Report No. 127

epa Research
Climate - Water - Sustainability
Identifying pressures • Informing policy • Developing solutions

What's our water worth?

Estimating the Value to Irish Society of Benefits Derived from Water-Related Ecosystem Services: A Discrete Choice Approach

Comhshaol, Pobal agus Rialtas Áitiúil
Environment, Community and Local Government

www.epa.ie

Environmental Protection Agency

The Environmental Protection Agency (EPA) is a statutory body responsible for protecting the environment in Ireland. We regulate and police activities that might otherwise cause pollution. We ensure there is solid information on environmental trends so that necessary actions are taken. Our priorities are protecting the Irish environment and ensuring that development is sustainable.

The EPA is an independent public body established in July 1993 under the Environmental Protection Agency Act, 1992. Its sponsor in Government is the Department of the Environment, Community and Local Government.

OUR RESPONSIBILITIES

LICENSING

We license the following to ensure that their emissions do not endanger human health or harm the environment:

- waste facilities (e.g., landfills, incinerators, waste transfer stations);
- large scale industrial activities (e.g., pharmaceutical manufacturing, cement manufacturing, power plants);
- intensive agriculture;
- the contained use and controlled release of Genetically Modified Organisms (GMOs);
- large petrol storage facilities;
- waste water discharges;
- dumping at sea.

NATIONAL ENVIRONMENTAL ENFORCEMENT

- Conducting over 1200 audits and inspections of EPA licensed facilities every year.
- Overseeing local authorities' environmental protection responsibilities in the areas of - air, noise, waste, waste-water and water quality.
- Working with local authorities and the Gardaí to stamp out illegal waste activity by co-ordinating a national enforcement network, targeting offenders, conducting investigations and overseeing remediation.
- Prosecuting those who flout environmental law and damage the environment as a result of their actions.

MONITORING, ANALYSING AND REPORTING ON THE ENVIRONMENT

- Monitoring air quality and the quality of rivers, lakes, tidal waters and ground waters; measuring water levels and river flows.
- Independent reporting to inform decision making by national and local government.

REGULATING IRELAND'S GREENHOUSE GAS EMISSIONS

- Quantifying Ireland's emissions of greenhouse gases in the context of our Kyoto commitments
- Implementing the Emissions Trading Directive, involving over 100 companies who are major generators of carbon dioxide in Ireland.

ENVIRONMENTAL RESEARCH AND DEVELOPMENT

- Co-ordinating research on environmental issues (including air and water quality, climate change, biodiversity, environmental technologies).

STRATEGIC ENVIRONMENTAL ASSESSMENT

- Assessing the impact of plans and programmes on the Irish environment (such as waste management and development plans).

ENVIRONMENTAL PLANNING, EDUCATION AND GUIDANCE

- Providing guidance to the public and to industry on various environmental topics (including licence applications, waste prevention and environmental regulations).
- Generating greater environmental awareness (through environmental television programmes and primary and secondary schools' resource packs).

PROACTIVE WASTE MANAGEMENT

- Promoting waste prevention and minimisation projects through the co-ordination of the National Waste Prevention Programme, including input into the implementation of Producer Responsibility Initiatives.
- Enforcing Regulations such as Waste Electrical and Electronic Equipment (WEEE) and Restriction of Hazardous Substances (RoHS) and substances that deplete the ozone layer.
- Developing a National Hazardous Waste Management Plan to prevent and manage hazardous waste.

MANAGEMENT AND STRUCTURE OF THE EPA

The organisation is managed by a full time Board, consisting of a Director General and four Directors.

The work of the EPA is carried out across four offices:

- Office of Climate, Licensing and Resource Use
- Office of Environmental Enforcement
- Office of Environmental Assessment
- Office of Communications and Corporate Services

The EPA is assisted by an Advisory Committee of twelve members who meet several times a year to discuss issues of concern and offer advice to the Board.

ACKNOWLEDGEMENTS

This report is published as part of the EPA Research Programme. The Research Programme is administered on behalf of the Department of the Environment, Community and Local Government by the Environmental Protection Agency which has the statutory function of co-ordinating and promoting Irish environmental research.

