a VOLY. Arguably this discount rate should be less than 5 per cent. Note that with a lower discount rate, for any given VOSL, the value of a life year falls. Retaining a VOSL of $1.0 million and 39 years of life expectancy, with a 3 per cent discount rate, the value of a life year would fall to $44,000.

Valuation Methods

Table 5.2 shows the main methods used to value health. The traditional approach was the cost of illness (COI) method, which was used both to value life and morbidity changes. Using the COI method, loss of health status is measured by the estimated loss of an individual's earnings. Loss of life is valued at the present value of earnings foregone.

The **COI method** measures ex-post costs. It does not attempt to measure the loss of utility due to pain or suffering or the loss of leisure time. An individual may be willing to pay for a health improvement even when she suffers no loss of output. Thus the COI method is generally regarded as providing a lower bound estimate of the true cost of an illness.

More fundamentally, the COI approach does not measure what people are willing to pay to avoid an illness or to reduce the risk of an illness or death. As discussed in Chapter 3, monetary valuations of benefits in CBA are based on the willingness to pay principle. The value of a welfare gain is the amount that an individual would be willing to pay for it.

Willingness to pay methods of valuation themselves divide into two main categories: revealed and stated preference methods. Revealed preference methods derive willingness-to-pay values from the observed actions of people, usually in some form of economic activity. Stated preference methods elicit valuations by asking people what they would be willing to pay for things.

The main revealed preference method used to estimate the value of life is the **hedonic wage method**. Employers pay workers a wage premium to accept a higher risk of accidents. If the premium and the risk can be estimated, an implicit willingness to pay for safety (in lower wages) can be estimated. The results from a large number of such studies have been used to infer the value of a statistical life (US EPA, 2000).

Table 5.2 Valuation methods for valuing health

Basic approach	Main subsets	Valuation methods
Human capital		Cost of illness
Willingness to pay	Revealed preference	Hedonic wage method Averted expenditures
	Stated preference	Contingent valuation Stated choice

The main difficulties with this approach are the unreliability of the risk estimates and the wide variation in results that emerges.

The **averted expenditure method** infers values from observation of expenditures designed to avoid an unwanted effect. The presumption is that an individual will continue to spend money to avert the unwanted effect so long as the benefit exceeds the cost. Thus someone's willingness to pay for improved health can be inferred from her defensive expenditure. In practice the data requirements are quite formidable. Averting expenditures are generally regarded as lower bound estimates of willingness to pay values. However, this approach has been used to estimate valuations of WTP for particular sets of illness (US EPA 2000).

Stated preference methods include **contingent valuation** (CV) and **stated choice** (SC) methods. Using CV, people are asked how much they would be prepared to pay (through tax or otherwise) for an improvement in health status. This assumes that individuals are the best judges of their own welfare and take into account all of the consequences in terms of potential death, pain and suffering, earnings and future health expenditures in making their expenditure decisions. There are many CV studies designed to estimate both the value of life and the value of avoiding illness.

The **CV method** assumes not only that potential beneficiaries are fully informed about the benefits and costs involved, but also that people give honest answers. This may be possible for discrete variations to existing programs. Clarke (1998) examined attitudes toward the location of breast cancer screening facilities in rural areas where travel costs and time were a consideration and obtained useful results, including the degree to which 'altruistic' and 'free-rider' considerations entered the valuation. But the basic program existed and was not in question. If the program had not existed, the issues would have been more complex. Where people believe that they have a right to a service free of charge, they are often not prepared to say what they would be willing to pay for the service (Abelson, 1996).

SC surveys ask respondents to chose between various options with different attributes and prices. The choice would typically contain a bundle of goods as well as a monetary component. The aim is to deduce the marginal value of a particular attribute of a commodity, such as increased safety. Stated choice surveys have been used to estimate morbidity values. They have the advantage that people often find it easier to rank choices than to declare what they are willing to pay for services or health states. However, they are a less direct way to elicit values than CV surveys.

For readers who wish to follow up methods of carrying out CV or SC surveys, the Guidelines strongly recommends *Economic Valuation with Stated Preference Techniques: A Manual* by Bateman et al. (2002). A practical short version is available on the website of the UK Department of Transport (www.dtlr.gov.uk).

5.4 Indicative Values of Life and Health

Estimated values of life (VOSLs) are based on aggregated estimates of individual values for *small* changes in mortality risks. If people are willing to pay $100 for a reduction in risk of 1/10000, the value of saving one statistical life is $1.0 million (10000 x $100).

There has been no major study of the value of a statistical life in Australia. Most Australian road authorities base their costs of a fatality on a COI approach. Drawing on this method, the NSW Roads and Traffic Authority (2000) estimates a VOSL of $827,400 in 2000. This approach underestimates the VOSL in Australia and it is proposed that the value of life should be based on international research until alternative Australian values are available and agreed.

US EPA (2000) reports an extensive review of 26 policy-relevant and reputable risk VOSL studies, including 21 wage-risk studies and 5 CV studies. The estimated VOSLs range from US$0.7 million to US$16.3 million. The US EPA recognises that many factors may affect the VOSL. For example, most people are willing to pay more for risk reduction when they have little control over the risk. Research has found that most people are willing to pay more for a reduction in mortality risk from air pollution,

which they cannot control, than for a reduction in mortality risk from motor vehicle accidents, over which they have some control (NERA, 1998).

The US EPA recommends that a central tendency figure of US$6.1 million in 1999 prices be adopted as the basic VOSL figure for use in US studies. This is significantly higher than the VOSL figure of £850,000 in 1996 prices applied by the UK Department of Environment and Transport (NERA, 1998). Of course, both the US and UK figures are much higher than Australian VOSLs. The UK figure would translate into about A$2.5 million in 2001 prices.

These Guidelines recommend that Australian environmental and health authorities review the international and local literature with a view to establishing a suitable VOSL for environmental and health purposes.[7] In lieu any agreed determination on VOSL, drawing on international studies, these Guidelines use an average value of A$2.5 million as a realistic figure for VOSL in Australia.

Once a VOSL is established, a constant value of a life year can be estimated. Allowing a life expectancy of 40 years and a consumer discount rate of 5 per cent, the constant VOSL would be approximately $150,000.

As has been seen, values for improvements in quality of life (reductions in morbidity or improvements in QALYs) can be derived from CV and averted expenditure studies. In practice, analysts must usually draw on established studies.

Tolley et al. (1994) provides a useful summary of morbidity values in the United States. They give estimated low, medium and high daily values for nine forms of acute morbidity (for example ear ache, asthma and food poisoning) and annual values for 14 cases of chronic morbidity (for example, angina, bronchitis and a broken leg). They also provide values for various injuries, dysfunctions and Alzheimers' disease.

Other useful sources of data on morbidity costs are Johanneson (1995), Desvouges et al. (1998), Ostro et al. (1999) and US EPA (1999) and US EPA (forthcoming).

7 Abelson (2002) provides an initial survey of the literature.

In lieu of Australian morbidity values, analysts may draw with care on international morbidity values. See, for example, Abelson 2002. Typically values would be adjusted at least for differences in income levels.

5.5 Valuing Other Environmental Benefits

The environment also provides a variety of non-health benefits in terms of amenity, ecological services and materials. Amenities include improvements in aesthetic attributes associated with environmental attributes. Examples are improvements in taste, odour, appearance and visibility.

Ecological benefits include improved productivity of natural resources and non-market benefits of improved recreation. Indirect ecosystem benefits include flood mitigation, soil retention and biodiversity conservation. Non-use benefits of environmental improvement occur when people are willing to pay for an environmental improvement even when it provides no direct services to them.

As shown in the case studies in Volume 2, the health effects of an environmental improvement may be closely related to other effects. For example, many of the policies designed to reduce the risk of disease from consuming oysters from Wallis Lake have significant amenity and ecological benefits. Likewise, policies designed to improve the amenity of the lake have health benefits. While it is desirable to identify particular marginal relationships of cause and effect, this may need to be done within a comprehensive analysis of environmental policies.

