Centre for Development, Environment and Policy

P106

Environmental Valuation: Theory, Techniques and Application

Prepared by Alberto M Zanni and Laurence Smith

This module is partially based on the earlier module:

*Environmental Valuation: Theory, Techniques and Applications*, prepared by Iain Fraser and Laurence Smith in 2009 and partly revised by Alberto Zanni and Laurence Smith in 2014, which itself was based upon:

*Environmental Valuation: Theory, Techniques and Applications*, prepared by Helen Bright, Uwe Lohmann and Jamie Morrison in 2002.
ABOUT THIS MODULE

The main issues of this module relate to the ways in which economic values can be placed on the environment, enabling environmental issues to be included in economic decision-making. Methods based on economic theory have been devised to assign monetary values to environmental goods and services, and these values can then be incorporated into decision-making at the project, sectoral and national levels. Although the methods and techniques which this module introduces represent the mainstream approach to environmental economic decision-making, there are many criticisms of such an approach, and the module also addresses these concerns and outlines alternative approaches to analysing economy–environment links.

The module first introduces the concept of environmental valuation and its motivations. The different measures of welfare change, such as consumer surplus, willingness to pay and willingness to accept are then introduced, in order to provide a theoretical basis for environmental valuation. The components of environmental economic value are analysed, with distinctions made between use values and non-use values, including option values and existence values. Cost–benefit analysis is also explained in the first unit, in order to introduce the main project/policy evaluation method where environmental economic values are normally used in practice.

Later units introduce the techniques of environmental valuation and their policy applications. There are many techniques available for valuing the environment, either based on revealed or stated preferences. The main revealed preferences approaches examined include the dose–response and cost–based approaches, travel cost method and hedonic pricing methods. The stated preference approaches reviewed are the contingent valuation method and discrete choice experiments. The exploration of environmental valuation techniques concludes with a discussion of the benefit transfer approach.

The penultimate unit examines applications of environmental valuation in developing countries and in the framework of climate change, as examples of challenging contexts and where to apply the different methods. In the last unit, a brief summary of the module is first provided. Subsequently, criticisms of environmental valuation are considered and a range of alternative methods are briefly reviewed. The module concludes with a look at the future of environmental valuation.
STRUCTURE OF THE MODULE

The module consists of ten units which are divided into three parts.

Part I

Part I introduces the reader to the main concepts, ideas and theory of environmental valuation, as well as its motivations. This part of the module first makes the case for environmental valuation and then introduces the concept of economic value. A number of welfare change measures are then discussed in order to introduce the main concepts of willingness to pay (WTP) and willingness to accept (WTA), whose estimation is the purpose of environmental valuation. Part I also introduces cost-benefit analysis (CBA), the main method where elicited environmental economic values are used in practice. Its main methodological steps are briefly discussed, as well as its limits.

Part II

Part II covers the main approaches to environmental valuation, organised around the two main categories of revealed and stated preference methods. The material in this part of the module covers a wide array of methods that draw on the theory developed in Part I. We consider environmental valuation methods that can be used very rapidly as well as those which require far more work on the part of the researcher to collect and analyse data. Practical steps in the application of the different methodologies and a number of case studies are discussed along the theoretical dimensions. An important aspect of the material covered in this part of the module is that many of the statistical techniques employed in the research literature will take the reader beyond the methods they will typically cover in basic econometrics courses. Advice on appropriate methods will be provided.

Part III

Part III of the module first provides an insight into some of the most challenging contexts in which to apply environmental valuation methods, ie developing countries and climate change. The module is also summarised in Part III with a closer look at the links between the various topics covered. Finally, we discuss various moral and ethical criticisms of environmental valuation, and suggest and briefly assess possible alternatives to both the methods and the CBA framework. We then conclude with a brief look at the likely future for environmental valuation.
WHAT YOU WILL LEARN

Module Aims

- To compare critically and contrast different perspectives on valuing the environment.
- To present the development of the theory of environmental valuation.
- To explain a range of environmental valuation methods and techniques.
- To assess critically these valuation techniques.
- To provide illustrations of the application of the valuation techniques in practice.
- To discuss possible alternatives to the conventional environmental valuation method.

Module Learning Outcomes

By the end of this module, students should be able to:

- understand and assess critically the economic theory of environmental valuation
- understand and assess critically a range of environmental valuation methods and techniques
- understand and assess critically the application of valuation techniques in practice and relevant challenges
- understand and interpret critically the results of published environmental valuation studies
- understand and assess critically the possible alternatives to conventional environmental valuation methods.

The examination for this module will focus on these learning outcomes. In the module some detailed mathematical derivations relating to theory and to valuation estimates are provided, and some guidance on selection of econometric estimation methods appropriate for specific valuation techniques. This more advanced quantitative material is provided for students who have undertaken appropriate prior study of quantitative methods as guidance for application of certain valuation methods in practice. Detailed mathematical derivations and econometric estimation techniques will not normally be the subject of examination questions for this module.
**Assessment**

This module is assessed by:

- an examined assignment (EA) worth 40%
- a written examination worth 60%.

Since the EA is an element of the formal examination process, please note the following:

(a) The EA questions and submission date will be available on the Virtual Learning Environment (VLE).

(b) The EA is submitted by uploading it to the VLE.

(c) The EA is marked by the module tutor and students will receive a percentage mark and feedback.

(d) Answers submitted must be entirely the student’s own work and not a product of collaboration.

(e) Plagiarism is a breach of regulations. To ensure compliance with the specific University of London regulations, all students are advised to read the guidelines on referencing the work of other people. For more detailed information, see the FAQ on the VLE.
STUDY MATERIALS

For each of the module units, the following are provided.

Key Readings
These are drawn mainly from the textbooks, relevant academic journals and internationally respected reports. They are provided to add breadth and depth to the unit materials and are required reading as they contain material on which you may be examined. Readings are supplied as digital copies and ebooks via the SOAS Online Library. For information on how to access the Library, please see the VLE.

Further Readings
A number of Further Readings are also suggested. These texts are not provided in hard copy, but weblinks have been included. Further Readings are NOT examinable and are provided to enable students to pursue their own areas of interest.

We have not found a current textbook well matched to the content and level of exposition intended for this module, and hence emphasise the Key Readings above. Students may, however, find that explanations of specific valuation methods and their application in existing textbooks provide an additional useful source of Further Reading.

References
All references cited in the unit text are listed in the relevant units. However, this is primarily a matter of good academic practice: to show where points made in the text can be substantiated. Students are not expected to consult these references as part of their study of this module.

Self-Assessment Questions
Often, you will find a set of Self-Assessment Questions at the end of each section within a unit. It is important that you work through all of these. Their purpose is threefold:

- to check your understanding of basic concepts and ideas
- to verify your ability to execute technical procedures in practice
- to develop your skills in interpreting the results of empirical analysis.

Also, you will find additional Unit Self-Assessment Questions at the end of each unit, which aim to help you assess your broader understanding of the unit material. Answers to the Self-Assessment Questions are provided in the Answer Booklet.
In-text Questions

This icon invites you to answer a question for which an answer is provided. Try not to look at the answer immediately; first write down what you think is a reasonable answer to the question before reading on. This is equivalent to lecturers asking a question of their class and using the answers as a springboard for further explanation.

In-text Activities

This symbol invites you to halt and consider an issue or engage in a practical activity.

Key Terms and Concepts

At the end of each unit you are provided with a list of Key Terms and Concepts which have been introduced in the unit. The first time these appear in the text guide they are **bold italicised**. Some key words are very likely to be used in examination questions, and an explanation of the meaning of relevant key words will nearly always attract credit in your answers.

Acronyms and Abbreviations

As you progress through the module you may need to check unfamiliar acronyms that are used. A full list of these is provided for you at the end of this introduction.
TUTORIAL SUPPORT

There are two opportunities for receiving support from tutors during your study. These opportunities involve:

(a) participating in the Virtual Learning Environment (VLE)
(b) completing the examined assignment (EA).

Virtual Learning Environment (VLE)

The Virtual Learning Environment provides an opportunity for you to interact with both other students and tutors. A discussion forum is provided through which you can post questions regarding any study topic that you have difficulty with, or for which you require further clarification. You can also discuss more general issues on the News forum within the CeDEP Programme Area.
# Indicative Study Calendar

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<thead>
<tr>
<th>Part/unit</th>
<th>Unit title</th>
<th>Study time (hours)</th>
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<td><strong>INTRODUCTION TO ENVIRONMENTAL VALUATION AND THEORY</strong></td>
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<td>Unit 1</td>
<td>Environmental Valuation and Cost–Benefit Analysis</td>
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<td><strong>PART II</strong></td>
<td><strong>ENVIRONMENTAL METHOD APPROACHES</strong></td>
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<td>Revealed Preference – Dose–Response and Cost-based Methods</td>
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<td>Unit 3</td>
<td>Revealed Preference – Travel Cost and Hedonic Pricing</td>
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<td>Unit 4</td>
<td>Contingent Valuation: Theory and Survey Design</td>
<td>15</td>
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<td>Unit 5</td>
<td>Contingent Valuation: Analysis and Case Studies</td>
<td>10</td>
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<td>Unit 6</td>
<td>Discrete Choice Experiments: Theory and Survey Design</td>
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<td>Unit 7</td>
<td>Discrete Choice Experiments: Analysis and Case Studies</td>
<td>10</td>
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<td>Unit 8</td>
<td>Benefit Transfer</td>
<td>10</td>
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<td><strong>PART III</strong></td>
<td><strong>APPLICATIONS AND CRITICISM OF ENVIRONMENTAL VALUATION</strong></td>
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<td>Unit 9</td>
<td>Application Challenges – Developing Countries and Climate Change</td>
<td>15</td>
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<tr>
<td>Unit 10</td>
<td>Summary of the Module, Criticisms of Environmental Valuation and Alternatives</td>
<td>15</td>
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**Examined Assignment**
Check the VLE for submission deadline