DISCLAIMER

The EPA Research Programme addresses the need for research in Ireland to inform policymakers and other stakeholders on a range of questions in relation to environmental protection. These reports are intended as contributions to the necessary debate on the protection of the environment.

EPA Research Programme 2014–2020

Published by the Environmental Protection Agency, Ireland

PRINTED ON RECYCLED PAPER

ISBN: 978-1-84095-544-6

Price: Free

July 2014

EPA Research Programme 2014–2020

Estimating the Value to Irish Society of Benefits Derived from Water-Related Ecosystem Services: A Discrete Choice Approach

(2011-W-MS-4)

EPA Research Report

Prepared for the Environmental Protection Agency

by

Socio-Economic Marine Research Unit, NUI Galway

Authors:

Geraldine Murphy, Stephen Hynes, Edel Doherty, Cathal Buckley and Rebecca Corless

ENVIRONMENTAL PROTECTION AGENCY

An Ghníomhaireacht um Chaomhnú Comhshaoil
PO Box 3000, Johnstown Castle, Co. Wexford, Ireland

Telephone: +353 53 916 0600 Fax: +353 53 916 0699
Email: info@epa.ie Website: www.epa.ie

Details of Project Partners

Geraldine Murphy*
Socio-Economic Marine Research Unit
JE Cairnes School of Business and Economics
National University of Ireland
Galway
Ireland
Email: Geraldine.Murphy@teagasc.ie

Stephen Hynes
Socio-Economic Marine Research Unit
JE Cairnes School of Business and Economics
National University of Ireland
Galway
Ireland
Email: stephen.hynes@nuigalway.ie

Edel Doherty
Socio-Economic Marine Research Unit
JE Cairnes School of Business and Economics
National University of Ireland
Galway
Ireland
Email: edel.doherty@nuigalway.ie

Cathal Buckley
Rural Economy Research Centre
Teagasc
Athenry
Co. Galway
Ireland
Email: cathal.buckley@teagasc.ie

Rebecca Corless
Socio-Economic Marine Research Unit
JE Cairnes School of Business and Economics
National University of Ireland
Galway
Ireland
Email: rebecca.corless@nuigalway.ie

**Current address*
Rural Economy & Development Programme
Teagasc
Ashtown
Dublin 15
Ireland
Email: Geraldine.Murphy@teagasc.ie

Table of Contents

Executive Summary

Despite difficulties associated with water valuation, there has been a strong desire nationally and internationally to value water and its characteristics. This is reflected in the growing number of non-market studies that have attempted to put a monetary value on the environmental, health and/or recreational benefits associated with water. These studies range from exploring preferences for specific features of particular waterbodies to studies that explore preferences for wide-scale changes to different waterbodies. The multi-attribute nature of water is also reflected in the changing and growing emphasis of legislation. An examination of water policy through previous European Union (EU) water directives, including the Nitrates Directive and the Bathing Water Quality Directive, demonstrates how it evolved from the emphasis on public health protection to environmental protection and, finally, as formed today, to the notions of 'sustainable use' of water and an integrating ecosystem-based approach to water management. Although in the past EU legislation on water was focused on specific environmental problems related to water quality, emphasis is now placed on the improvement of the ecological quality of water and its eco-system functions, by using a broader, more integrated approach. Greater emphasis has also been put on the value of 'healthy' waterbodies within these directives.

To estimate the full range of benefits of water to society, it is beneficial to use a method that is capable of capturing the multidimensional features that are encapsulated within complex environmental goods such as water. In this regard, the choice experiment (CE) (the most commonly applied discrete choice method) methodology has particular advantages over other types of non-market valuation techniques. In a CE framework, choices are broken down into component attributes/features, which are presented to respondents normally as a choice set composed of a combination of the attributes/features. Respondents are then presented with a sequence of these choice sets, each containing alternative descriptions of a water/river alternative, differentiated by attributes and levels. Respondents are asked to state their preferred alternative within the choice set. By observing and modelling how respondents change their preferred alternative in response to the changes in the levels of the attributes/features (such as quality levels), it is possible to determine how respondents trade off between the different generic features of water (Bockstael and Opaluch, 1983[1]).