Table 5.3 provides a list of environmental benefits and service flows and common valuation methods for these service flows. Most of the methods were described in Section 5.3. However, two methods are new and warrant a brief description and one method is a minor variation on a previous one.

Hedonic property analysis is similar to hedonic wage analysis. In this case, property

Table 5.3 Benefit categories, service flows and commonly used valuation methods

Benefit category	Examples of service flows	Common valuation methods
Human health		
Mortality risks	Reduced risk of • Cancer fatality • Acute fatality	Cost savings Hedonic wage analysis Contingent valuation
Morbidity risks	Reduced risk of • Cancer • Asthma • Nausea	Cost savings Averted expenditures Contingent valuation Stated choice analysis
Amenities	• Taste • Odour • Visibility • Noise	Averted expenditures Hedonic property analysis Contingent valuation Hedonic property analysis
Ecological benefits		
Market: products	Provision of food, fibre, fuel, timber, fur, leather	Net value of output gained
Non-market: Recreation and aesthetics	Provision of: • Recreational opportunities, eg. fishing, hiking, swimming • Scenic vistas	Averted expenditures Hedonic property analysis Travel cost analysis Contingent valuation
Indirect: ecosystem services	Examples include: • Climate moderation • Flood moderation • Soil retention • Biodiversity preservation • Pest control	Net value of output gained cost savings Averted expenditure Contingent valuation
Non-use: existence values		Contingent valuation
Material damage		Net value of output gained or cost savings

Source: based on US EPA, 2000.

owners are willing to pay a price premium for environmental amenity. By relating the property price to its various characteristics, it is usually possible to estimate the premium attached to the amenity and the implicit willingness to pay for amenity. There have been many such studies (see Smith and Huang, 1995; and Bockstael, 1996).

Travel cost models provide estimates of recreational demand and benefits. These models are based on the observation that visits to recreational amenities are inversely related to the travel costs. Given data on the numbers of visits and trip costs, the inverse relationship between trips and costs can be estimated and people's willingness to pay for access to the amenity can be estimated (Freeman, 1993).

The minor variation is an important one. When an environmental change brings about a change

in output, the social value of the change in output is the *net* value of output gained or lost. Net value is gross value less the cost of inputs required to achieve an output.

5.6 Conclusions on Valuations

The various valuation methods that have been described in this chapter are summarised in Box 5.3. This identifies some of the main uses, strengths and limitations of the methods.

Of course, it is often not feasible to conduct primary research for each cost-benefit study. The resources required to carry out a comprehensive CBA of an environmental health issue are considerable. Analysts often have to adopt and modify benefit values found in other studies; especially research studies, rather than undertake a large amount of primary data collection and analysis.

The process of *benefit transfers* involves the transfer of existing estimates of non-market values to the present study, which invariably differs in some features from the original studies. Ideally, a meta study would have analysed the reasons for the differences between studies, so that the most relevant values can be selected. However, it is common practice to adopt mean estimated values from studies that are considered broadly similar. In some cases it may be appropriate to adopt a higher or lower value to reflect some special local conditions.

Box 5.3 Summary on willingness-to-pay valuation methods

Valuation method	Main use of method	Main strengths	Main weaknesses
Revealed preferences			
Market data	Measures value of gain or loss of output	Easily observable Provides important data on productivity impacts	Does not measure non-market goods like quality of life
Hedonic wage method	Measures value of life and safety	Provides main market-based method of valuing safety	Wages not always a reliable indicator of risk
Hedonic property prices	Measure value of environmental amenities	Has many applications and a reliable method	Requires extensive data
Travel cost analysis	Measures value of recreational amenities	Produces reliable answers if site is accessible and study well-done	Has to deal with multi-trip purposes and the value of travel time
Averted expenditure	Measures WTP to avoid illness	Provides a useful lower bound to values	Caution required when expenditure has several benefits
Stated choice methods			
Contingent valuation	Can be used to measure any impact	Has many applications	Respondents often find it difficult to express a monetary value for a non-market good. Answers may be biased.
Stated choice	Can be used to measure any impact	Respondents may give more accurate answers than in CV surveys	Requires substantial professional resources

6

Estimating Costs of Environmental Health Policies

6.1 General Estimation Methods

As we have seen, costs and benefits are essentially symmetrical. The cost of anything is the value of what is given up. Thus, if some event causes ill health, the cost is simply the negative of the value of the benefit that was discussed in Chapter 5. Thus, in this chapter we do not discuss the costs of morbidity because the principles of valuing (or costing) health were discussed in the last chapter. In this chapter, we discuss the costs of implementing environmental health policies, with the focus on costing the resources involved.

As described in Chapter 3, the cost of using a resource is its **opportunity cost**. When a regulation requires firms to spend millions of dollars on controlling emissions, resources are diverted to this purpose and away from the production of other goods. When a consumer pays an increased price for some commodity, their capacity to consume other goods is reduced. The total social cost of a policy is the total value of goods and services foregone.

Costs, like benefits, may be borne by four main groups: private firms, government, consumers and third parties. Environmental interventions usually require one or more of the following:

- private firms to comply with regulations of some kind,
- government to provide environmental protection infrastructure and to monitor regulations;
- private individuals to modify their behaviour in some way.

Each of these interventions has a cost for private firms, government or consumers.

Costs to Private Firms

When a regulation requires a firm to comply with an environmental standard a firm may adopt one of several strategies. It may:

- purchase, install and operate new pollution control equipment,
- change its production process by using different inputs or mixtures of inputs,
- capture the waste products and sell or reuse them,
- reduce production, or
- in an extreme case relocate its plant.

In estimating the costs imposed on firms, the common and most convenient assumption is that *output is unchanged*. The economic analyst must then estimate the costs that firms bear to comply with the regulations. Given that firms may comply with regulations by various means, including many kinds of process changes, ideally the analyst should estimate the minimum cost of compliance. However the analyst cannot be expected to determine the optimal production response. In the Mount Isa Mines case study in Volume 2, even after a four-year study, the mining company had not determined a preferred method for dealing with sulfur dioxide emissions. The analyst must therefore work with estimated compliance costs.

In general, analysts may estimate costs in three ways. They are by:

- engineering or process studies of the inputs required to achieve various outputs,
- examining a firm's accounts to determine costs associated with certain outputs, and
- statistical (econometric) studies of the cost functions of firms. Cost functions show the relationship between output and cost.

In most CBA studies of environmental interventions, estimated costs are based on engineering models. These specify the capital and operating inputs required and the capital, maintenance and operating costs that will satisfy the environmental regulation.

For most purposes, in Australia, the financial costs that firms incur are close approximations to the real costs of the resources used. These costs should be recorded at the time that they are incurred, not depreciated.

In the first instance, the compliance costs of regulations are borne by producers. However, they may be passed on in higher prices to consumers. Of course, the costs should be counted only once.

Firms may also meet environmental regulations *by reducing output* or in extreme cases by closing a plant. In this case, the net cost borne by the firm is the loss of profit. With reduced output, there will be loss of revenue. However, a firm may achieve savings in operating expenditures. The cost to the firm is the loss of net revenue.

When a firm reduces its output, two further costs may be borne by employees and consumers. When workers are laid off and unemployed, they lose wages until they can find alternative work. These are real economic costs. However, economic evaluations often treat these costs as transitional costs that are not large enough to include in the estimated costs. This was the assumption in the case study on Legionnaires' disease in Volume 2.

Secondly, consumers may lose some consumer surplus. This surplus is the difference between what consumers are willing to pay for a service and the price they actually pay. They lose this surplus when a service is no longer available. These are welfare losses and in principle should be included, and sometimes are, in economic evaluations. However, losses of consumer surplus are difficult to measure and are usually relatively minor costs, and so are often not included in evaluations.

Costs to Government

Government may incur costs in providing public infrastructure or environmental protection services, for example waste treatment services. Estimates of the real resource costs should include the value of unpriced resources that could be used for other purposes, for example public land.