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<td>Examination entry</td>
<td>July</td>
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<tr>
<td>Revision and examination preparation</td>
<td>Jul–Sep</td>
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<tr>
<td>End-of-module examination</td>
<td>Late Sep—early Oct</td>
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**ACRONYMS AND ABBREVIATIONS**

<table>
<thead>
<tr>
<th>Acronym</th>
<th>Description</th>
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<tbody>
<tr>
<td>AHP</td>
<td>analytic hierarchy process</td>
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<tr>
<td>ASC</td>
<td>alternative specific constants</td>
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<td>BT</td>
<td>benefit transfer</td>
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<tr>
<td>CBA</td>
<td>cost–benefit analysis</td>
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<td>CE</td>
<td>choice experiment</td>
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<td>CEA</td>
<td>cost–effectiveness analysis</td>
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<td>CIA</td>
<td>cost–impact analysis</td>
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<td>CL</td>
<td>conditional logit</td>
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<tr>
<td>CM</td>
<td>choice modelling</td>
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<tr>
<td>CpS</td>
<td>compensating surplus</td>
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<td>CS</td>
<td>consumer surplus</td>
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<td>CV</td>
<td>compensating variation</td>
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<td>CVM</td>
<td>contingent valuation method</td>
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<td>DCE</td>
<td>discrete choice experiment</td>
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<td>EIA</td>
<td>environmental impact assessment</td>
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<td>EOP</td>
<td>effect on productivity</td>
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<td>EPA</td>
<td>Environmental Protection Agency</td>
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<td>ES</td>
<td>equivalent surplus</td>
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<td>ESA</td>
<td>environmentally sensitive area</td>
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<td>ESP</td>
<td>Ecosystem Services Partnership</td>
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<td>ESVD</td>
<td>Ecosystem Services Valuation Database</td>
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<td>EV</td>
<td>equivalent variation</td>
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<td>FV</td>
<td>future value</td>
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<td>GDP</td>
<td>gross domestic product</td>
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<td>GIS</td>
<td>geographic information systems</td>
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<td>GP</td>
<td>goal programming</td>
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<td>HPM</td>
<td>hedonic pricing method</td>
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<td>HPV</td>
<td>hedonic pricing value</td>
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<tr>
<td>IIA</td>
<td>independence from irrelevant alternatives</td>
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<tr>
<td>ITCM</td>
<td>individual travel cost method</td>
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<td>LCM</td>
<td>latent class model</td>
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<td>LSA</td>
<td>life satisfaction approach</td>
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<td>MC</td>
<td>marginal costs</td>
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<td>Acronym</td>
<td>Description</td>
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<tr>
<td>MCA</td>
<td>multi-criteria analysis</td>
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<td>MD</td>
<td>marginal damage</td>
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<td>ME</td>
<td>measurement errors</td>
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<td>ML</td>
<td>mixed logit</td>
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<td>MNL</td>
<td>multinomial logit</td>
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<td>MOP</td>
<td>multi-objective programming</td>
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<td>MPC</td>
<td>marginal private cost</td>
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<td>MSC</td>
<td>marginal social cost</td>
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<tr>
<td>MXL</td>
<td>mixed logit</td>
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<tr>
<td>NGO</td>
<td>non-governmental organisation</td>
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<td>NL</td>
<td>nested logit</td>
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<tr>
<td>NOAA</td>
<td>National Oceanic and Atmospheric Administration</td>
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<tr>
<td>NPV</td>
<td>net present value (also present value (PV))</td>
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<tr>
<td>OECD</td>
<td>Organisation for Economic Co-operation and Development</td>
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<tr>
<td>OLS</td>
<td>ordinary least squares</td>
</tr>
<tr>
<td>PES</td>
<td>payments for environmental services</td>
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<tr>
<td>PFM/PF</td>
<td>production factor method/production factor</td>
</tr>
<tr>
<td>PS</td>
<td>producer surplus</td>
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<tr>
<td>PV (1)</td>
<td>present value (also net present value (NPV))</td>
</tr>
<tr>
<td>PV (2)</td>
<td>property value</td>
</tr>
<tr>
<td>RFF</td>
<td>Resources for the Future</td>
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<tr>
<td>RUM</td>
<td>random utility model</td>
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<tr>
<td>RUT</td>
<td>random utility theory</td>
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<tr>
<td>SCF</td>
<td>standard conversion factor</td>
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<tr>
<td>SEA</td>
<td>strategic environmental assessment</td>
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<td>SMS</td>
<td>safe minimum standards</td>
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<tr>
<td>SP</td>
<td>stated preference</td>
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<tr>
<td>SRTP</td>
<td>social rate of time preference</td>
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<tr>
<td>SSSI</td>
<td>site of special scientific interest</td>
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<tr>
<td>TCM</td>
<td>travel cost method</td>
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<tr>
<td>TE</td>
<td>transfer error</td>
</tr>
<tr>
<td>TEEB</td>
<td>The Economics of Ecosystems and Biodiversity</td>
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<tr>
<td>TEV</td>
<td>total economic value</td>
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<tr>
<td>TRNMP</td>
<td>Tubbataha Reefs National Marine Park</td>
</tr>
<tr>
<td>WESML</td>
<td>weighted exogenous sampling maximum likelihood</td>
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<tr>
<td>Acronym</td>
<td>Description</td>
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<tr>
<td>WTA</td>
<td>willingness to accept</td>
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<tr>
<td>WTP</td>
<td>willingness to pay</td>
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<tr>
<td>ZTCM</td>
<td>zonal travel cost method</td>
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</table>
UNIT INFORMATION

Unit Overview

This unit introduces the concept of environmental valuation and its motivations, as well as cost–benefit analysis (CBA), the method where elicited environmental economic values are generally used in practice. We first make the case for environmental valuation, and then introduce the concept of economic value. The main concepts of willingness to pay (WTP) and willingness to accept (WTA) are then discussed. In the second part of the unit, CBA is introduced, and its main methodological steps briefly discussed. The important issue of discounting is also treated in Section 2, as well as criticisms of CBA as an approach.

Unit Aims

- To introduce environmental valuation as an economic and policy practice.
- To evaluate critically the use of money as a common measuring tool in assessing environmental costs and benefits.
- To introduce the concept of willingness to pay (WTP) and willingness to accept (WTA) and their role in environmental valuation.
- To explain the conceptual basis of cost–benefit analysis (CBA).
- To outline the main methodological steps in undertaking CBA.
- To critically assess the importance of discounting in CBA.
- To introduce major criticisms of CBA as an aid to decision-making.

Unit Learning Outcomes

By the end of this unit, students should be able to:

- present arguments for and against the use of monetary values in environmental policy-making
- understand and critically assess how WTP and WTA measures can be used in environmental valuation
- understand and critically assess how CBA can help to provide clarity and insight with respect to complex environmental issues
- understand CBA and its main methodological steps and potential limitations.
Unit Interdependencies

Unit 2
In Unit 2 we describe and explain dose–response and cost-based approaches to non-market valuation. These methods are based on the specific motivations driving the demand for environmental values that we discuss in Unit 1. Values calculated from the methods discussed in Unit 2 are often used in CBA.

Unit 3
In Unit 3 we introduce and explain an additional two revealed preference methods: the travel cost and the hedonic pricing methods. Both approaches are based on the necessity of providing economic values to environmental goods and services, and take behaviour observed in existing markets to obtain economic values. Again, values obtained from these methods are often used in CBA.

Unit 4
In Unit 4 we introduce and explain the contingent valuation method. This approach to produce non-market valuation estimates is based upon a hypothetical market context, and is often used in CBA. This method allows us to place economic values on another important environmental asset: non-use values.

Unit 5
In Unit 5 we present and discuss practical applications of the contingent valuation method.

Unit 6
In Unit 6 we introduce and explain the discrete choice experiment (DCE) method. This approach produces non-market valuation estimates based upon a hypothetical market context. This method allows us to place economic values on non-use values. Values obtained from choice experiments studies are often used in CBA.

Unit 7
In Unit 7 we present and discuss practical applications of DCE method.

Unit 8
In Unit 8 we introduce the various approaches to benefit transfer and alternatives to the basic CBA. Benefit transfer takes non-market valuation estimates from existing studies and employs these in similar decision-making contexts. As with all the valuation methods examined, benefit transfer allows us to place economic values on the environment. Benefit transfer is often used in CBA application. In this unit we also look at alternatives to the traditional CBA framework.
Unit 9
In Unit 9 we examine how estimates of economic value of the environment are employed in two particular contexts: environmental valuation in developing countries, and valuing climate change. These are two very important and challenging contexts when attempting to attach economic values to environmental assets and perform CBA.

Unit 10
In Unit 10 we summarise the module and focus on criticism of environmental valuation techniques and CBA. Such criticism is often based on a different vision of value. In this unit we also discuss the institutional framework for environmental valuation in different countries and the political economy behind this. Consideration of these issues will enable us to better assess the necessity of estimating economic value for environmental assets.
**Key Readings**


  This paper provides a very neat overview of how economics and the environment are linked and how, in turn, this relates to environmental valuation. Specifically, the paper uses a very comprehensive example (agricultural landscape management options) to show how environmental valuation can be linked to environmental resource management that is informed by understanding the links between the components of the system. The need to understand these links arises because the ecosystem service approach explicitly links ecology and economics so that policies that impact an ecosystem are understood in terms of their impact on society and the environment.


  This paper provides an interesting discussion about the conflict between positive and normative justifications for CBA. It discusses various issues treated in this unit, such as the discrepancy between WTP and WTA and the issue of discount rate, in a comprehensive but very accessible way.