This report uses the CE approach to estimate the generic values that the Irish public associate with Irish waterbodies. Also, individuals may not view different waterbody types (coastal, lakes, rivers) as holistic management units but as waterbodies with similar ecosystem services being provided. For this reason, this report also investigates whether Irish citizens have different benefit values associated with alternative waterbody types. Special attention is given in this report to whether respondents' preferences for alternative means of paying for water management impacted on the values they assigned to Irish waterbodies.

Waterbodies may be valued for a number of reasons. They provide use values in the form of provisional, supporting and cultural goods and services, as well as non-use values in the form of supporting services. The non-use aspect of supporting services means that they cannot be valued using real, or approximations of real, markets. CEs are a type of stated preference (SP) technique, meaning they present respondents with a hypothetical good for valuation. Hence, the CE used for this report was capable of eliciting estimates for both use and non-use values of waterbodies by presenting them all to respondents in the form of hypothetical goods. Another reason for the use of the CE methodology in this report is that it is efficient. Unlike other SP techniques, CEs can be used to estimate welfare-consistent values for a number of

1. Bockstael, N. and Opaluch, J., 1983. Discrete modeling of supply response under uncertainty: the case of the fishery. *Journal of Environmental Economics and Management* **10(2):** 125–137.

policy changes related to an ecosystem using just one survey.

The CE in this report was used to estimate respondents' values for five attributes, four representing the health of ecosystems, water clarity and smell, access to recreational activities, and the conditions of banks and shorelines. Each of these attributes had three levels of provision. The fifth attribute was the type of waterbody affected by the policy change: rivers, lakes or seas. Finally, the payment vehicle was an annual increase in personal income tax for 10 years. Respondents were asked to choose their preferred option of three options on a total of six choice cards. The sample of 850 individuals surveyed aptly represented the Irish population. Results from the survey were analysed using a conditional logit (CL) model, as well as a mixed logit (MXL) model, the latter of which was used to account for heterogeneity in respondents' preferences for the various attributes. Results from both models were used to estimate respondents' marginal willingness to pay (MWTP) for each of the attribute levels. MWTP estimates were then employed to calculate compensating surplus (CS) values for the total economic value (TEV) of improvements to Irish rivers, lakes and seas. In other words, the values of improving the first four attributes in the survey from their lowest to their highest levels were separately estimated for the three waterbody types. Finally, these CS values were aggregated to produce values that represent the TEV of benefits provided by rivers, lakes and seas for the entire population of Ireland.

An initial review of findings from the survey showed that respondents' concern for the five waterbody attributes varied significantly according to the number of times they visited waterbodies in the past 12 months. There is also evidence that individuals' use of rivers, lakes and seas differs substantially. This is apparent when viewing the types of recreational activities that respondents pursue, the regularity of respondents' visitation and the distances that respondents travel to each of the three waterbody types. In addition, respondents displayed mainly positive opinions on the environmental quality of Irish waterbodies, but the extent of this positivity varied somewhat across waterbody type. A total of 43.85% of respondents were zero bidders, meaning they were unwilling to pay for improvements to Irish waterbodies on any of the six choice cards presented to them. Zero bidders who were deemed protest responses were excluded from the sample used to model the preferences for waterbody attributes. The preferred payment vehicle identified by the survey was a once-off lump sum (33.83% of bidders) whilst the vehicle used in the survey (an increase in personal income tax for 10 years) was only the second most popular payment type listed in the survey (22.34% of bidders).

Both the CL and the MXL models showed that the most important attribute for respondents was water clarity and smell and the least important was access to recreational activities. In addition, the two models indicated that the amount respondents were willing to pay for improvements to waterbodies was significantly less if they preferred a different payment vehicle to the one used in the study. The highest MWTP estimates were for a good status of water clarity and smell (€46.48 per respondent per year in the CL model), which indicates that respondents place a high price on the aesthetic value of waterbodies. The lowest MWTP estimate was for secondary access to recreational activity (€11.01 per respondent per year), which is most likely due to the fact that some visual-only recreationalists (of which there were many in the sample) associate access to secondary recreational activities with marginal disutility.