As with private firms, some government costs may be passed on to consumers by increased taxes or charges. Thus government may recoup some of its expenses. This determines who bears the government expenses (the taxpayer or the user of the service), but it does not alter the underlying nature of the expense.

Government may also incur regulatory costs in monitoring, administering and enforcing new regulations. These costs may be significant and, if so, should not be ignored.

Costs to Consumers

Consumers may bear costs due to higher prices for services or a loss of consumer surplus when the output of services falls or is restricted in some way.

In addition, some environmental health regulations fall directly on consumers. For example, the costs of compulsory swimming pool fencing fall directly in owners of swimming pools (see the first case study in Volume 2. In order to reduce road accidents, government imposes numerous restrictions on traffic speeds and on drinking and driving. Government also prohibits cigarette smoking in some public places.

Regulations that change private behaviour have a potential cost as well as benefit. The welfare cost of a regulation is the amount that people would pay to lift the regulation, for example what a person would pay to travel at a high speed, to recreate in boats in crowded or pristine waterways, or to smoke in places where smoking is not permitted.[8] There are many studies of willingness to pay values, for instance willingness to pay to save time or to recreate in certain areas.

8 There is a basis for arguing that the welfare cost of the regulation is the amount that government would have to pay individuals to compensate for the regulation. **Annex B** discusses willingness to pay versus willingness to accept measures of value.

Where such research exists, it may be possible to apply the appropriate loss of value to the case under study.

Effects on Third Parties

Finally, regulations may affect third parties, that is, agents who are not directly involved in the production or consumption of a regulated activity. These may be firms who lose some producer surplus or individuals who lose some consumer surplus. Again, any such costs should be included in the economic evaluation if they are significant and have not already been included.

6.2 Summary

Environmental regulations may impose costs on private firms, government, consumers and third parties.

Regulations typically require firms to install and operate new pollution control equipment or to change their production process in some way. Firms may also reduce production or relocate operations. Generally the economic analyst estimates the costs of complying with regulations on the assumption that output is unchanged. The cost to a firm of reduced output or relocated production is the loss of net revenue. Also, workers may lose wages and consumers lose some consumer surplus when output falls.

Government may incur costs in providing either public infrastructure or various environmental protection services, for example waste treatment services. Government may also incur costs in monitoring, administering and enforcing new regulations.

Both firms and government may pass on increased costs to consumers. These costs should not be counted twice. However, some environmental health regulations fall directly on consumers and require consumers to change their behaviour. The measure of the welfare cost of a regulation is the amount that people would pay to stop the regulation.

Regulations may also affect people who are not directly involved in production or consumption of a regulated activity. These may be firms who lose some profit or individuals who lose some consumer surplus.

7

Economic Evaluation and Decision Making

7.1 Introduction

Economic evaluation is a technical guide to policy makers, but does not in itself provide a complete guide to policy making. This chapter reviews the main contribution of economic analysis to policy making and discusses the treatment of equity impacts, implementation issues in economic evaluation, including what users of economic evaluations should look for, and the relationship between economic evaluation and policy making.

7.2 The Main Outcome of Economic Evaluation: Net Social Benefit

CBA seeks to find the policy that maximises net social benefit (or net present value). The net social benefit is the sum of all benefits less all costs, with allowance for the timing of the benefits and costs.

A policy that maximises net social benefit is efficient. It maximises the value of goods and services available to the community, including the value of health and non-marketed goods. When the benefits exceed the costs, any losers from a policy can be compensated, so that potentially some people gain and no one loses. Even if a particular policy disadvantages some people, who may, for example, have to pay higher prices or taxes, in the long run most people gain if society adopts efficient policies rather than less efficient ones.

The process of CBA is robust and comprehensive. The valuation of costs and benefits is based on the values or preferences that individual members of society hold. The valuation is based on what individuals are willing to pay for an environmental change. In a properly conducted CBA there is no double counting of costs or benefits.

It is sometimes argued that CBA is concerned with only one objective, namely maximising the aggregate value of consumption, and that it is therefore inferior to multi-objective evaluation procedures. This is a misconceived criticism. CBA allows for numerous objectives (benefits) to be met, with the values and implicit weights determined by individual preferences. By contrast, multi-objective evaluation procedures (such as planning balance sheets) usually substitute expert opinion for individual preferences. However, it is a valid criticism that some CBA reports provide only a single NPV figure and so fail to convey the richness of the information and the analytical procedures in the CBA.

Although a CBA usually monetises most impacts, economic analyses should present and describe non-monetised effects when these are important for decision making. Also, a risk analysis should show how the outcomes could be affected by realistic alternative values of key variables.

However, efficient policies are not always fair for two main reasons. First, willingness-to-pay values depend on income. Often poor people suffer the worst health. In Australia, even though indigenous communities often suffer the poorest health, they may be able to pay only small amounts of money for improved health.

Second, even if willingness to pay (WTP) values were averaged and assumed to be the same for everyone, a policy may disadvantage some people who receive no compensation. It is rare for a policy to have no adverse impact on anyone. Thus, policy makers are often interested in the distributional impacts of policies and analysts should provide this where they are an important issue, notably when the adverse impacts hurts less well-off groups.

7.3 Distributional Analysis

The basic process of distributional analysis consists of two main steps. First identify the social groups that matter. Second, working within the framework of the results of the CBA, estimate the impacts on these social groups. In practice, neither step is simple, especially the second one.

The community has to be divided into social groups because it is impractical to show the impacts on each individual. These social groups may reflect the interests of producers, consumers, people who suffer morbidities, or government. The groups may also be chosen to reflect ethnicity, income, age, sex, area of residence and so on. Often decision makers are especially concerned with local area impacts and call for a local area or region economic impact assessment.[9] Inevitably the selection of social groups involves a value judgement.

To estimate the incidence of costs and benefits it is important to work within the CBA framework because this ensures consistency between the CBA and the distributional analysis. However, this raises several issues.

First, as we have noted, a strict CBA would use WTP values that reflect individual ability to pay for goods and services including health. In practice, it is conventional to use average WTP values, especially for the value and quality of life, in CBA studies. This ensures that resources are not used to provide a better environment for the rich than the poor.

Second, because CBA is concerned principally with net social benefit, it may not explicitly include transfer payments such as indirect taxes or subsidies. An indirect tax, like the GST, increases the cost to the consumer but provides revenue to government. The GST has no net social impact and may be excluded from the presentation of costs and benefits. However, a distributional analysis should include transfer payments.

Third, final impacts may differ from initial impacts because impacts are shifted between groups. For example, increased production costs initially hurt producers. In practice a high proportion of increased costs is usually passed on to consumers, especially in domestic markets. It is more difficult to pass on the cost in export markets. When costs are borne by producers, the analyst may have to assess whether the cost is borne by shareholders or employees.

Fourth, CBA treats expenditures as costs (because expenditure has an opportunity cost) and generally includes only primary impacts. Suppose that expenditure on water quality increases local tourism, CBA may include the increased profits of tourism service providers as benefits but generally does not count the second round (multiplier) effects on other local firms.[10] This is because all expenditure is likely to produce some multiplier benefits. If the focus is on the local distributional impact, these local multiplier effects may be important. However, it is important to distinguish between the net economic benefit of a project to the community as a whole (which does not count expenditures as benefits) and the net economic benefit to the local area, which may include local benefits arising from expenditure financed by non-local authorities or firms.

Having estimated the distributional effects, it may be asked what should the analyst do next? The options are to present the distributional results as they stand or to produce a revised net social benefit figure that weighs the costs and benefit according to some welfare weighting. The CBA literature strongly favours the first option (Abelson, 2003). Indeed, it stresses the importance of presenting a transparent description of the distributional effects. There is no technical basis for estimating distributional weights, which should reflect social or political judgements. A single weighted NPV figure is a mixed efficiency / equity measure that has no clear meaning.