  This Key Reading is included to provide a practical illustration of concepts discussed in this unit. If you are short of time you should prioritise study of the unit itself and Key Readings above, before this reading. In this paper a framework for comprehensive integrated assessment of environmental projects is developed and applied. The framework combines theory with practice, bringing a pragmatic and efficient approach to the rigorous assessment of projects for a large number of environmental assets in the north central region of the state of Victoria, Australia. Key features of the study include extensive participation of decision-makers and stakeholders, integration of a comprehensive set of information about projects, explicit assessment of uncertainties and information gaps, and analysis of the most appropriate policy mechanism for each project.


  Chapter 6 (pp. 85–89) provides a very informative introduction to total economic value (TEV). It explains how the various components of economic value as they apply to the environment are defined and included in a measure of total economic value. Again, treat this Key Reading a second priority. Scan it more quickly at first to enhance your understanding of the components of TEV, and re-read it as part of your revision and examination preparation.
**Further Readings**


Chapters 1 and 2 (pp. 1–39) give a useful introduction to economic valuation of natural resources and the measuring of values, benefits and costs.


REFERENCES


**MULTIMEDIA**


In this podcast Alberto Zanni introduces this module. He provides an overview of its structure, aims, learning outcomes, methods of assessment and the learning materials. We recommend that you listen to this podcast before you commence your study of the module.

This audio file is available on your e-study guide.


In this podcast Alberto provides an overview of the aims, learning outcomes and content of Unit 1. You can listen to this podcast first as a means of gaining an introduction to the Unit, or later in your study to complement and review the material you have been reading.

This audio file is available on your e-study guide.
1.0 ENVIRONMENTAL AND ECONOMIC VALUES

Section Overview

This section discusses the reasons for economic valuation of environmental assets. Strengths and limitations of this approach are discussed. Subsequently, the concept of economic value is introduced, and its different components explained. This is followed by a brief theoretical discussion of willingness to pay (WTP) and willingness to accept (WTA) measures and their main use in environmental valuation. This section concludes with an overview of the main environmental valuation methods that will be reviewed and explained in this module.

Section Learning Outcomes

By the end of this section, students should be able to:

- understand and critically assess the motivations driving the demand for the generation of environmental values
- understand that the demand for environmental values is not universally accepted and that environmental valuation remains a controversial area of research and practice
- understand the difference between WTP and WTA
- be familiar with the difference between equivalent and compensating measures and how they relate to WTP and WTA.

1.1 Why value the environment?

Environmental economists face an ever-increasing demand for environmental values to be estimated. The important linkages between the environment and the economy are now more and more recognised, with the expressions ‘natural capital’ – the physical and non-physical aspects of nature providing value to humans, and ‘ecosystem services’ – the benefits humans derived, under various forms, from natural resources, used to describe and highlight the importance of natural resources for the economy (BES, 2015). Environmental issues are therefore taking an ever-greater prominence in the society and, by reflection, at the political and policy-making level, as well as having been integrated in regulation and law. In particular, environmental values are frequently asked for and used in cost–benefit analysis (CBA) exercises. These are carried out to analyse and appraise existing or future projects or policy schemes, and assess their contribution to the society’s welfare.

The use of economic values to inform environmental decision-making has become accepted and adopted by many institutions and organisations that have instituted environmental procedures and guidelines for public sector projects that emphasise the need for environmental valuation and cost–benefit analysis. For developing countries in particular, given the often even more important link between environmental assets and their economy, environmental valuation is becoming an increasingly important aspect of decision-making. Multilateral agencies such as the World Bank have initiated environmental valuation procedures and guidelines as an integral part of the planning process; and indeed, valuation exercises that are
transparent and provide information for policy-makers and the public are frequently a valuable approach to resource and environmental management.

Decisions on the viability and desirability of projects and policies need to take account of multiple issues or outcomes, and thus require consideration of multiple criteria. CBA provides a methodology through which multiple costs and benefits can be compared in a common unit of account, so long as they can be valued in monetary terms. Thus, environmental values have been introduced in CBA applications together with a wider range of societal benefits, such as quality of life, cultural value and equity. These are now often examined together with the more conventional economic objectives of income, jobs and economic growth. Assigning an economic value to the environment, as well as to other non-market goods and services such as culture or quality of life may seem inappropriate at first, but is a logical approach in seeking to create comparable metrics and better inform decisions in terms of economic outcomes.

A further argument is that valuing the environment will give environmental issues more weight and influence in decision-making. Issues not valued in monetary terms may be listed and considered, but may also be relatively neglected in terms of their importance. Expressing environmental change in terms of money can also be an effective means to communicate the importance of environmental issues to both affected populations and their decision-makers.

In this evolving policy environment, projects and new policy schemes are becoming more and more complex. For example, it has become increasingly important to produce evidence to support the design and implementation of environmental policy, based on comprehensive evaluation of any trade-offs between human economic activity and environmental degradation. Evidence can show how the natural environment may provide ecosystem services of very significant economic value.

Sound scientific evidence can also be an important means of raising awareness, improving understanding and helping to build consensus between competing groups. At the heart of much of this policy change have been many examples of policy analysis that weigh up the costs and benefits of the policy choices being confronted. As part of this process economists have experienced a growing demand on the part of policy-makers for evidence of the costs and benefits associated with environment change.

The key issue we face here is that the vast majority of environmental goods and services are not traded in markets. Indeed, many of the concerns expressed about the state and use of the environment are a result of the lack of prices with which society can express their preferences about and for the environment. It is inevitable that goods that are not priced may be overused and degraded. An example of this is the use of the atmosphere to dispose of waste gases. In response to this demand for prices that accurately reflect society’s preferences, economists have devised an array of techniques and methods for putting economic values on environmental goods and services that are not marketed in order to fully include them in CBA exercises. There is also a view that considers that environmental concerns have not been adequately addressed in the past because they have been ignored in CBA and, consequently, not taken into account when decisions were made and development planning formulated. The approach is reflected in the following statement:
'Our central message [...] is: economic (monetary) valuation of non-marketed environmental assets may be more or less imperfect given the particular asset together with its environmental and valuation contexts; but, invariably, some valuation explicitly laid out for scrutiny by policy-makers and the public, is better than none.'


Environmental valuation is not without controversy. There are still many environmentalists, politicians, as well as some economists (especially those normally referred to as ecological rather than environmental economists), who are uncomfortable, if not openly hostile, to the methods employed by other economists to undertake environmental valuation. Some of the criticisms are based on a reasonable assessment of the limits of the different techniques, some of which are accepted and acknowledged by their advocates as well. However, some of the criticisms stem from an ethical driven rejection of the use of economic value as a means with which to inform and undertake resource management, especially when valuation techniques clearly place themselves within the sphere of neo-classical economics (whose rationale assumes that individuals are self-interested in their motives and that social decisions should reflect what individuals want). The ever-growing concern for the environment in society, as well as for social justice and equity, has certainly increased the number of those looking for alternatives. The controversy could be lessened by pointing out that it is not the environment itself that is being valued, but individual preferences for environmental goods and services, these being a measure of the well-being (or utility) that those affected attach to these goods or services. Another often useful way to make environmental valuation more acceptable is to consider that what environmental economists are actually valuing is again not the environment itself, but rather its improvement or degradation, and they are therefore providing evidence to boost preservation or avoid further damages. Furthermore, use of non-market valuation and CBA gives weight to the interests of groups in society who may otherwise be excluded from decision-making processes, since not everyone has a well-organised lobby or access to legal and technical advisors.

In any case, individual preferences for the environment do not always narrowly respond to solely self-interested economic needs but are often motivated by a number of additional psychological and sociological factors, including altruism, intergenerational equity and the concern for the rights of non-human species. Value is a multi-dimensional concept, and individuals may include in their non-market valuation not only those elements arising from them being a direct or indirect user of the specific environmental good or service, but also an element of intrinsic value, as they perceive an obligation on society to protect the environment for its own sake and to conserve it for the future. The need to widen the array of motivations and attitudes shaping preferences that individuals and society display towards nature has therefore motivated the development of economic models considering a larger range of variables; thus also reducing possible sources of bias. Some of the criticisms directed at the concepts and methods of environmental economics can appear to be motivated by a limited appreciation and understanding of the recent evolution of applied economics.
For those methods based on surveys, advances in data collection techniques, and the widespread use of the internet, have allowed analysts and policy-makers to collect a vast amount of information to better inform the elicitation of value. These issues will continue to remain controversial. We shall explore them further in this introductory unit and will return to them later. What is important to understand is that the economics profession, and environmental (and ecological) economists in particular, view environmental valuation as an ever-evolving activity, and this makes this particular discipline an active and very exciting part of the study of applied environmental economics.

As you complete the study of this module, keep in mind this discussion of the merits of environmental valuation and see if you can add your own opinions and points to it. Form your own opinions on when and where the valuation techniques covered in this module can best be used.

1.2 Economic values

In economic analysis markets provide information on demand and supply flows, and on prices for many goods and services. Unless there are known distortions to correct for, such market prices can be taken as economic values. As we will see later, information from some markets can also be used to estimate the value of environmental goods and services. However, for a number of reasons, markets will often not provide the best means for valuation of goods and services supplied by nature. Environmental goods are often intangible; think, for example, about air quality or tranquillity (meant as absence of noise), the benefits of which while very obvious are very difficult to monetise. It is also very complicated, costly and impractical to apply property rights to many environmental goods. Think, for example, about the oceans, the air we breathe or the atmosphere. These, and other practical issues, have been reflected in what economic theory refers to as market failures:

- **Externalities** occur when actions carried out by an individual affect other people, who are neither compensated (in case of a loss), nor asked to pay (in case of a benefit). Obviously the individual has no monetary incentives to take into account the impact of his/her action on others.