1 Introduction

This report outlines the development and implementation of a discrete choice experiment (CE), which is used to determine Irish citizens' preferences for a number of water-related attributes from different types of waterbodies. A key aspect of this report is to provide an estimate of the monetary valuation that Irish citizens place on improvements in key quality attributes (such as ecological or aesthetic attributes) of Irish waterbodies. Despite a number of studies that have explored aspects of water quality and valuation in Ireland, no major CE valuation exercise on water quality features has been conducted to date. Therefore, apart from a few studies that have estimated economic values associated with particular water features, no studies have attempted to estimate generic values for a range of water features for the general population of Ireland. The research presented in this report seeks to fill this gap in the literature both in terms of how economic values generated from this study compare with economic valuations conducted in other regions and also in terms of the knowledge gap that exists in Irish residents' generic values for water-related features.

1.1 Background

Estimating the economic values and benefits of waterbodies requires the valuation of multidimensional features that characterise the economic values of water. Also, as pointed out by Young (2005, p. 29) "*there is no single economic value of water. What is being measured is the welfare change associated with some policy-induced change in the attributes of the commodity*". Young (2005) distinguishes between the commodity and environmental benefits derived from water. In particular, commodity benefits are derived from personal drinking, cooking, sanitation, from contributing to productive activities on farms and in commercial businesses and industries. Recreation and education are benefits that are derived from the environmental aspects of water. Waste disposal can be viewed as either a commodity or an environmental benefit of water, depending on what type of treatment infrastructure is in place. In most instances, environmental benefits from water contribute to the public good character of water because of their non-rival nature. Another potential economic value associated with water is the non-use (passive use) value that derives from the fact that people are willing to pay for environmental services from water that they will neither use nor experience.

In terms of economic measurement tools, valuation of water resources has been undertaken by valuation techniques that can be broadly categorised into revealed and stated preference methods. Revealed preference (RP) methods are based upon data drawn from observations of behaviour in real markets from which inferences may be drawn on the value of a related non-market good. The real market acts as a proxy market for the environmental good or service. Stated preference (SP) methods involve asking individuals specifically about their willingness to pay (WTP) for changes in the supply or quality of a public good. In the case of SP methods, therefore, they are capable of capturing economic values associated with the direct use of a water resource (such as recreational values) as well as economic values that are non-use (such as improved water quality). RP methods are limited to capturing direct use values only. As a result, in the case of water resources that produce a number of services not traded in markets, SP methods that induce individuals to express preferences through WTP have an advantage over revealed methods in determining the total economic value (TEV) (which comprises both use and non-use values) of the resource. For this study, the SP methodology of CEs was used to elicit these values. An advantage of CEs over other valuation methodologies is that they are capable of estimating both use and non-use values associated with quality improvements. In the case of waterbodies, since they provide a range of multifaceted benefits, it was deemed important to use a methodology that can capture all these economic benefits.

1.2 Overview of Objectives

The overriding objective of this report is to use a discrete choice method to calculate generic values for water-related attributes as held by the Irish public. Within this wider objective, this report has several goals. The first goal is to provide, for the first time, Irish citizens' monetary values for a suite of attributes associated with Irish waterbodies. As a follow-on from this, this study also investigates whether the type of payment vehicle used in a CE impacts on the value that respondents place on the environmental good being measured. The reason for this is that, in the current economic climate, citizens may be adverse to the idea of paying additional taxes for water quality improvements but may prefer some other means of payment. The third goal is to determine whether individuals have different preferences for, and therefore assign different values to, improvements made to various waterbody types – related to rivers, lakes and the sea.

1.3 Stages of the Project

To achieve the goals described above, this project workload was divided into four main stages. Firstly, a literature review was conducted of national and international papers to ensure that the most appropriate attributes, and up-to-date experimental designs, were used in the CE. Secondly, development of the CE questionnaire was undertaken, which required combining findings from the literature review with information gleaned from experts and focus group discussions. The final output from this stage was a CE questionnaire that was suitable for administration to the general Irish population. The third stage was the administration of the survey to a representative sample of Irish households. Finally, the data were collated and analysed using a number of statistical models. The results from the analysis provided monetary values that Irish citizens hold for attributes of and improvements to Irish waterbodies.