9 In Australia a general analysis of distributional impacts is usually called a distributional analysis or an incidence analysis, whereas an analysis of local impacts is called an economic impact assessment. By contrast, USEPA (2000) uses the term 'economic impact assessment' to describe general distributional analysis and 'equity assessment' to describe the impacts on a specific sub-population group.

10 Most CBAs are based on partial equilibrium models. A partial equilibrium model provides estimates of the costs and benefits of markets that are directly affected by an environmental intervention. A general equilibrium model estimates changes in output, prices and welfare of all economic sectors. This is desirable for a major policy change, such as the proposed Kyoto agreement on greenhouse gases. However, for most purposes partial equilibrium analysis is sufficient.

7.4 Resource Allocation and Priority Setting

Cost-benefit analysis has quite general applications in resources allocation and priority setting work. As Hadix et al (1996) state, cost-benefit analysis is used to:

(1) decide whether to implement specific programs,

(2) choose among competing options, or

(3) set priorities on options within resource constraints.

Any priority setting exercise involves resource allocation decisions and hence an analysis of the costs and benefits. If few data are available, a simplified cost-benefit analysis may still be useful.

However, cost-benefit studies do have some limitations (see Box 7.1). It may not be possible to quantify some important impacts, valuations depend on the distribution of income, and a cost-benefit study may be insensitive to political considerations (which may also be a strength).

Limitations such as those listed in Box 7.1 have led some economists to look for alternative models for some resource allocation decisions especially when data are not readily available. In a report for the Commonwealth Department of Health and Aged Care, Segal and Chen (2001) identify nine other methods for setting priorities for health care, for example including program budgeting and marginal analysis. They conclude that such methods can 'contribute to the prioritisation of health problems'. However, they also conclude that these methods 'fail to incorporate decision rules for priority setting in a situation of resource scarcity … and that they cannot provide a mechanism for adjusting health services mix towards optimal'.

These Guidelines concur with the Hadix et al (1996) view that CBA is the most general and powerful method of economic evaluation for dealing with resource allocation issues – which is most issues. Moreover, as Hadix et al observe, CBA 'is the only method that allows comparison of a *health* program with a *non-health* program in terms of economic resources'.

7.5 Implementation Principles

The resources required to carry out a comprehensive CBA of an environmental health issue are considerable. The issues are often multi-dimensional. They are rarely simply health issues. But even as health issues, they are often complex. There is often considerable uncertainty about health impacts. In practice, the resources committed to environmental health studies in Australia are generally modest compared with American studies or with the resources required to provide a comprehensive assessment.

Because study resources are limited, studies must focus on key issues. Analysts should carefully determine what issues are likely to be important economically, and politically, determine data

Box 7.1 Main Strengths and Limitations of Economic Evaluation

Strengths	Limitations
Based on a comprehensive theory of value	Value depends on distribution of income
Can include all important costs and benefits	May not be able to quantify some important impacts
Provides a means to compare costs and benefits	Does not allow for social judgements
Provides a weighting according to timing	May underestimate the value of future benefits
Can show distributional impacts	May ignore or hide distributional impacts
Can assess impacts of risky events	May not allow sufficiently for risky impacts

needs before rushing out to collect data, and ignore minor issues. In order to ensure that the study is acceptable to policy makers, the analyst should determine what policy makers consider to be the major and minor issues at an early stage in the study.

Analysts often have to adopt and modify benefit values found in other studies, especially research studies, rather than undertake a large amount of primary data collection and analysis. This is a legitimate and necessary activity, but care is required to ensure that the area from which values are transferred is comparable to the subject area of the economic evaluation.

Environmental health studies invariably require inputs from several disciplines. Managers of such studies sometimes commission the data collection and then call in an economist to prepare a CBA. When a CBA is the end product of a study, economic expertise should be employed at the start to establish the data to be collected. Otherwise unnecessary data may be collected and important data not collected.

A related role of the economic analyst is to ensure that there is no double counting of benefits. In environmental impact matrices, separate columns (or rows) are often included to represent physical impacts, ecological impacts and economic impacts (for example improved water quality, flora and fauna diversity, and recreational benefits, or improved water quality and improved health). This risks a double counting of benefits. In CBA, the end benefits are the source of value.

Finally, many benefits are uncertain. It is recommended that analysts should quantify and monetise benefits whenever plausible estimates can be made and use sensitivity tests to show how the results of the CBA may vary with alternative assumptions about benefit values. When there are insufficient data to justify monetising a benefit,

Box 7.2 What should users of economic evaluations look for?

In Chapter 2 we outlined the nine key steps in a full economic evaluation. Users of economic evaluations should use this list of steps as a checklist for any economic evaluation. The following are some other specific questions that a user of an economic evaluation may usefully check.

- Have the environmental health problems been clearly identified?
- Has an adequate and reasonable baseline scenario been identified?
- Are alternative prevention strategies well identified and examined?
- Are the costs and benefits properly identified?
- Is the time frame well defined?
- Is the economic approach to the study clear and appropriate?
- Are there any major unknowns?
- Does the discount rate affect the results?
- Are the risks adequately identified and the implications addressed?
- What are the distributional implications of alternative strategies?
- Are the main results shown clearly?
- Are the data shown or available so that another party can check the results?

the analyst should state explicitly that this possible benefit has not been included in the CBA.

7.6 Economic Evaluation and Policy Making

Cost-benefit analysis is intended to assist policy making through the presentation and analysis of information. In order to be effective, economic analysis should be an integral part of the whole policy development process. Economic analysts should participate in an interactive way with policymakers, administrators and other professionals from the preliminary evaluation of potential options through to the final economic report. The value of economic analysis is greatly enhanced if officials understand the contribution of economic analysis at an early stage of policy development and do not request an economic analysis at the end of the study process simply to justify a project to the relevant treasury department.

Although economic evaluations often focus on single number (NPV) results, in order to be credible and influential, economic analyses should describe clearly and fully important data sources, references, assumptions used and their justifications. The presentation must be clear and transparent, the derivation of the output clear, and the results testable.

As far as possible, an economic evaluation should monetise the effects of a policy and should describe the major components of total cost and benefit. This helps policy makers to compare the various elements of cost and benefit. Of course, this presumes that the physical effects of environmental impacts can be quantified, generally by other disciplines.

The economic evaluation should also present the non-quantified effects of policy options and an analysis of the sensitivity of the results to plausible variations in the variables.

When important benefits cannot be quantified, it may be necessary to adopt a cost-effectiveness method of evaluation. In this case the analyst estimates the cost of achieving a specified outcome of set of benefits, such as a physical level of air quality or years of life gained.

In many cases, policy makers will be interested in the distributional impacts of a policy. The analyst must take care to ensure that the results of the distributional analysis are consistent with the economic evaluation. For example, the distributional analysis should measure the net benefit or cost to each social group and generally treat expenditures as costs rather than as benefits.

The Nature of Environmental Health Issues

A.1 The Scope of Environmental Health

Environmental health is about creating and maintaining environments that promote population health. Human health determinants include physical, chemical, biological and social factors in the environment.

The practice of environmental health covers 'the assessment, correction, control and prevention of environmental factors that can adversely affect health, as well as the enhancement of those aspects of the environment that can improve health' (enHealth Council, 1999). In order to achieve good population health, environmental health is concerned with both:

- the prevention or minimisation of environmentally related disease and injury; and
- the promotion of health through the maintenance of a *natural* and *built* environment that is conducive to health.

Following WHO (2000), environmental health issues can be classified as follows:

- Water, hygiene and sanitation
- Food safety and food standards
- Vector borne disease control
- Waste disposal
- Contaminated land
- Housing conditions and the built environment
- Air quality
- Climate change and ozone depletion
- Occupational safety and health
- Noise pollution
- Healthy ecosystems
- Other

This annex describes the main issues arising in each of these areas and the health and other environmental impacts that occur in a polluted environment.[11] As will be seen, it is often not possible to separate health effects from other effects. Environmental policies must therefore address the range of possible impacts that can occur.