- **Non-exclusions and the commons**: this describes the case of environmental goods for which it is impossible or not practical to deny open access, and some of their users can over-exploit the resources; in effect, hiding their inherent scarcity. This is the case of the open seas, for example, as for years over-fishing has kept the price of the fish relatively low with no link to real scarcity of the resource.
Non-rivalry and public goods: this is the case of environmental goods and services whose provision is non-rival (providing good air quality to one individual does not reduce the quality enjoyed by another one) and non-excludable (when it is not practical, and therefore too expensive, to exclude someone from the particular good). Again, in this case, property rights cannot be established, and market forces will neither deliver nor provide the true economic value of the environmental goods.

Because of the reasons listed above, non-market valuation becomes necessary, and economists have developed a range of methods to estimate economic values for non-marketed environmental goods and services.

Value is a fairly abstract concept, and its definition changes depending on the dimensions or perspectives that are being looked at. From an economic perspective, value measures the capacity of goods and services of satisfying human needs and wants. This can be achieved through both market and non-market goods, and the contribution of the latter (think about health, good air to breath, good scenes to view) to define human well-being has been recognised in economics. The theory still considers that people have well-defined preferences over different goods and services, and are therefore in the best position to carry out consumption choices. However, recent developments have supported the idea that market and non-market goods are, in most cases, substitutable, and if consumption of one market good reduces, increase in consumption of a non-market one can maintain the individual at the same level of utility; for this reason, individuals trade off among them.

We will return to the trade-off concept when explaining willingness to pay (WTP) and willingness to accept (WTA) in Section 1.3; but before that we need to introduce the concept of total economic value (TEV) (Turner, 2001).

Here we consider two main components of TEV (see figure in 1.2.1), but please note that not everyone is in agreement about the terminology and you may find some other classifications in other sources. The two main components we consider here are:

- use value
- non-use value.

Use value represents people’s willingness to give up money to use, or their willingness to accept monetary compensation for being unable to use, a particular environmental resource. This may include direct use (actual use), indirect use (for example buying items whose production process involve a particular natural asset) and option value, with the second being the value an individual places on the expected future use or non-use of an environmental good (note, some authors will classify option value as a form of non-use value). Non-use value, sometimes also referred to as passive use, represents people’s willingness to pay to keep a resource simply in existence, or their willingness to accept compensation for the resource ceasing to exist; both regardless of whether they currently use it or will do so in the future. In these cases, motivations arise from feelings of concern about the particular environmental amenities, in some other cases altruistic motivations play a role, with the individual worried about other people not being able to benefit from the amenities; and when these sorts of concerns refer to future generations we talk about bequest values. Having said that, please note there is no reason to assume that the various components of TEV are mutually exclusive.
1.2.1 Components of total economic value

An example can be useful at this point. Think about your own demands and preferences for an environmental resource, for instance a national park in your own country. If you are willing to pay a subscription to a conservation trust to preserve a park, is it because you intend to visit the park in the near future for wildlife viewing, bird-watching or general relaxation? Or is it because you know the park is being threatened with closure and you hope your subscription will help to keep it open, perhaps for future visits by yourself or your children? Or is it because you contribute to a number of environmental organisations and causes in a broader preservation effort, perhaps out of respect or sympathy for other living things, but you do not intend actually to make use of these national assets yourself?

1.3 WTP and WTA

(Explanations and graphical presentations in this section are mainly drawn and adapted from a previous version of this module study guide and the book by Freeman et al, 2014).

In the previous sections we briefly discuss why markets cannot be solely relied upon to provide a measure of economic value for environmental goods, and discussed what economic value is about. In this section we briefly look at the theory behind economic values, and we introduce the concepts of willingness to pay (WTP) or willingness to accept (WTA) compensation for changes in some environmental amenities. Theory assumes value is determined by, and must be an accurate reflection of, individual preferences and that these should be measured in monetary terms. WTP and WTA are therefore assumed to be a measure for preferences, and a positive preference for something will show up in a positive WTP for it. We can further assume that people will not be WTP for something that they do not want. Thus, the WTP concept gives an automatic indicator of preferences and is the foundation stone of environmental valuation. Another important implication of this
approach is that it is also assumed that societal welfare can be measured in monetary terms by adding individual monetary values. However, theory does not tell us what people like and how they like things, and for this we need empirical applications. Relying on individual preferences can be considered controversial, as discussed in the form of questions and answers below.

**If there is some sort of environmental degradation, but people do not care about it, then should it be given a high or low monetary value?**

*Answer*

According to the above assumption, in this case the monetary value should be small or even zero.

But, if people have strong preferences for keeping the environment as it is, then the monetary value put on environmental degradation should be large.

Clearly, the assumption that individuals’ preferences count is a value judgement, but if we can accept it (if we cannot, then environmental valuation becomes redundant) then the next question must be:

**How can these environmental preferences be revealed and measured?**

*Answer*

Economic theory provides the solution. As we have already discussed, the degree of satisfaction or level of economic welfare experienced by individuals can be measured in terms of the prices they were prepared to pay for the consumption of goods and services. Frequently, however, an individual consumes a good or service without actually paying for it. In this case the price that an individual would be willing to pay can be derived from survey data, or other means.

WTP and WTA are intended to measure preferences but their ultimate goal is to quantify the changes – positive and negative – in individual welfare coming from changes in the provision of environmental goods and services. But how do we get welfare measures from WTP and WTA? To do so, we need to revisit and refresh some concepts from microeconomic theory.

**Consumer surplus, compensating and equivalent variations/surpluses**

The basic measure of welfare is the change in the *consumer surplus* (CS). If you can recall the basic case of the consumer facing two goods and looking for the optimal consumption combination, changes in CS are measured graphically as changes in the area below the ordinary, uncompensated, or Marshallian demand curve (the curve showing the relationship between price and quantity demanded, with income kept constant) and above the horizontal price line, when there is a change in the price of one of the goods.

Now, CS can be an adequate measure of welfare change but does suffer from the fact that income (or more properly the marginal utility of it) is kept constant and it is therefore best suited to the cases of goods whose quantity purchased is independent from income, and for those where we are in possession of price information. This is
certainly a restrictive assumption that makes it problematic to use in comparative analysis, especially when considering consumers’ reaction to change in provision of unpriced environmental goods. Other alternative measures do exist; these are the compensating variation (CV) and surplus (CpS), and the equivalent variation (EV) and surplus (ES).

CV/CpS and EV/ES, in contrast to CS, are measured using the compensated or Hicksian demand curve, ie that showing the relationship between price and quantity demanded, with utility kept constant. The advantage of using the Hicksian framework relies on the fact that we can measure changes in income in the form of monetary incentive or compensation to maintain the same level of utility, and this makes it intuitively more appealing to the case of non-market goods, as in the case of environmental valuation.

But let’s see now what these compensating and equivalent measures precisely represent. Here we look at the case when an individual gains utility from all marketed goods and services and from the use of environmental quality. The environment is unpriced and as such the level of use is not determined by market forces, and increasing the level of environmental quality does not affect income. The relationship between the change in environmental quality and the price level of the other goods is a bit more complex though but we leave that aside for now, and we will get back to it when discussing the various valuation techniques.

1.3.1 Compensating measure of welfare change with an environmental improvement

\[ X(\text{all marketed goods or income}) \]

\[ CV/CpS \]

\[ x_0 \]

\[ x_1 \]

\[ q_0 \]

\[ q_1 \]

\[ U_0 \]

\[ U_1 \]

\[ BL_0 \]

\[ BL_1 \]

where

\( X \): all marketed goods/income
\( Q \): environmental quality
\( U_0 \): indifference curve giving level of utility \( U_0 \)
\( U_1 \): indifference curve giving level of utility \( U_1 \)
\( BL_0 \): initial budget line
\( BL_1 \): line parallel to \( BL_0 \) intersecting with \( U_0 \) at \( q_1 \) (point C)
\( A \): utility maximising combination of \( X \) and \( Q \), with quantity \( x_0 \) of \( X \) and quantity \( q_0 \) of \( Q \)
\( B \): utility maximising combination of \( X \) and \( Q \), with quantity \( x_0 \) of \( X \) and quantity \( q_1 \) of \( Q \).

Source: unit author
Now consider that there is an environmental policy proposal that, if implemented, would improve environmental quality from $q_0$ to $q_1$ (figure in 1.3.1). If the level of income remained the same, this policy would lift the individual onto a higher indifference curve $U_1$.

There are now two questions we can ask in order to try to measure the preferences of the individual for the move from $q_0$ to $q_1$.

1. What are you willing to pay to secure the move from $q_0$ to $q_1$?
2. How much would you be willing to accept if the proposed change did not occur?

The response to the first question lies in the concept of CV/CpS, explained in the following question.

**What amount shows the compensating measure of welfare change?**

**Answer**

The compensating measure of WTP is shown by $x_0 - x_1$ and tells us how much income the individual should be willing to give up to ensure that the improvement in environmental quality occurs.

Let’s now turn to the second question. The WTA approach poses the question of how much the individual would require if the proposed change did not occur, and the answer may be that amount that would still allow the individual to attain the higher utility level ($U_1$) although the improvement does not take place.

We can draw an indifference curve diagram to illustrate the WTA measure of welfare change that is the equivalent measure.

### 1.3.2 Equivalent measure of welfare change with an environmental improvement

![Diagram showing the equivalent measure of welfare change with an environmental improvement](image-url)
where

- \( X \): all marketed goods/income
- \( Q \): environmental quality
- \( U_0 \): indifference curve giving level of utility \( U_0 \)
- \( U_1 \): indifference curve giving level of utility \( U_1 \)
- \( BL \): budget line
- \( A \): utility maximising combination of \( X \) and \( Q \), with quantity \( x_0 \) of \( X \) and quantity \( q_0 \) of \( Q \)
- \( B \): utility maximising combination of \( X \) and \( Q \), with quantity \( x_0 \) of \( X \) and quantity \( q_1 \) of \( Q \)
- \( D \): utility that can be attained after EV/ES payment.