1.4 Structure of Report

This report contains six chapters plus four appendices. Chapter 2 highlights findings from the literature review. It outlines the many types of goods and services provided by aquatic ecosystems as well as discusses a number of methods that are used to value them. Information is also provided on a number of international papers that have used CEs to estimate values for waterbody attributes. Chapter 2 concludes with an overview of studies that have estimated values for goods and services provided by Irish waterbodies in the past.

Chapter 3 describes how the final CE design was developed for this study. Section 3.1 discusses the focus groups used to inform attribute selection. Section 3.2 outlines how the attribute and attribute levels were defined for the CE. Section 3.3 describes how these attributes and levels were combined to create choice cards that were capable of estimating respondents' preferences for the different attribute levels. Section 3.4 details the sampling procedure that was followed to administer the survey. Finally, Section 3.5 briefly describes the statistical analysis used in the report to model the preferences of respondents for alternative waterbody characteristics.

The summary statistics contained in Chapter 4 provide information on the choice data gathered as part of the CE as well as the supporting questions accompanying the survey. Section 4.1 describes how often respondents use Irish waterbodies, as well as detailing certain socio-economic, demographic and regional differences between those who visited a waterbody in the past 12 months and those who did not. Section 4.2 outlines reasons why improvements to seas, lakes and rivers may be valued differently by individuals. Finally, Section 4.3 looks at issues that are expected to influence the values that respondents assign to waterbody attributes, including the effect of payment vehicle type.

Chapter 5 discusses the results from the CL and MXL models. Section 5.1 describes respondents' rankings of preferences for waterbody attributes. Section 5.2 then presents monetary values that have been estimated for Irish waterbody attributes using the models presented in Section 5.1. These estimates represent respondents' marginal willingness to pay (MWTP) for improvements in the attributes (compared with the lowest possible values). In addition, it displays separate values for improvements to seas, lakes and rivers, respectively.

Finally, Chapter 6 provides an overview of the main conclusions drawn from this report. It discusses key findings and provides information on both potential limitations of the research and potential avenues of future research.

The appendices provide additional information on certain topics provided in this report that may be of interest to the reader. Appendix 1 provides details on the attributes and levels used to estimate generic values for waterbodies in other CE studies. Appendix 2 provides details on the statistical analyses carried out for this report. The figures in Appendix 3 provide a breakdown of how respondents use Irish waterbodies. In particular, they specify the type of recreational activities carried out at, and the user profiles of, Irish waterbodies. Finally, Appendix 4 presents estimates of compensating surplus measures and aggregate values associated with the value of medium improvements in the attributes to Irish waterbodies.

2 Overview of Related Literature

Ecosystem functions improve human welfare through the supply of a variety of utilisable goods and services, as well as through the provision of non-use values. Changes in welfare levels that occur as a consequence of the existence of these goods and services can be measured using a variety of different methods. This chapter describes the many ways that waterbodies may be valued as well as how to measure these values. Particular attention is paid to the role that CE plays in the water valuation literature.

Section 2.1 outlines the differences between use and non-use values, with a view to explaining how their impact on human welfare levels can be measured. Section 2.2 describes the many methods that exist for estimating ecosystem values. In doing so, it provides an overview of the advantages and disadvantages of each method. Findings from CEs evaluating waterbodies are provided in Section 2.3. It divides studies into those that take a holistic and those that take a multidimensional approach towards waterbody valuation. Special attention is paid to the importance of the choice of status quo levels as well as to the type of payment used in CEs. Section 2.4 describes the limited number of studies that previously valued waterbodies in Ireland. Finally, Section 2.5 concludes with an overview of topics discussed in this literature review.

2.1 Ecosystem Goods and Services

The presence and workings of ecosystems improve human welfare in many ways. Improvements to our welfare can result from using or not using the ecosystem. Categories of use values provided by ecosystems include provisional, regulatory and cultural goods and services. Because ecosystems act as suppliers of material and energy inputs for human consumption, they produce provisional goods and services. Examples of provisional goods and services provided by waterbodies include drinking and bathing water, hydropower and fish. Ecosystem functions are also used directly by humans to improve our well-being in the form of regulatory services. For example, the nutrient and hydrogeologic cycles performed by waterbodies are used by humans to dispose of waste products and to safeguard our homes from flooding, respectively. Finally, human interpretations of ecosystems result in the production of cultural goods and services, such as recreation and education (UKNEA, 2011).