A.2 Main Environmental Health Issues

Water, Hygiene and Sanitation

An ample supply of safe potable water is the most critical determinant of health, both for consumption purposes and to assure hygiene. As the cryptosporidium scare in 1998 in Sydney showed, safe water cannot be taken for granted. An adequate supply of safe drinking water requires good management of the catchment and storage areas for supplies of potentially potable surface water and good treatment of the water supply, including disinfection and testing.

Recreational water safety is also important. Recent examples of failure include the outbreak of cryptosporidium in ACT swimming pools and blue green algal blooms in waterways.

Appropriate disposal of wastewater is critical in maintenance of good health. The outbreak of hepatitis A due to the faecal contamination of oysters in Wallis Lake exemplifies the dangers of water pollution. In remote areas of Australia, re-use of wastewater may also be important for water supply.

Food Safety and nutrition

While a source of vital nutrition, food can also be a source of disease and mishap. Food must be

11 enHealth Council (1999) provides a fuller description of environmental health issues in Australia.

protected from microbiological contamination, toxic substances and sharp objects and must be sold with sufficient information for consumers to choose their nutritional components, and avoid specific undesirable components, for their own diet. The principal objective of food regulation is to maintain a safe and suitable food supply and enable consumers to make informed choices.

Food standards determine what a food may or may not contain, and includes issues relating to genetic modification and permission for the use of processes such as irradiation. Standards are developed constantly to meet the changing desires of consumers and the food industry. The process aims to ensure a safe and wholesome food supply, while allowing industry innovation.

Food safety standards aim to ensure that food is kept free of contaminants that may render it unfit for consumption. This scope of this regulation is 'paddock to plate' with many participants, from the farmer to the retailer. Regulatory enforcement of food standards serves public health objectives.

Vector-borne Disease

Important vector-borne diseases current in Australia are Murray Valley encephalitis, Ross River virus disease and related viral diseases (Barmah Forest etc). Japanese encephalitis, dengue and malaria may emerge or re-emerge as serious problems in the future. Vector-borne disease could increase in Australia with the spread of vectors, the movement of infected human populations and climate change. Vector-borne disease is spreading rapidly worldwide for reasons that are not fully understood, but probably includes the high level of international travel.

Prevention of vector-borne disease in Australia relies predominantly on mosquito control and public education. Control for species of mosquitoes that are not already in Australia occurs at the quarantine barrier. For those species that are present, killing larvae is the only truly effective method, but it is not possible where there are large breeding areas around small populations. In such cases, 'fogging' with insecticide is used, with mixed success, to control adult (flying) mosquitoes.

Waste Disposal

In Australia, most aspects of waste management are well controlled. The important health issue is to separate humans from the toxic, putrescible and human wastes that they produce. Management of these wastes is organised around the three main waste streams:

- *Household and industrial waste*. Effective and safe removal and disposal is routinely undertaken for all except some remote rural dwellings.
- *Hazardous waste*, including chemical, radioactive, and some clinical waste. The technologies for disposal are well understood. However, disposal costs are often high and safe practices are not always followed. Problems may also arise when disposal sites are being developed or redeveloped. Minimising generation of hazardous waste is a priority for waste management agencies and for producers of such wastes.
- *Liquid waste* includes wastewater and sewage. It is generally safely and effectively managed, usually through reticulated sewerage and treatment.

Contaminated Land

Contaminated land is often linked to waste management as the clean up of contaminated land may generate large waste streams. Also the engineering technologies underpinning management of both are similar.

When there is no off-site contamination, the clean up of contaminated land is usually driven by a cost benefit process. The land is fenced and cleaned up when the value of the land warrants it.

However, off-site impacts through airborne effects or leakages into the water system may warrant a clean up of the site. The cost can be high, as it was for blue asbestos in Wittenoom and for lead in Broken Hill and Port Pirie. The polluting firm usually bears the clean up costs. However, in some cases, the polluter has long gone and government has to bear the cost of clean up.

Contaminated land is generally a legacy of past poor practice. Contemporary environmental standards should ensure that, once the legacy is dealt with, the issue is a minor problem.

Nevertheless, further contaminated sites are likely to be identified for some time.

Housing Conditions and the Built Environment

Adequate housing is a fundamental determinant of good health. People in low standard housing usually suffer the joint health problems associated with poor housing and low incomes.

The *Building Code of Australia* (BCA) establishes housing standards but the BCA often does not apply outside towns. Housing may be built, especially in remote indigenous communities, which does not comply with the BCA. Moreover, slums may occur in cities even when housing is constructed to BCA standards due to a failure to maintain proper standards of housing.

Many public health concerns are associated with housing. For example, fences are generally required for swimming pools in order to prevent drowning and temperature controls are required for water heaters to prevent scalding.

There are also concerns about the amenity of the built environment including but not restricted to housing. Factors such as alienation of the elderly, or creating safe and attractive environments for children, are issues where planners and architects are the key environmental health practitioners.

Air Quality

Environmental standards and practices have largely controlled harmful emissions from point sources, for example chimney stacks. These point sources now rarely constitute a substantial health risk in Australia. However, they may contribute to the overall level of pollution when, say, inversion occurs and a trapped layer of atmospheric pollution from many sources fails to disperse. Household wood-burning heaters sometimes cause problems from particulate emissions.

Diffuse sources of pollution, in particular vehicle emissions, which include carbon monoxide, oxides of nitrogen, sulfur dioxide and particulate matter, are more difficult to manage. The level of pollution constitutes a significant actual or potential health problem in large cities, mainly for the respiratory and cardiovascular system.

An air quality issue that causes occasional problems is the emission of Legionella bacteria from large air conditioning cooling towers. Control of these bacteria is difficult and standards in use have occasionally proven to be inadequate.

Indoor air quality is also important. Tobacco smoke is the most common and usually the most serious pollutant but other pollutants can be problematic, for example ozone from office machinery or gases given off by insulation in caravans.

Global Environmental Health Issues

Climate change presents many environmental health challenges, especially in planning for health in new generations. Global warming may substantially alter ecosytems and habitats. This may in turn increase the incidence of infectious diseases, particularly vector borne disease. The depletion of the stratospheric ozone layer increases solar radiation and cancers.

Noise Pollution

Noise affects hearing, amenity and wellbeing. There is a growing view that community noise can have harmful health effects at levels that do not cause deafness. Sleep disturbance, general annoyance, disturbance of normal speech, and mental disturbances are associated with excessive environmental noise, as well as the more serious and well-described deafness.

Other Environmental Health Issues

Other examples of environmental health issues include:

- *Chemical safety*. Chemicals are critical in many areas, for example food and water residues. All states and territories have public health legislation, usually separate from public health Acts, which control public exposure to chemicals of various types. The chemicals include medicines, use of pesticides, other household chemicals, particularly safe storage and use in the home; and public exposure to chemicals used in industry. The Commonwealth is increasingly regulating this area in an effort to achieve a national system of regulation.

- *Animal wastes*. Livestock waste is a major contaminant of water quality via catchment run-off. Domestic pet waste can also pollute water via urban run-off.
- *Radiation safety* is an important aspect of environmental health. Medical x-rays and radon in homes are sources of radiation.
- *Occupational health and safety* may also be regarded as a major environmental health issue.
- *Public assembly*. Large crowds, for example in major entertainment events or night clubs, can constitute a health problem.
- *Nuisance and amenity*. Nuisances include impacts such as odour and insects that in the main are just annoying but may also present a health hazard; for example stable flies (Stomoxys calcitrans).

Indigenous Environmental Health

Indigenous environmental health is a special case where many health problems are concurrent, with a consequential high incidence of disease in the indigenous community in many urban as well as rural and remote indigenous communities. As reported by the the enHealth Council (1999), the special problems of indigenous communities include:

- Poor respiratory conditions due partly to overcrowding in dwellings;
- Urinary tract calculi due to poor water supply;
- Infection by intestinal worms;
- Trachoma, which is related to both poor sanitation and poverty; and
- Infectious diarrhoeas.