Source: unit author

The amount \( x_2 - x_0 \) in the figure in 1.3.2 gives the equivalent measure (the WTA measure of welfare change). We can now see that the two measures, compensating and equivalent diverge. The reason for this is the use of differing reference points. The reference point for the CV is the initial (lower) utility level. We assume that the environmental improvement occurs and then try to elicit the reduction in income that would bring the individual back to the initial utility measure. This is done to compute a measure of compensation needed from the individual to ensure the environmental quality improvement takes place. The reference point for the equivalent measure is the subsequent (higher) utility level. We assume that the proposed environmental improvement does not occur and try to elicit the amount of extra income (equivalent to the improvement of environmental quality in utility terms) the individual would require to stay just as well off in terms of utility.

In examining the issue with the two graphs we used the general terms compensating and equivalent measures, but how do we distinguish between variation and surplus type measures. The answer is simple and depends on what type of environmental variables we are dealing with. For the case of continuous environmental goods or bads – for example, the level of a pollutant – we talk about compensating and equivalent variation. In the case where consumers face discrete changes in the level of environmental quality – for example, they are asked to decide whether to release of not a green area for construction – we talk about equivalent and compensating surpluses. The graphical analysis for ES and CpS is the same as above, difference arises when utility functions have to be estimated, due to the discrete nature of the variables, but we will look at these later on in this module.

Now, let’s revisit the issues above in a relatively simple and intuitive but formal way. To do so, we use the indirect utility function first. So we have a consumer facing \( P \) prices for the market goods and spending income \( M \) on them. Imagine the level of environmental quality increasing from \( q_0 \) to \( q_1 \) (the corresponding notation for a discrete case should be \( q_i \) and \( q_j \)) and so what we are looking at is an amount of income \( M \) to be taken away from a consumer such that she remains at the initial (lower) level of utility, \( u^0 \):

\[
v(P, M, q_0) = v(P', M - CV, q_1) = u^0
\]

In the equation above, the amount we are referring to is the CV (or CS in the case of discrete goods). Another way of looking at this is to use the expenditure function
(that showing a consumer attempting to minimise total expenditure to achieve a given level of utility). That is, CV is equal to the difference between the expenditures necessary to maintain utility at $u^0$ for the level of environmental quality:

$$CV = e(P, q_0, u^0) - e(P, q_1, u^0) = M - e(P, q_1, u^0) > 0$$

It now follows that CV is defined as the difference between two levels of expenditure. The calculation of these measures involves deriving the expenditure functions and calculating surface through integrals. Because of its complexity, this is not treated in this module; you will however find a treatment of this procedure in most textbooks.

Let’s turn now to the equivalent measures. The reasoning is exactly the same as above, but we need to add the EV/ES to the amount of expenditure ($M$), and consider the new level of utility, as EV/ES describes the change in income necessary to enable the consumer to enjoy the same new utility generated by the change in environmental quality without this change to occur.

We have just used the case of an improvement in environmental quality, but what happens in case of environmental degradation. Again there are two alternative ways of addressing the valuation problem:

- First, to ask the question ‘How much money would you be willing to accept to compensate for the loss in environmental quality?’ For this question, the WTA concept is associated with the CV/CpS measure.

- Second, to ask ‘How much would you be willing to pay to avoid the loss occurring?’ For this question, the WTP concept is now measured by the EV/ES.

The table in 1.3.3, below summarises the welfare measures of a proposed change in environmental quality.

### 1.3.3 Welfare measures

<table>
<thead>
<tr>
<th>Proposed Change</th>
<th>Measure</th>
<th>Measure of welfare change — continuous</th>
<th>Measure of welfare change — discrete</th>
</tr>
</thead>
<tbody>
<tr>
<td>Welfare Gain</td>
<td>Environmental gain WTP to ensure change occurs</td>
<td>CV&lt;sub&gt;WTP&lt;/sub&gt;</td>
<td>CpS&lt;sub&gt;WTP&lt;/sub&gt;</td>
</tr>
<tr>
<td>Welfare Gain</td>
<td>Environmental gain WTA if gain does not occur</td>
<td>EV&lt;sub&gt;WTA&lt;/sub&gt;</td>
<td>ES&lt;sub&gt;WTA&lt;/sub&gt;</td>
</tr>
<tr>
<td>Welfare Loss</td>
<td>Environmental loss WTP to avoid loss occurring</td>
<td>EV&lt;sub&gt;WTP&lt;/sub&gt;</td>
<td>ES&lt;sub&gt;WTP&lt;/sub&gt;</td>
</tr>
<tr>
<td>Welfare Loss</td>
<td>Environmental loss WTA if loss does occur</td>
<td>CV&lt;sub&gt;WTA&lt;/sub&gt;</td>
<td>CpS&lt;sub&gt;WTA&lt;/sub&gt;</td>
</tr>
</tbody>
</table>

An important aspect of these measures is that, unlike CS, equivalent and compensating measures do not require an assumption about the marginal utility of income being constant. This is because they are measured along a constant utility (original) indifference curve. This brings us to a more detailed discussion over their differences and similarities.

The relationship between consumer surplus (CS) and compensating and equivalent measures

As you might expect there is a relationship between these various measures. Theory tells us that for a small price change or in the case when there is no income effect on demand the three measures are equivalent. For the case of a price decrease of a normal good (or increase in the quality level of a normal environmental good) EV > CS > CV; but there is indeed some evidence that differences among the three measures are often minimal in empirical applications under other circumstances. As discussed previously, CS is an adequate measure of surplus only under certain conditions, as being based on the Marshallian curves it only shows different combinations of demand and price levels, leaving aside income and preferences, while CV and EV are true measure of welfare. However, CV and EV are based on Hicksian demand functions, which are generally very complex to produce.

CS generally lies between EV and CV, and, if there is no income effect, the three measures are supposed to be equivalent. This does not always apply when considering environmental goods. However, when the data necessary to build Hicksian demand curves are not available CS can be considered an adequate approximation of both CV and EV. Nevertheless, researchers have developed complex techniques enabling the calculation of CV and EV from ordinary Marshallian demand functions, and the choice of which measure to use does depend on data and resources availability.

What is, however, more interesting for us is the divergence between CV and EV as measures of WTP and WTA.

1.4 Divergence between WTP and WTA measures

Intuitively, do you think that WTP and WTA measures for the same good should differ by very much?

Answer

Economic theory suggests not, but empirical studies have often revealed marked differences between the two measures.

Obviously it is important to understand why the two measures may be different as choosing one or another in empirical analysis could bias the values obtained. There is a lot of literature attempting to explain the difference between the two measures, and new empirical evidence in different contexts is continuously added. Here, we briefly list the main reasons identified in the literature (Freeman et al, 2014):

- Disparity seems to be partly linked to experience of the good in question, with highly experienced individuals displaying lower disparity in their responses.
• WTP is restricted by an individual’s ability to pay (income), while WTA is not. It is therefore reasonable for WTA to be higher than WTP in practice.
• There is evidence that the fewer the number of available market substitutes for the non-market environmental good (so that the specific good would be difficult to replace if lost), the greater the divergence between WTA and WTP.
• Finally, there is evidence, initially coming from the psychology literature, that individuals tend to value the loss of something they already have more highly than the gain of something they do not yet have, and this should explain most cases of WTA being higher than WTP. This is referred to as the ‘loss aversion’ or ‘endowment effect’.

Because of the last two reasons in particular, analysts and policy-makers, as well as other stakeholders, should not dismiss large WTA values as being an overvaluation of an environmental good. These could indeed be a signal of legitimate measures of preference for unique, non-replaceable and essential environmental assets.

1.5 A brief overview of environmental valuation methodologies

We have discussed the motivations for eliciting an economic value for environmental assets, and explained the theory behind the WTP and WTA welfare measures of value. But before treating the cost–benefit analysis method, we briefly introduce here the environmental valuation methods that are available and will be discussed in this module.

We use here the classification used in most textbooks. This is based on the source of the data used to infer value for environmental goods and services.

** Revealed preference methods**

These methods elicit values for environmental goods and services by looking at actual behaviour by individuals or organisations. Prices, goods and services purchased, trips undertaken, are some of the examples of the information that may reveal the value individuals attach to particular environmental assets.

Among the revealed preference methods we can find:

• **Dose–response approaches:** these are methods which rely on the analysis of the physical relationship between environmental factors and markets. The effect on productivity and human capital are two examples of these methods.

• **Cost-based approaches:** these methods rely on actual or potential cost incurred by consumers, and link those to desired or undesired environmental change.

Both the dose–response and cost-based approaches provide analysts and policy-makers with a relatively simple way of assigning a value to environmental goods, especially in the case where information is scarce. They can be an effective help to decision-making and to inform the design of environmental policies. They have, however, limited capability to produce theoretically compliant welfare measures. That does not apply to two additional fairly popular revealed preference methods:
• **Travel cost method:** this method uses a combination of surveys and information from surrogate markets to estimate WTP for activities (generally recreational) and related amenities in areas of environmental significance, or WTP to collect natural resources.

• **Hedonic pricing method:** this method values environmental or health quality through the use of the housing and land markets.

**Stated (or expressed) preference methods**

These methods obtain measurements of value through individual reaction to hypothetical questions that, directly or indirectly, ask consumers to state their WTA or WTP for environmental change. Two main methods are part of this group:

• **Contingent valuation:** in this method individuals are asked to reveal their WTA or WTP for an hypothetical environmental change, with responses said to be contingent to the particular situation depicted in the survey instrument.