In addition to supplying usable goods and services, ecosystems provide supporting services, which are not used by humans but nonetheless improve our welfare levels. Examples of supporting services provided by waterbodies include resistance and resilience in surrounding ecosystems, wild species diversity, biogeochemical cycling and contributions to biological and genetic diversity (UKNEA, 2011). Values that accrue as a consequence of supporting services are referred to as non-use values. Non-use values may be motivated by selfish reasons or by altruism, either for other members of the current generation or future generations (Hanley and Barbier, 2009). The TEV of an ecosystem is given as a combination of its use and non-use values[1].

2.2 Measuring Ecosystem Use and Non-Use Values

Ecosystem goods and services that are used by humans, or the use values of ecosystems, are measured using a variety of methods. The type of method used is determined by whether the good in question is private or public. On the private–public scale, an absolute private good is described as being both excludable and rival, where excludable means that it is possible to stop those who pay a zero price from consuming it and rival implies that one individual's use of the good or service in some sense precludes or prevents another individual from using it (Young,

1. A third element of TEV is sometimes given as the option value, which is claimed to be akin to an insurance premium, meaning individuals are willing to pay to secure the resource's availability in the future. However, economists now know that option values do not exist as a separate element of TEV but are absorbed by use and non-use values (Hanley and Barbier, 2009).

2005). The majority of provisioning goods are more private than public, whereas regulatory and cultural goods and services tend to be public in nature.

RP methods are concerned with estimating prices for ecosystem goods or services using either conventional or proxy markets. Values for private goods that exist as a consequence of ecosystem processes are often realised through conventional market prices. Otherwise, for those (predominantly public) goods and services that cannot be valued using market forces, RP techniques may be used to infer a non-market price from observations of behaviour in real markets[2]. Examples of these RP methods include averting behaviour, hedonic pricing (HP) and travel cost (TC). As the name suggests, averting behaviour models are concerned with estimating individuals' WTP to avoid a loss in utility resulting from a decrease in the standard of the services being provided by an ecosystem (Hanley and Barbier, 2009).

The HP approach is based on Lancaster's characteristics theory of demand, which states that goods can be described as a bundle of attributes and therefore the price of the good is a function of these attributes and their levels of provision (Lancaster, 1966). HP is most commonly used with house or land prices to determine marginal values for environmental attributes such as air quality, distance to amenities or a clean waterbody, all of which are presumed to make up part of the value of the property.

The TC method is used to estimate the value of sites that people travel to for recreation. It is based on the theory that travel time and travel costs represent the price of access to a site. The distance and number of trips can be modelled to represent the WTP of individuals for the site. Various TC models can be used, including count models and random utility models (RUMs), the latter of which allows for variation in levels at the site and for potential substitute sites (Hynes et al., 2008).

2. At this point, it is worth noting that Ireland is one of the few countries in the EU where, to date, water pricing is almost completely absent (Stithou et al., 2012). Consequently, even the valuation of drinking and bathing water in Ireland requires some method of non-market valuation.

Any estimation of ecosystem values using non-market RP methods requires a link between the use of the ecosystem and observable market behaviour (Boyle, 2003). Therefore, although these methods have been used extensively in the literature to produce important benefit values for various ecosystems, a major drawback of their methodology is that they are incapable of measuring non-use values. Thus, they cannot be employed to estimate the TEV of an ecosystem service, which in the context of a study like this is a drawback.

SP methods provide an alternative method of non-market valuation to RPs. Broadly speaking, SPs are concerned with generating a hypothetical market for ecosystem goods and services and asking respondents how much they are willing to pay for an improvement (or their willingness to accept (WTA), for a decline) in its supply. A major advantage of using SPs over RPs is that supporting services can also be presented to respondents as hypothetical goods or services, meaning SPs can be used to estimate non-use values for ecosystems. Use of a hypothetical market allows SPs to be more flexible than RPs. For example, they can be designed to ask respondents their TEV for a change to an entire ecosystem (usually as a consequence of a policy change) or for a single ecosystem good or service. This ability to directly estimate TEV means that SPs are capable of overcoming issues such as separability and collinearity, which are associated with RP techniques (Hynes and Campbell, 2011).