Many factors, including poverty, disempowerment, and alienation, contribute to poor indigenous health. Consequently, specific cause and effect are difficult to identify. It is also difficult to show that addressing one condition will improve health when other conditions are not addressed simultaneously. This is a familiar problem in dealing with poor conditions in any country.

Despite evidence of some environmental health improvement, programs such as the training and employment of Indigenous Environmental Health Workers (EHW) have not thrived. Reasons are complex but are linked to reward, status, and sometimes to the failure of others in the community to respond to the efforts of the EHW. Consequently, the improvements have not been sustained. This issue was identified as a priority in the second Indigenous Environmental Health Workshop (a meeting of the EHWs), along with others issues such as food safety and quality, and housing.

A.3 Impacts of a Polluted Environment

Table A.1 lists the kinds of impacts that arise in a degraded environment. Following WHO (2000), hazards are divided into traditional and modern. Hazards producing an acute effect are traditionally recognized as hazards, whereas other hazards are now recognized as potentially harmful as a result of exposure to small amounts over a longer period of time or only after long period of disease development. The link between environment and health status is more difficult to prove if a disease does not manifest itself until a long time after an exposure or if the exposure history runs concurrently with that for other chemicals.

Another common distinction is between direct impacts on humans and indirect impacts on human welfare though systems and processes (US EPA, 2000). Direct impacts include mortality rates, the incidence of cancers, chronic and other illnesses, reproductive and developmental effects. Amenity impacts may also be experienced directly by humans. For example, the quality, taste and odour, of drinking water is a direct amenity effect. Impacts that affect human welfare through systems or processes include material damages and ecological effects.

Health Impacts

Environmental risk factors are important is determining the incidence of disease. Smith et al (1999) estimate that 25–33 per cent of the global burden of disease can be attributed to environmental risk factors, with children under five bearing the largest burden.

Table A.2 presents some main relationships between exposure situations and health

Table A.1 Location and types of hazard

Medium or location	Traditional hazards	Modern hazards
Water, food, sanitation	Lack of access to safe drinking water Food contamination with pathogens Disease vectors breeding Inadequate basic sanitation Drinking water pathogen outbreaks	Water pollution from urban areas, industry and intensive agriculture. Potentially, any environmental component capable of being taken up into foods eg heavy metals
Air	Infectious diseases Indoor air pollution from dirty fuel Industrial air pollution	Building materials, paints and solvents Urban air pollution from motor vehicles, coal power stations and industry
Workplace	Biological, chemical, radiation, mechanical and physical hazards (agricultural and cottage industries)	Biological, chemical, radiation, mechanical and physical hazards (production lines / modern products)
Other outdoor environmental	Inadequate solid waste disposal Road traffic accidents Natural disasters, including floods, droughts and earthquakes	Solid and hazardous waste accumulation Deforestation and land degradation Climate change and ozone depletion Road traffic accidents

Source: WHO (2000).

Table A.2 Potential relationships between exposure situations and health conditions

Health condition	Polluted air	Excreta & household wastes	Polluted water	Polluted food	Unhealthy housing	Global change
Acute respiratory infections	●				●	
Diarrhoeal diseases		●	●	●		●
Other infections		●	●	●	●	
Vector-borne diseases		●	●		●	●
Injuries and poisons	●		●	●	●	●
Mental health conditions					●	
Cardiovascular diseases	●					●
Cancer	●		●	●		●
Chronic respiratory diseases	●					●

Source: WHO (2000)

conditions. A polluted environment causes diarrhoeal diseases, acute and chronic respiratory infections, vector borne diseases, injuries, cardiovascular diseases and many forms of cancer.

Of the areas of environmental health outlined above, one that has received much attention in Australia is food borne disease, which is mainly microbial in origin. ANZFA (1999) estimated that there were 4.2 million cases of food-related illness annually which cost the Australian community $2.6 billion. More recently, according to a national study of gastrointestinal illness conducted by Ozfoodnet, there are over 5 million cases of food borne illness every year. The actual number of cases is higher than notified cases, as most people with food poisoning never attend a medical practitioner. Of those that do, few have satisfactory stool or vomit samples collected and tested.

Significant costs can also be incurred when there are suspected major health effects. Over several weeks, from late July to September 1998, Sydney Water detected high levels of *Giardia* and *Cryptosporidium* in some of its dams. Warnings were given to boil water over most of Sydney during much of that time. Although there was no evidence of any increase in infections from the organisms detected in the water supply during the period, the alert led to significant investment in water filters and use of energy for boiling water.

Health impacts due to a degraded environment are often difficult to estimate because of the long time frames involved. Illness is often caused or affected by many factors. For example chronic bronchitis can be caused or affected by many forms of air pollutants, tobacco smoking and so on.

Exposure to a specific environmental hazard may lead to a range of health problems. For example, high exposure to lead in adulthood may damage the blood, kidneys or reproductive system as well as impairing hearing, vision and muscle coordination.

Identifying the health impacts with reasonable accuracy is an essential condition for a robust economic analysis.

Other Environmental Impacts

There are many other environmental impacts. Ecosystems provide services that benefit humans: humans derive food, energy, building materials, technology and amenity from the earth's resources. An example of a defined system is a freshwater lake providing recreational and boating sites. A wetland may provide a service by being a breeding ground for fish and fowl. On a more global scale, the water cycling system provides the regional rainfall.

Following the World Bank (1992), environmental effects may be broken down into health, productivity, and amenity effects. Productivity effects are ecological impacts that affect the human use of natural resources, for example improving commercial fishing, increasing agricultural yields, and enhancing recreational opportunities.

Amenity effects of the environment include taste, odour, appearance and visibility. The costs or benefits associated with these factors depend on how the senses are affected and how individual welfare is affected. The impacts depend in the value of sensory experiences rather than on physical or material effects. These issues given little attention (see the case study on sulfur dioxide emissions in Mount Isa).

Of course, benefits are often interrelated. An improvement in air quality may simultaneously reduce diseases associated with airborne contaminants and improve visibility. An improvement to drinking water may reduce health risks and improve the odour and colour of drinking water. These interrelationships make it difficult to separately value health and aesthetic effects.

There are several examples of productivity impacts as well as health costs in recent food-borne disease outbreaks in Australia. These include:

- the Garibaldi mettwurst case in South Australia, in which 150 cases, including 23 serious cases in children and one death, were reported, and the company was closed down;
- a salmonella outbreak from peanut butter which resulted in total withdrawal of that brand and later re-launching by Kraft;

- the Wallis Lake oyster incident in 1997, which had a direct effect on the food supply and population health, caused some 440 cases of hepatitis A and one death, affecting the sale of oysters and other seafood.

The important point is that in order to evaluate a change in environmental states, all effects, not only health effects, should be taken into account.

Ecological effects may also provide passive benefits, sometimes described as 'non-use' benefits. These arise from a variety of motives including, for example, a person's own utility from knowing that cleaner sources exist or will be preserved for future generations.

In principle, non-use benefits should be included in a benefit-cost calculus. However, because non-use benefits do not involve any consumption, or indeed any action by the individual, they are more difficult to value than are use benefits.

A.4 Summary

The aim of environmental health policy is to improve the environment and so to improve population health. This annex has described the many ways in which a degraded environment can cause illness. Water and air pollution, inefficient waste disposal, poor compliance with food standards, vector borne disease and poor housing conditions are major causes of poor health.

A degraded environment can also cause other problems, notably a loss of productivity and amenity. In order to evaluate a policy that improves the environment, all the benefits of environmental improvements should be taken into account.

However, it is not sufficient to establish a general case for environmental improvement. In an evaluation of proposed environmental health policies, the circumstances of each situation, the benefits to be achieved and the costs that are incurred by a proposed policy change need to be taken into account.

Willingness to Pay and Willingness to Accept Measures of Value

Analysts should use willingness to pay (WTP) measures of benefits and resource costs. The value of a benefit, and the cost of a resource, are the maximum amounts that people are willing to pay for them. Technically, they are the maximum amounts that people are willing to pay for a policy change and be no worse off than *before* the change. This amount is known as the *compensating variation*.