• **Attributed-based discrete choice stated preference experiments, or choice experiments** are techniques asking individual to express their preferences for different hypothetical situations, described by a number of attributes (including environmental ones) presented at different magnitude levels.

Revealed and stated preference methods mainly differ in terms of the source of the data they make use of. There are, however, other differences. Revealed methods can be used for eliciting use values, however, for non-use values, stated preferences are needed. **Existence values** are more difficult to define as they do not relate to current or future use of the resource by human beings. Subscriptions to conservation trusts that are unrelated to intended visits, either now or in the future, may capture some of this feeling. However, as we shall discover, it is very difficult, and some would argue impossible, to integrate existence values into an environmental valuation framework which is founded on human preference revelation and the pursuit of individuals’ self-interest. Normally the choice over which method to use will rely on the specific context, resources and data availability.

In theoretical terms, stated preference methods employ Hicksian demand curves and as such yield compensating and equivalent measures of welfare; while revealed preference methods yield Marshallian demand curves and as a result changes in the CS measure.

Finally, there is what is referred to as benefit transfer techniques. This is where valuations calculated for one application are transferred for use in a second application. Benefit transfer methods have grown in popularity because they can allow for the completion of quick studies at a relative lower cost.
Section 1 Self-Assessment Questions

Question 1

True or false?
Economists have worked in isolation in developing environmental valuation methods and techniques.

Question 2

Why are measures of WTA generally larger than WTP?

Question 3

Provide an example of a valuation problem that can be addressed in terms of WTP and WTA.
2.0 COST–BENEFIT ANALYSIS

Section Overview

In this section we briefly introduce cost–benefit analysis (CBA). CBA is the most common tool used by economists to appraise the economic viability of projects. This is achieved by describing, in monetary terms, costs and benefits of a particular project or policy option, sometimes in relation to one or more alternatives. The valuation techniques that we mentioned in the previous section are used in cost–benefit analysis (CBA).

We present the case for CBA and its main methodological steps. Then we discuss the issue of discounting. We conclude this section with a discussion of the many criticisms addressed to the traditional CBA approach.

Section Learning Outcomes

By the end of this section, students should be able to:

- understand and critically assess the scope of use of CBA and its methods
- understand the strengths and limitations of CBA
- understand and critically assess how values for market and non-market resources, goods and services can be combined
- understand the rationale behind discounting.

2.1 Cost–benefit analysis and environmental valuation

Cost–benefit analysis is a decision-making procedure that allows analysts and policy-makers to weigh up the gains (benefits) and losses (costs) of a decision, project or policy for the society. It reflects a logical approach to decision-making, assessing advantages and disadvantages of different options in order to inform a decision about which one to pursue.

CBA has strong grounds in economic theory, as it represents a test of economic efficiency – whether benefits exceeds costs – in the allocation of scarce resource; and its economic foundations were established in the early 19th century to provide an economic justification for large transport infrastructural projects like new roads or bridges. It was then linked to welfare economics in the mid-20th century and still represents the main aid to policy-making and the evaluation of existing policies and investments. It is based on two main economic principles, the Pareto principle, according to which there is an improvement in welfare if a change brought by a policy or project improves the situation for at least one person, without making things worse for anyone else; and the Kaldor–Hicks principle, which says that there is an improvement in welfare in a society if the gainers of a policy or project could compensate those who lose from it and still be better off.

As any methodology aiming at helping individuals or organisations in complex decision-making, CBA is certainly not immune from criticism, especially when applied to environmental projects and policies, and alternative decision-making tools are available. We will look at the criticism later in this section, but here are the reasons
normally given to justify the use of CBA over other methods or over the alternative of doing nothing (Pearce et al., 2006):

- CBA provides a rational analytical framework to policy decisions, which are otherwise sometimes taken without a proper assessment of cost and benefits and their main bearer/recipients. This is achieved by forcing participants into the identification and valuation of costs and benefits, providing decision-makers with a common metric, money, with which to compare outcomes.

- CBA allows for the identification of different alternative paths or strategies for the achievement of a particular goal, it provides information not only to the main recipients, but also to other interest groups.

- CBA allows analysis for decisions not only about which project to carry out, but also on the possible scale, technologies and other methods to be employed; it can therefore provide a measure of what can be achieved even if the project is carried out only partially, or in alternative ways.

- CBA is capable of showing the way cost and benefits are distributed across the society, and therefore better informs about the potential social consequences of any decision.

- CBA highlights the importance of the time element in decision-making, allowing for the consideration of distribution of cost and benefits over time and over different generations.

- CBA is based on individual explicit preferences (either expressed or revealed by behaviour of individuals in markets), and those are the main determinants of decisions when aggregated for the viewpoint of society as a whole.

In the previous section we discussed the reasons behind the idea of assigning an economic value to changes in environmental quality. The main usage of these values is to incorporate them into formal CBA exercise in order for the environment to be fully considered in analysis of costs and benefits of particular projects or policies. This is a relatively recent achievement, as earlier applications of CBA did not properly take the environmental impact of different policy alternatives into account. Furthermore, CBA is also used for the assessment of environmental policies as well as environmental protection projects, and in this case its link with environmental valuation becomes even stronger. CBA is also now widely used in developing countries and its usage as a decision-making tool has followed the implementation of environmental laws and regulations in such countries.

In a recent paper, Annema and Koopmans (2014), give an interesting list of good practice criteria that should be followed when considering environmental impacts within CBA. The authors refer in particular to the case of the evaluation of transport and spatial projects, but their criteria can reasonably be applied to other cases:

- **Completeness** – Are all potentially relevant environmental changes included in the CBA?

- **Clear presentation of environmental impact** – Are all potential environmental changes treated clearly in the summary and summarising table? Are the environmental changes only presented in monetised forms or also in physical terms (emissions and decibel levels, pollutant concentrations, for example)?
• **Inclusion of uncertainties** – Are limitations of methods and assumptions treated? Is a sensitivity analysis carried out?

• **Explicit treatment of discount rate choice** – Is the impact of the *discount rate* chosen for the valuation of environmental changes made clear to the decision-makers?

_can you think of any other principle of good practice when considering environmental impacts in CBA?_

### 2.2 Methodological steps in CBA

There are many ways of categorising the steps taken in CBA. Here we divide the process into six main steps:

- **Step 1**: defining the project or policy
- **Step 2**: identifying relevant costs and benefits and categorising them
- **Step 3**: monetising cost and benefits (including the environmental ones)
- **Step 4**: introducing distributional weights
- **Step 5**: introducing time horizons and discounting
- **Step 6**: applying the decision rule to assess a project’s worth and make a recommendation.

Each of these steps is briefly discussed in turn.

**Step 1: defining the project or policy**

The first step is to describe the main elements of the project or policy under consideration and set the framework for analysis. Importantly, it is necessary to define the key objectives, and how the policy or project intends to achieve them. At this point, project proponents should also highlight the possible alternative options, if any, that could be undertaken to achieve the same, or similar objectives, as well as the consequences of no action.

Then, it is essential to point out what should be the main benefits and who will be the main beneficiary of them, and the same should be done for the costs.

? Imagine the government of a developing country is considering the construction of a rail link connecting two densely populated areas of the country, so far linked only by a poor and fairly dangerous road system. What elements should be included in the definition of the project?
Answer

First of all the proponents should describe the technical aspect of the project, for example the length of the link, the number of stations to be built, its capacity in terms of train per hour, etc. Then, the key objectives should be listed. These could range from improving mobility and accessibility of the relevant population, increasing employment and economic growth, and reducing the environmental impact of road transport. Details should be given about predicted travel demand and who should be the main beneficiaries of this link and of reduced travel time between the two cities. Will the new link improve business? Will it be used for personal travel or for freight as well? Will it improve tourism flow? The main costs should be made explicit, as well as who should bear them. Would it be the central government? Regional ones? Are any foreign companies or governments participating? Last, but not least, the description of the project should contain a detailed list of the predicted environmental impacts of the railway construction on the interested areas in terms of land use, noise and emissions, both during construction and during operations.

Step 2: identifying relevant costs and benefits and categorise them

In the second step, the main costs and benefits identified above are described in detail and a decision is taken about which of them will be accounted for in the specific exercise. This is sometimes referred to as the issue of 'standing', where analysts decide which segments of the population to consider. Given that CBA should measure social welfare, ideally we should look at the society as a whole, and the only decision we can take is about the geographical spread of our analysis. Are we going to consider people living in a region only, or at national or international level? There is a need to set spatial and temporal boundaries for the analysis.

Costs and benefits have then to be categorised, and we normally distinguish between:

**Real or transfer:** Real costs and benefits are those actually generating gain or losses for the whole society. Transfer payments (costs or benefits) simply represent a transfer of wealth across different segments of the population.

**Direct or indirect:** There are costs and benefits directly generated by the project, as well as indirect ones, when the project has an impact on the wider society or any other third party through a multiplier effect.

**Tangible or intangible:** There are costs and benefits that are easily quantifiable, if not in monetary terms, in physical ones, for example the number of hectares of land necessary for the project, or the reduced travel time (although obviously there are valuation techniques capable of subsequently transforming them from physical to monetary units). Others are more intangible and will require special valuation efforts. Think, for example, about the loss of wild forest areas, the impact on community spirit, the change in landscape, the impact on birds’ migratory routes, etc.

**Financial or social:** Some costs and benefits are represented by cash flows for individuals or organisations; others refer to the entire society and cannot be measured by simple cash flows.

For the rail project discussed above, we have seen that the main direct benefits should be faster and more secure links between the two cities. Intermediate stations could also spread benefits to other areas. In terms of costs, these are likely to
include the cost of acquiring new land for the rail scheme, the costs of land clearance and construction of the rail link itself. Cost for new stations facilities and trains should also be considered as well as the energy necessary for them. How this energy is going to be sourced should also be explicit.