Contingent valuation (CV) and choice modelling (CM) are both types of SPs. The CV methodology uses questionnaires to describe hypothetical markets for an environmental good or service, to outline the institutional context in which it would be available and to identify the manner by which it is to be financed. Interviewees are asked to provide their maximum WTP for a change in the provision of the good, which, given the theoretical basis of CV, is assumed to relate to respondents' underlying preferences in a consistent manner (Hanley et al., 2001). An issue associated with the experimental design of CVs is embedding bias. Embedding bias occurs when the impact of more than one change on an ecosystem needs to be estimated. In this scenario, individuals' WTP for the various changes need to be evaluated using individual and separate markets. The TEV that results from adding the resulting WTP estimates can then be biased because individuals may double count how much they value specific ecosystem functions (Bateman et al., 2002).

CMs are capable of overcoming the issue of embedding bias because they value ecosystem goods and services simultaneously and in relation to each other. CMs are a family of survey-based methodologies for modelling preferences for goods, where goods are described in terms of their attributes and the levels that they take (Hanley et al., 2001). Types of CMs include contingent ranking, contingent rating, paired comparisons and CEs. These methods primarily differ in terms of how they elicit respondents' preferences for different ecosystem scenarios by ranking, scoring, or choosing their most preferred options from a list. Pairwise comparisons and contingent ranking are particularly useful for estimating trade-offs between simultaneous changes in a number of environmental goods without having to include monetary valuation (Willis et al., 2002). On the other hand, CEs are specifically designed to assign monetary values to ecosystem goods and services in addition to estimating individuals' preferences for their provision. An advantage of the CE methodology is that it adheres to Lancaster's characteristics theory of demand, meaning it has strong theoretical underpinnings, unlike the other CM methodologies. In fact, provided respondents are presented with a zero cost, no scenario change option on each choice card (meaning they are not obliged to make a forced choice), CEs always produce welfare-consistent values (Hanley et al., 2001).

In relation to waterbody valuation, CEs have two main advantages over CVs. Firstly, CEs provide the opportunity to explore in detail trade-offs between individuals' preferences for various levels of attributes that infer different use and non-use values. Given the wide variety of use and non-use values provided by waterbodies, this is a key benefit afforded by the CE design (Norton et al., 2011). Secondly, CEs ask respondents' preferences for different levels of attributes that infer different use and non-use values over a range of payment amounts. Consequently, one CE can be used to estimate welfare values for a number of policy changes related to an ecosystem, which is not the case for CV.

2.3 Choice Experiments

One of the main objectives of a CE survey is to identify a realistic hypothetical market for evaluating the non-market good of interest. Similar to other SP techniques, the non-market good being 'sold' to respondents in a CE survey needs to be identified in terms of its area, scale and the time frame required to obtain the good. Once the good has been identified, it is divided into component parts, each of which represents a source of the value of the good. These components are called attributes. Different levels of each attribute are combined into bundles to represent the good in various states of different quality. These bundles are called alternatives. Respondents are asked to state their preferred alternative from a set of usually three or four alternatives, which is presented to them on a choice card. Respondents are shown a number of choice cards, each of which contains the status quo alternative. The status quo alternative is the bundle of attributes that costs the respondent nothing. The other alternatives are associated with different costs. This provides a mechanism to determine how much people are willing to trade off various environmental quality attributes against the cost of achieving quality improvements.

2.3.1 Holistic approach

Waterbodies have been evaluated in the CE literature using two distinct approaches. The difference between the two approaches is related to how they incorporate the component characteristics (such as ecological status, recreational value and water clarity) of waterbodies into the study. The first approach combines all of these characteristics into one attribute in the study. For this reason, it is referred to as the holistic approach. A difficulty with this approach is describing all of the waterbody characteristics under one attribute. Hime et al. (2009) created a tool called the water ladder to overcome this difficulty. The water ladder outlines how to convey waterbodies, in terms of their many characteristics, and standards of the waterbody, usually as good, moderate or bad, to members of the public. The water ladder thereby permits the creation of holistic CEs, which have an attribute for the waterbody (in terms of all its characteristics) and levels of the attribute (good, moderate or bad). Then, the other attributes in holistic CEs are used to investigate respondents' preferences for improvements to the waterbody in different locations (Bennett et al., 2008; Poirier and Fleuret, 2010), at different spatial scales (Brouwer et al., 2010), for different waterbody types (Glenk et al., 2011) or over different timescales (Metcalfe et al., 2012).