The implicit assumptions underlying this approach are that individuals do not have prior claims on public environmental assets that provide services to them and that the level of utility *before* the policy change is the reference point.

Suppose that the environment is polluted, for example by a power plant producing sulfur dioxide (SO_2) emissions over residential areas. Taking the existing level of utility as the reference point, the analyst would estimate what people are willing to pay to reduce the SO_2 emissions and compare this amount with the costs of reducing SO_2 emissions.

An alternative way to view this issue is to take the situation *after* the policy change as the reference point. In this case, the lower level of SO_2 emissions would be the reference point. The analyst would then estimate the amount that a firm would be willing to pay to increase its emissions and compare this with the amount that households would require as compensation for the increase in emissions. When the reference point is the utility of households *after* a policy change, the benefits and costs are known as *equivalent variations*.

The issue may also be construed as one of property rights. If no one has prior property rights to the air, what people are willing to pay for clean air (or to pollute the air) represents the value of clean air or the value of the right to pollute the air. WTP values apply. If people have a property right to clean air, they must be compensated for the loss of clean air. WTA amounts apply.

This does not create an issue for evaluation when WTP and WTA amounts are similar, which is the case for small values. However, where a property right is valuable, there may be significant differences between WTP and WTA values.

Nevertheless, most economic literature recommends general use of WTP values for three reasons. (i) WTA values are difficult to determine. (ii) In most cases, when changes are small, WTP and WTA values are quite close. (iii) The environment is a general public good to which private property values do not apply.

However, it should be stressed that this is an important issue involving ethical as well as technical issues. From an ethical or political view, WTA values may be considered more appropriate than WTP values in some cases.

Time Discounting of Benefits and Costs

As discussed in Chapter 3, the technically correct discounting procedure is to use a shadow price for capital to reflect the value of consumption foregone and then to discount consumption benefits by the consumer rate of discount.

Suppose that an agency proposes a capital investment of $1000 that will produce $70 of benefits each year for 40 years. Suppose also that the producer rate of discount is 5 per cent (including tax paid to government) and that the consumer rate of discount is 3 per cent. There is no inflation. Would this be a viable investment?

If the producer rate of discount is 5 per cent, an investment of $1000 provides $50 per annum in perpetuity or $50 for 40 years with $1000 returned in year 41. Discounting the latter at 3 per cent per annum gives a present value of $1447. In other words, when the rate of return foregone is 5 per cent, an investment of $1000 for 40 years is equivalent to giving up consumption with a present value of $1447.

Discounting $70 of benefits per annum over 40 years with a discount rate of 3 per cent produces a present value of consumption gained of $1592. The net present value of the project is therefore $145 ($1592 – $1447). The project is economically viable.

Alternatively, suppose that the initial capital investment of $1000 stands and that the stream of benefits is discounted by 5 per cent. The present value of the benefits is $1189 and the net present value of the project is $189 ($1189 – $1000). Again the project is viable.

In general, if 100 per cent of the capital expenditure invested in a project represents other capital expenditure foregone, using the producer rate of discount provides the same result for project viability as does the use of a shadow price of capital along with the consumer rate of discount.

Suppose that a project has a capital cost of C and a perpetual stream of annual benefits (b). Discounting the benefits by the consumer rate of discount (r), the present value of the benefits is given by:

$$PV(b) = b/r \qquad (C.1)$$

If we turn to the capital cost and discount the perpetual stream of benefits foregone in an alternative project by r, the present value of these costs is:

$$PV(C) = (C \times p) / r \qquad (C2)$$

where p is the producer rate of return. Therefore a project has a positive net social benefit if

$$b/r > (C \times p) / r \qquad (C.3)$$

$$\text{or} \quad b > (C \times p) \qquad (C.4)$$

In words, if the consumer rate of discount is applied to both benefits (consumption gained) and costs (consumption foregone), a positive net present value requires that annual benefits exceed the product of the capital invested and the producer rate of discount.

Resources for Economic Evaluations

The literature on cost-benefit analysis, environmental and health economics is voluminous. These Guidelines themselves contain many references to all aspects of economic evaluation methodology and valuation. For example Chapter 5 cites many references to the valuation of costs in Australia and internationally.

Australian Resources

In Australia, the Australian Institute for Health and Welfare is the major source for national data on the incidence of disease and injury, health care costs, and QALYs. (See www.aihw.gov.au). Chapter 5 provides further references.

Within Australia, all Commonwealth and State departments of health and the environment have informative web sites. Further general info on the work of the National Public Health Partnership see http://www.nphp.gov.au/, or for the enHealth Council see
http://enhealth.nphp.gov.au/

The state health departments generally provide useful information about environmental health issues (see especially publications). For example, if the reader wants to find out about the Ross River virus, which was a possible case study for these Guidelines, several web sites contain data and literature on the topic. The environment departments have data on environmental quality. The NSW EPA has also published a particularly useful and wide-ranging literature survey on environmental valuations, entitled *Envalue* (http://www.epa.nsw.gov.au/envalue/).

The Commonwealth Department of Health and Ageing's web site contains the following two major directories dealing with environmental health.

The *Directory of Environmental Health Data* is an audit of routinely collected environmental health data and identifies results from regular ongoing monitoring of environmental health factors. See http://www.health.gov.au/pubhlth/strateg/envhlth/database1.htm.
Categories include vectors, air, water, climate change, land and noise. The data base allows the user to read, search, copy and print.

The *Directory of Environmental Health Standards, Guidelines and Report* contains a review of environmental health information. An audit was conducted on environmental health standards and guidelines and other publications held within local, state and Commonwealth governments, and advisory and expert bodies. The database allows the user to search for reports, journal articles, standards and/or guidelines on a range of environmental health issues, including air, water, climate change, waste, noise and many more topics.

See http://www.health.gov.au/pubhlth/strateg/envhlth/database2.htm.

The enHealth Council has published a range of documents that are available from its website http://enhealth.nphp.gov.au/council/pubs/ecpub.htm.
In particular, the following documents are of relevance to economic evaluation:

- *National Environmental Health Strategy*. Commonwealth of Australia, 1999.
- *National Environmental Health Strategy Implementation Plan*. Commonwealth of Australia, 2000.
- *Health Impact Assessment Guidelines*. enHealth Council, 2001.
- *Environmental Health Risk Assessment: Guidelines for Assessing Human Health Risks from Environmental Hazards*, enHealth Council, 2002.

Other Australian resources include '*Communicable Diseases Intelligence*' that is published by the

Communicable Diseases Network Australia. This is available through the web site
http://www.health.gov.au/pubhlth/cdi/cdihtml.htm.
It describes the most serious infectious disease issues in Australia (environmentally or otherwise acquired). It has reported outbreaks of legionella, for example, although not the major incident at the aquarium, see: Formica N et al. 2000. *Legionnaires' disease outbreak: Victoria's largest identified outbreak*. Comm Dis Intell 24:199–202.

The *NSW Public Health Bulletin* usually contains information on any major public health issue that occurs in NSW. Available on the internet at
http://www.health.nsw.gov.au/public-health/phb/phb.html

Information on food safety, food hygiene and food standards are available from the Australia New Zealand Food Authority (ANZFA). The ANZFA publication *'Food Safety Standards Costs and Benefits: an analysis of the regulatory impact of the proposed national food safety reforms'* is available through their web site:

http://www.anzfa.gov.au/mediareleasespublications/publications/foodsafetystandardscostsandbenefits/index.cfm

International Resources

Information on emerging infectious diseases is available on line from the National Center for Infectious Diseases, Centers for Disease Control and Prevention, Atlanta, USA at
http://www.cdc.gov/ncidod/EID/index.htm

Internationally, *Guidelines for Preparing Economic Analyses* (US EPA, 2000) provides a major resource. The US EPA spent five years from 1996 to 2000 preparing these Guidelines, drew on over 50 persons to provide primary inputs to the Guidelines and obtained reviews from 15 leading US environmental economists. The US EPA Guidelines are more technical and place less emphasis on health than our Guidelines, and of course have a different geographical perspective. However, the US Guidelines provide an outstanding resource for any Australian analyst carrying out an environmental health CBA. They also contain a very large literature base, including extensive data on the value of life and morbidity costs. See http://yosemite.epa.gov/ee/epa/eed.nsf/pages/homepage?Opendocument. This web site also contains many studies of environmental policies.