So far we have identified some of the direct costs and benefits of the project, but there may be many indirect social and environmental impacts that need to be taken into account. In the case of the proposed rail scheme, possible environmental costs relating to increased noise and pollution have to be assessed and valued. The identification of possible social and environmental impacts of proposed projects will often need a separate social and environmental impact assessment.

All costs must always be specified over the project lifecycle, as many costs are likely to occur at the beginning of the project. Others, like environmental costs and benefits, often manifest themselves further into the future.

An important principle is that all costs and benefits should be identified on an incremental basis, that is based on a comparison of ‘with versus without’ situations. That is a comparison of the situation over time with the new policy or project compared to the situation over time that would prevail if nothing new were done.

So, for example, the capital cost of a new dam built to supply irrigation water to an existing rainfed farming area is all an incremental cost; in the ‘without’ situation there is no dam. But benefits generated by the dam in the form of agricultural production will not be the total value of future agricultural production. These benefits should be identified as the incremental difference between future irrigated production and the predicted level of production for continued rainfed production.

Similarly, environmental costs and benefits should be identified on an incremental basis. For example, will the introduction of irrigation cause an incremental increase in biodiversity because canals and better watered field margins provide better habitat for wildlife, or will it cause an incremental decrease in biodiversity because of intensification of production and increased use of pesticides; all compared to the predicted prevailing conditions with continuation of rainfed farming?

In practice, there will be a tendency to narrow down rapidly on a single policy or project design. Identifying costs and benefits and assembling the necessary data for this can be a demanding process. However, for CBA to be most effective as a planning and decision tool, sufficient time should be allowed for an iterative appraisal of alternatives for scale, technology or other aspects of implementation approach. The final project design, subject to a final and comprehensive CBA, ought, at least in principle, to be the best available design for that purpose.

**Step 3: monetising cost and benefits (including the environmental ones)**

In this stage we need to provide an economic value for all costs and benefits described in Step 2. In order to do so, we do not simply take market prices, as often distortions hide the real WTP, but convert them into a measure of economic value where we consider the value for the society and not simply a measure of cash flow across individuals or organisations (known as financial rather than economic costs). This is often done by looking at shadow prices or opportunity costs, which describe the value of resources in their next best alternative use.
For those cost and benefits, which are difficult to measure as we may not have a market, or any measure of financial cost, we need to apply valuation techniques. This is obviously the case of environmental costs and benefits.

**Step 4: introducing distributional weights**

In practice, use of CBA has often ignored distributional issues – how costs and benefits affect people with different incomes – and in some cases policies producing a benefit for wealthier segments and costs for individuals with a lower income have been accepted on the basis of a net benefit overall.

This can be considered important just in terms of equity and social justice, but is also has particularly relevance to environmental valuation. In the case of an environmental value, for example, WTP is a choice that is constrained by ability to pay, and the poorer sections in society have less opportunity for market expression of their preferences, and likewise the revealed values that poorer people attach to environmental assets and quality are likely to be much lower because they are income constrained.

However, over the years various techniques have been tested and practised to adjust cost and benefit estimates in order to consider equity issues. One of the most commonly used techniques is to insert distributional weights, where monetary values are weighted in accordance with the income of the recipients. In some other cases, distributional concerns take the form of constraints imposed on the design or implementation of the project, for example, when planners make provisions for accessibility measures, or affordable homes, as a condition for a project to be approved.

It should be noted that the use of distributional weights is quite demanding of data, so that assessment can be made of the incidence of costs and benefits for different income groups or segments. Also, although a range of methods is described in the literature and can be applied, determination of the value of the weights to use always requires an element of subjective judgement.

**Step 5: introducing time horizons and discounting**

This applies to any cost and benefit identified, but let’s focus here on the environmental ones. In many cases, environmental costs manifest themselves over the long term, often after the benefits of the project have faded away. Think about the construction of a nuclear power station and the issue of radioactive waste. The same applies to environmental benefits, which are often long term, and may well outlive other costs.

The time boundary of the project will have been specified and what you need is a measure of aggregation of all the costs and benefits occurring overtime, in order to quantify them now, at the moment of decision. The method for this is discounting; when costs and benefits that occur in the future are discounted into present day values.

CBA typically employs the rule that if benefits are greater than costs then a project is potentially viable. As seen above, we have to consider the time horizon, and the formula used to assess costs and benefits over time is as follows:
\[
\sum_{t} (B_t - C_t)(1 + r)^{-t} > 0
\]

where

- \( B \): benefits
- \( C \): costs
- \( r \): discount rate
- \( t \): time periods.

This formula takes all costs and benefits incurred over the time period of a project. They are aggregated and discounted, and this yields an estimate called the net present value (NPV). If its value is positive, then the project can be considered viable.

However, as seen at the beginning of the section, it is necessary to perform sensitivity analysis at this point, to show changes in NPV if certain assumptions about costs and benefits are considered differently. For example, if the geographical limits are modified, if the discount rate is changed and so on. At this point, it should also be very useful to precisely describe the elements that were not included in the calculations, and the reasons for doing so. These could be some important intangible elements, for example, for which no satisfactory measure of economic value could be obtained. The choice of the discount rate is of paramount importance, and we discuss this issue further in Section 1.3.

At this stage it is important to carry out an adequate assessment of uncertainty and risk. At the minimum, a sensitivity analysis should be carried out for the benefit or cost estimates that have the most ‘standing’. In other words those parameters that carry most weight in the analysis and have most influence on the final results. If analytical capacity and data resources are sufficient then more systematic and rigorous approaches to risk analysis can be employed.

**Step 6: applying the decision rule to assess a project’s worth and make a recommendation**

CBA typically employs the rule that if benefits are greater than costs then a project is potentially viable. Thus, the NPV formula yields a value greater than zero. If there are several competing projects and all have benefits greater than costs then the choice of project can be made by looking for the project that yields the highest benefit to cost ratio.

Results are finally communicated to policy-makers in the form of a recommendation. This should be accompanied by an assessment of uncertainty and risk that presents the results of sensitivity and/or risk analysis. A final decision will be taken at the political level. The monetised outcome from the CBA can be expected to inform and influence this decision, but a CBA can never be completely accurate and comprehensive in its coverage of all issues and values. Hence, the political decision-making process may still take account of other issues. Critics of CBA and economic analysis should ask themselves how well the decision-makers would be informed about these other issues.
2.3 Discounting and net present values

Clearly defining and estimating cost and benefits is not a simple task, and it is one that requires most time in practical CBA applications. However, arguably, the most controversial issue in CBA is the choice of discount rate, as different rates can generate very different results, especially for projects whose impacts have a very long time span.

Using a discount rate is necessary to aggregate costs and benefits that occur at different points in time and is defined formally as the ‘individual’s marginal rate of inter-temporal substitution or rate of time preference’ (Freeman et al, 2014: p. 184). Basically, what the definition means is that individuals have different time preference (for example, they are not indifferent between £1 of benefits today and £1 sometime in the future), and generally prefer to obtain benefits sooner rather than later. Therefore, discounting allows monetary costs and benefits accrued in different periods to be expressed in a common metric and considered in CBA. The common metric is the NPV introduced previously. NPV allows all future values to be converted to a value today.

The controversy in the choice of the appropriate discount rate comes from the fact that we are trying to assess cost and benefits that will be spread across different generations, as in the case of climate change, and it is obviously not possible to eventually set up a compensation framework. So, the solution to this is to consider a social welfare function, in order to make welfare comparisons across generations, as it is normally assumed that ‘society’ tends to be more concerned about the future than individuals, who may not give the same weight or importance to future events beyond the lifespan of their children or at most grandchildren. The idea of a social welfare function was devised in the 1920s by Frank Ramsey, and it is known as the Ramsey equation:

\[ r = \rho + \mu g \]

where

\( r \): discount rate

\( \rho \): is rate of pure time preference which reflects the degree of impatience for the benefits of consumption today

\( \mu \): the consumption elasticity of marginal utility (how fast marginal consumption decreases when consumption increases)

\( g \): per capita growth rate of consumption (how fast consumption increases).

The second term in the Ramsey equation represents how one extra dollar is worth more to a poor person compared to a wealthy individual. The implication that stems from this is that the richer future generations end up being, the higher will be the resulting discount rate.

In practice, the choice of the parameters employed in the Ramsey equation is based on value judgements. The first term in the Ramsey equation requires a judgement to be made about the importance a researcher attaches to the welfare of future generations. Similarly, the second term also requires value judgements to be made, especially with respect to the utility derived by individuals in different contexts.
But how should we set the discount rate in practice, and what are the consequences of low and high discount rates?

Very low discount rates are generally advocated when preference is not given to current generations over future generations generally for ethical reasons. Some people even advocate for zero or negative discount rates, especially for projects with longer-term environmental effects. A low discount rate was the approach followed, for example, by the much-debated Stern Review on the economics of climate change (2007). Others argue for a higher discount rate linked to the return on investments, the argument being that this will achieve more efficient allocation (or rationing) of the limited capital available for investment now, and thus producing the optimal stream of future benefits.

However, it is important to note that the discount rate does not necessarily need to be constant over time. There are indeed economists advocating a decreasing discount rate over time, especially for those projects or policies with a very large lifespan. Their reasoning is based on the necessity of taking uncertainty into account, especially given that it is difficult to predict the rate of technological progress.

But the impact of selection of a low discount rate is not that straightforward, and there are indeed many critiques of this approach, including arguments that the environmental consequences will not necessarily be positive. Although high discount rates tend to discriminate against projects with long-term environmental benefits, they also work against damaging capital intensive (and thus transformative) projects, like hydroelectric dams, with long payback periods, and therefore reduce the chances of them being launched. In addition, low discount rates may speed up the overall level of investment and economic growth. This will undoubtedly accelerate the demand for natural resource inputs, and increase the waste outputs from production, leaving fewer resources available and a more polluted environment to be inherited by future generations. But this last point is also debatable, as new investments could also create new technologies capable of dealing with waste more efficiently.