Another useful reference is *Considerations in Evaluating the Cost-effectiveness of Environmental Health Interventions* prepared by the World Health Organisation (WHO, 2000) (http://www.who.int/environmental_information/Disburden/WSH00-10/WSH00-10TOC.htm). This provides an overview of the environmental health literature, numerous references, discussion of benefit and cost estimations, and of the treatment of time and uncertainty. The discussion and references are usefully structured around the main environmental health interventions in water quality, food safety, vector control, waste management, air pollution, and occupational safety.

Other WHO Publications are sometimes useful though often targeted at underdeveloped economies rather than OECD countries (see http://www.who.int/home-page/). See also http://www.who.int/peh/Burden/burdenindex.htm for discussion of the amount of disease from the environment; cost effectiveness documents are at
http://www.who.int/peh/Burden/costeff.htm

Also information on climate change and health can be found at
http://www.who.int/peh/climate/climate_and_health.htm

There are many references for cost-benefit analysis. *Cost-Benefit Analysis: Concepts and Practice* by Boardman, Greenberg, Vining and Weimer (2001) provides an excellent starting point. This is a recent and up-to-date text written in an accessible style. It has a strong focus on valuation issues and practices. It also provides an extensive bibliography on relevant subject matter, including air pollution, water supply and pollution, noise pollution, waste disposal, hazardous waste, and public works.

Glossary

Benefit-cost ratio
The ratio of the present value of a stream of benefits to the present value of a stream of costs for a particular project.

Consumer rate of discount
The interest rate at which consumers are willing to lend

Consumer surplus
The difference between the maximum amount that a consumer is willing to pay for a good and the amount that he actually pays.

Contingent valuation
A method of eliciting individual valuations by asking people how much they value something

Cost-benefit analysis
A method of evaluation that attempts to measure all benefits and costs using a single monetary metric

Cost-effectiveness analysis
The cost of achieving a given output

Cost of illness
The loss of earnings associated with morbidity

Cost-utility analysis
Cost per unit of health benefit

Discount rate
The weight used to discount future benefits and costs

Disability adjusted life year
A measure of health status where 0 is perfect health and 1 is complete disability (death)

Financial analysis
Analysis of financial transactions of a particular entity

Fixed cost
Costs that are held constant, independent of the level of production and the time frame of analysis

Marginal benefit
Additional, extra or incremental, benefit.

Marginal cost
The incremental cost of producing one more unit of output. Also known as variable or avoidable cost

Marginal revenue
The additional revenue obtained with the sale of one more unit of output.

Net present value
The estimated value of a stream of benefits net of costs discounted to present value terms

Net social benefit
Total benefit less total cost

Opportunity cost
The real marginal cost of a resource or action. It is the value foregone by using the resource, or by acting, in one way rather than another.

Present value
The capital value now of outcomes occurring in the future

Producer rate of discount
The interest rate that firms are willing to pay for capital

Producer surplus
Producer profit over and above all payments required for all factors of production

Quality adjusted life year
A measure of health status where 1 is perfect health and 0 is complete disability (death)

Revealed preference approach
Inferring willingness to pay values from people's behaviour

Stated choice
A method of eliciting individual valuations by asking people to rank alternatives

Third parties
People who are not consumers or producers of a subject service

Transfer payment
A payment from government to an individual that is independent of the performance of any service

Value of a life year
The value of a healthy life year

Value of statistical life
The average value of life for someone aged about 30

Variable costs
Costs that change in response to changes in the level of output produced by a firm

Willingness to accept
The minimum amount that an individual will accept as compensation for some loss

Willingness to pay
The maximum amount that an individual will pay for a benefit

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enHealth Council Publications

N.B. Any monographs published before 1999 were produced by the National Environmental Health Forum, which the enHealth Council has replaced.)

Foundation Documents

The National Environmental Health Strategy 1999
The National Environmental Health Strategy Implementation Plan 2000

Human Environment Interface

Water Series

Guidance for the control of Legionella (1996)
Guidance on water quality for heated spas (1996)
Guidance on the use of rainwater tanks (1998)

Soil Series

Health-based soil investigation levels, 3rd ed. (2001)
Exposure scenarios and exposure settings, 3rd ed. (2001)
Composite Sampling (1996)

Metal Series

Aluminium, 2nd ed. (1998)
Zinc (1997)
Copper (1997)

Air Series

Ozone (1997)
Benzene (1997)
Sulfur dioxide (1999)

Exposure Series

Child activity patterns for environmental exposure assessment in the home (1999)

General Series

Pesticide use in schools and school grounds (1997)
Paint film components (1998)
Guidelines for the control of public health pests – Lice, fleas, scabies, bird mites, bedbugs and ticks (1999)

Counter Disaster Series

Floods: An environmental health practitioner's emergency management guide (1999)

Environmental Health Justice

Indigenous Environmental Health Series

Indigenous Environmental Health No. 1 (1999)
Indigenous Environmental Health No. 2 (2000)
Indigenous Environmental Health No. 3 (2001)

Environmental Health Systems

National standard for licensing pest management technicians (1999)
Environmental Health Risk Perception in Australia (2000)
Health Impact Assessment Guidelines (2001)

You can obtain copies of the above publications from:
http://enhealth.nphp.gov.au/council/pubs/ecpub.htm
or ph. 1800 020 103 and ask for extension 8654.

Terms of Reference and Membership of the enHealth Council

The enHealth Council, a subcommittee of the National Public Health Partnership, brings together top Environmental Health officials at the Federal and State/Territory level along with representation from the Australian Institute of Environmental Health, the environment and public health sectors, the Indigenous community and the wider community. The Council has responsibility for providing national leadership, implementation of the National Environmental Health Strategy, forging partnerships with key players, and the development and coordination of advice on environmental health matters at a national level. The advice development process is strongly based on collaboration and consultation.

Terms of Reference

1. Provide national leadership on environmental health issues by:
   i) coordinating and facilitating environmental health policies and programs
   ii) establishing strategic partnerships between environmental health stakeholders
   iii) setting priorities for national environmental health policies and programs
   iv) providing an open consultative system for policy development
   v) facilitating cost effective use of environmental health resources
2. Drive the implementation of National Environmental Health Strategy
3. Provide guidance on national environmental health issues to Commonwealth, States and Territories, and Local Governments, and other stakeholders
4. Undertake the development of environmental health action plans at the national level and facilitate their development at a local and state level.
5. Promote and develop model environmental health legislation, standards, codes of practice, guidelines and publications.
6. Strengthen the national capacity to meet current and emerging environmental health challenges.
7. Provide a pivotal link between international fora and environmental health stakeholders in Australia and strengthening Australia's collaboration with countries in the Asia-Pacific region.

Membership

Chair

Mr Michael Jackson, Executive Director – Population Health, Health Department of WA.

Members

State and Territory Health Department representatives:

Australian Capital Territory
Manager Health Protection Service

New South Wales
Director Environmental Health

Northern Territory
Program Director Environmental Health

Queensland
Manager Environmental Health

South Australia
Director Environmental Health

Tasmania
Director Environmental and Public Health

Victoria
Manager Environmental Health

Western Australia
Director Environmental Health

New Zealand
New Zealand Ministry of Health

Commonwealth Department of Health and Ageing – Director of Environmental Health

Australian Institute of Environmental Health

Environment Australia

Public Health Association of Australia

Australian Consumers' Association

National Indigenous Environmental Health Forum

Australian Local Government Association

Aboriginal and Torres Strait Islander Commission

National Health and Medical Research Council.

Secretariat

Services provided by the Environmental Health Section of the Commonwealth Department of Health and Ageing.