An alternative to low discount rates, and an often preferred, option is to incorporate sustainability constraints (or safe minimum standards (SMS)) explicitly into CBA as a means of protecting the interests of future generations. The sustainability constraint may involve a shadow project to offset any undesirable environmental effects, or to substitute for the lost environmental asset (ie any loss of natural capital). For example, a development project that involves the destruction of a wetland area may include monies to fund a shadow project to restore a partly degraded wetland in the region under consideration.

We will return to the issue of discount rate when we discuss the specifics of environmental valuation in the context of climate change.
2.4 Criticism of CBA

CBA is certainly not immune from criticisms, and these are not only based on the choice of discount rate. It is also likely that by reading this unit you have reflected on some of its disadvantages already. We list here some of the most important criticisms:

- **The economic rationality of CBA**: criticism of this is based on an ethical perspective contrary to the idea of putting a monetary value on things such quality of life, a life itself, health, and environmental goods. Advocates of CBA will remind critics that the method nonetheless provides decision-makers with a logical framework and an improved accounting of costs and benefits in monetary terms, which in any case will inevitably be considered and compared.

- **The Kaldor-Hicks principle**: the principle itself as a guidance to CBA decisions is criticised, especially when there is no legal protection in the case of people refusing to compensate others for environmental losses, and for long-term environmental effects.

- **The importance given to individual, rather than collective, preferences**: this is also strongly criticised, and CBA is often deemed to be too ‘technocratic’ and not ‘democratic’ enough. Critics wonder whether individuals on their own are the best placed to carry out choices for such common goods like the environment, and whether they are going to properly consider the needs of future generations.

- **The necessity of value judgements**: this is also another controversial matter, based on the criticism that choices of valuation methods used within CBA, including the use of WTP and WTA as appropriate and full measures of society’s valuation of environmental goods, are based on value judgements.

- **Distributional issues**: although these can be considered, use of CBA in practice does not always take into consideration how costs and benefits apply to segments of the population with different incomes, while the methods to be best used for this remain a matter of debate even among economists.

- **Existence values and other very intangible environmental costs or benefits**: these are often not considered (or fully assessed) in valuation exercises, and therefore neither in CBA.

- **Cumulative and indirect effects**: criticisms are made that these are not adequately taken into account.

- **Exclusion**: the voice of many groups may be excluded from environmental valuation methodologies, which as we have seen are based on preference revelation and WTP. Two particular groups of people that are likely to fall into this category are those living overseas and those living in the future.

- **Risk and uncertainty**: in practice, use of CBA does not always take these two important dimensions sufficiently into account.

- **The importance of the discount rates**: as seen previously, minimal variations in the level of the discount rate can generate considerable changes in the results, especially for projects with a long time horizon.
Some of the criticisms outlined above have some validity. Some can be countered, at least in part, by adjustments and improvements made to the CBA method. Some of these enhancements have been discussed above. CBA can also be defended on the grounds that its methods can, and should, be made transparent and publicly available. Thus all calculations, assumptions and choices made, can at least in principle be audited by others, and challenged as necessary.

Of particular concern for this module is the issue about value judgements, and clearly the challenge is to make environmental valuation techniques as effective and as objective as possible.

Finally, it can be said that some of the critics of CBA have perhaps overestimated its power in influencing decision-making at the political level, given that practical examples suggest that in most cases its role has been informative rather than the main determinant of decisions (Laurans et al, 2013). There are indeed alternatives to CBA, and we will examine them later in this module.
Section 2 Self-Assessment Questions

Question 4
List the six steps involved in conducting a CBA to assess a policy proposal or a new project.

Question 5
Why do we need to employ discounting when undertaking CBA?

Question 6
True or false?
Is a lower discount rate always the best approach to take adequately into consideration the future environmental impact of a project/policy?
UNIT SUMMARY

This unit first discussed the motivation behind the economic valuation of the environment by pointing out the increasing demand for environmental goods and services coming from the society. The discussion has highlighted the advantages of such an approach as well as the criticisms. We then introduced the concept of total economic value (TEV) and its components:

- **use value**: representing people’s willingness to give up money to use, or their willingness to accept monetary compensation for being unable to use, a particular environmental resource

- **non-use value**: representing people’s willingness to pay to keep a resource simply in existence, or their willingness to accept compensation for the resource ceasing to exist, regardless of whether they currently use it or will do it in the future.

Then, the unit provided a brief introduction to the classical theory behind the economic concepts of willingness to pay (WTP) and willingness to accept compensation (WTA) and their corresponding welfare measures:

- **compensating variation/surplus (CV/CpS)**: income necessary to keep an individual at his/her initial utility level after the change in environmental quality has occurred

- **equivalent variation/surplus (EV/ES)**: income adjustment necessary to maintain an individual at his/her subsequent utility level if the change in environmental quality does not occur.

The divergence between WTA and WTP was also discussed and can be explained by the degree of substitutability between marketed goods and environmental quality and the gains/losses dichotomy. We then went on to introduce the various environmental economics valuation methods.

The second half of the unit briefly introduced and examined cost–benefit analysis (CBA). The six steps involved in its application were discussed one by one. The important issue of discounting was then considered. The calculation of net present value (NPV), which is used to evaluate proposed projects and policy options was introduced, and the environmental consequences for using either a low or a high discount rate were briefly highlighted. The unit concluded with a discussion over the main criticisms addressed at CBA. These are normally based on its economic rationality nature and the reliance on the Kaldor–Hicks principle, as well as the over-reliance on value judgements. We have noted that some of the criticisms have been addressed by enhancements to practice.
UNIT SELF-ASSESSMENT QUESTIONS

Question 1

Can you think of examples of environmental goods and services for which there are no markets, or, if there is a market, the price does not reflect the full social value?

Question 2

Explain why fundraising efforts to establish a national park are likely to be less successful than fundraising efforts to prevent the loss of a national park with the same characteristics.

Question 3

A reservoir is going to be built. The reservoir will provide multiple benefits – flood control, irrigation, fishing and electricity. The table below assigns monetary values to the costs and benefits of the project. Assume that the capital costs comprise materials, labour, equipment such as earthmovers and other vehicles, and fuel. The annual operating costs and benefits that will accrue from the project are also listed.

<table>
<thead>
<tr>
<th>Capital costs</th>
<th>Annual operating costs</th>
<th>Annual benefits</th>
</tr>
</thead>
<tbody>
<tr>
<td>Item</td>
<td>Value (£’000)</td>
<td>Item</td>
</tr>
<tr>
<td>Labour</td>
<td>400</td>
<td>Labour</td>
</tr>
<tr>
<td>Equipment</td>
<td>200</td>
<td>Transport</td>
</tr>
<tr>
<td>Fuel</td>
<td>75</td>
<td>Fertiliser/seed</td>
</tr>
<tr>
<td>Materials</td>
<td>120</td>
<td>Nets</td>
</tr>
</tbody>
</table>

Assume that the lifetime of the project is estimated to be 20 years, that all capital costs occur in year 0, and that operating costs and benefits start in year 1 and end in year 20.

(a) What is the NPV of the project if the discount rate is 5%?
(b) Repeat the calculation for discount rates of 8%.
(c) Repeat the calculation for discount rates of 12%.
Question 4

(a) Why is society’s discount rate thought likely to be lower than that of individuals?

(b) Will lowering the (social) discount rate necessarily benefit the environment?
**Key Terms and Concepts**

<table>
<thead>
<tr>
<th>Term</th>
<th>Definition</th>
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<tbody>
<tr>
<td>compensating variation</td>
<td>A welfare measure that implies a consumer is just as well off after a price reduction as before.</td>
</tr>
<tr>
<td>consumer surplus</td>
<td>Consumer surplus measures the value over and above the market price of a good a consumer is willing to pay.</td>
</tr>
<tr>
<td>discount rate</td>
<td>This is the rate used to convert a stream of costs/benefits into present values and net present value.</td>
</tr>
<tr>
<td>equivalent variation</td>
<td>How much extra income is required so as to leave an individual at a higher level of utility than if a price fall had not occurred.</td>
</tr>
<tr>
<td>existence value</td>
<td>The willingness to pay to keep a good or service in existence even when no direct use is ever intended.</td>
</tr>
<tr>
<td>non-excludable</td>
<td>An individual cannot be deprived of useful consumption of the good even though he or she may refuse to pay for it.</td>
</tr>
<tr>
<td>non-rival</td>
<td>Use or consumption is non-rival if that use means that the quantity of that particular good available to others is not diminished.</td>
</tr>
<tr>
<td>non-use value</td>
<td>The willingness to pay to keep a good or service in existence even when no actual, planned or possible use is intended.</td>
</tr>
<tr>
<td>option value</td>
<td>The value associated with preserving the option to use a good or service in the future.</td>
</tr>
<tr>
<td>public goods</td>
<td>A good that is non-rival and non-excludable.</td>
</tr>
<tr>
<td>Ramsey equation</td>
<td>The Ramsey equation is the approach adopted to estimate the social rate of time preference.</td>
</tr>
<tr>
<td>total economic value</td>
<td>The value placed on a good or service including use and non-use values.</td>
</tr>
<tr>
<td>use value</td>
<td>A measure of value that stems from the actual use, planned use or possible use of a good or service.</td>
</tr>
<tr>
<td>willingness to accept</td>
<td>What a consumer is willing to accept to maintain or keep a particular good or service.</td>
</tr>
<tr>
<td>willingness to pay</td>
<td>What a consumer is willing to pay to consume a particular good or service.</td>
</tr>
</tbody>
</table>