A major benefit of taking a holistic approach to waterbody valuation is that the use of tools such as the water ladder, which describes waterbodies using generic levels, makes the comparison of holistic studies across time and space possible.

2.3.2 Multidimensional approach

The second approach used to value waterbodies using CEs is referred to as the multidimensional approach. These studies include the characteristics of the waterbody as different attributes in the study. This means that the location, spatial scale, waterbody type and timescale of the study is usually not included in the choice sets presented to respondents. Instead, a description of the whole waterbody being evaluated is given to respondents before the CE takes place. The type of waterbody being studied, location, spatial scale and time frame vary greatly throughout the multidimensional literature. Examples of papers focusing on the valuation of lakes or coastal waters include assessments of Cheimaditida Lake (as part of the wetlands) in Greece (Birol et al., 2008b), Lake Champlain in New York and Quebec (Smyth et al., 2009), and Gocek Bay in Turkey (Can and Alp, 2012; Hynes et al., 2013). However, the majority of CE literature evaluating waterbodies focuses on rivers. Rivers may be evaluated in terms of their administrative regions (Birol et al., 2008a), as single stretches (Hanley et al., 2006a) or as entire river catchments (Robinson et al., 2002). The length of time that improvements are expected to last can be given as a fixed length of time (Heberling et al., 2000; Birol et al., 2008a) or in perpetuity (Hanley et al., 2006b; Glenk et al., 2011).

2.3.2.1 Attributes and levels

Multidimensional approaches are concerned with disaggregating the value of waterbodies into its characteristics to be used as attributes in the study. The final attributes and levels used are intended to represent the many goods and services provided by the waterbody and vary throughout the literature (see Appendix 1). Reasons for this variation include the nature of the waterbody being studied, features of the population being sampled, and the objectives of the study in question. The most commonly included provisional service in CE studies for waterbodies is water supply. It has been measured by describing it in terms of supply fluctuation (Alvarez-Farizo et al., 2007) and in terms of its quality, e.g. whether it contains pathogens (Tait et al., 2012).

Values for regulatory services performed by waterbodies that have been assessed using CEs include water flow (Willis et al., 2002; Hanley et al., 2006b; Tait et al., 2012) and flood abatement (Birol et al., 2008a). Water clarity is also often included in the CEs as some form of aesthetic attribute. Litter, smell and clarity (Alvarez-Farizo et al., 2007), sewage (Hanley et al., 2006a) and pollution (Stithou et al., 2012) have all been used to describe aesthetics and water clarity.

Most multidimensional studies include at least one attribute for cultural services. Recreational values are measured as the number or type of activity that is available to the respondent in general terms (Morrison and Bennett, 2004; Stithou et al., 2012), in terms of physical accessibility (Birol et al., 2008a; Kataria et al., 2012) or in terms of days of closure to visitors (Smyth et al., 2009). Birol et al. (2008b) also included an attribute for education and research in their valuation of the Cheimaditida wetlands (including Lake Cheimaditida) in Greece.

Non-use values, or benefits provided by supporting services, are usually captured by CEs as attributes for the ecological status of the waterbody. Ecology may be described solely in terms of the type of biodiversity found in the waterbody. For example, an attribute for a specific group of species, such as native fish, may be included in the CE. These attributes are usually measured quantitatively, e.g. number of native species present (Morrison and Bennett, 2004; Kragt et al., 2011). Alternatively, studies may include attributes that are more general in their description of the biodiversity of the waterbody and are qualitative in their measurement of change, e.g. descriptions of the level of variety of plants, fish or birds (Hanley et al., 2005; Alvarez-Farizo et al., 2007; Birol et al., 2008a).

Many goods and services are described together because they are not produced by waterbodies in isolation. For example, water clarity (Alvarez-Farizo et al., 2007), smell (Hanley et al., 2006b) and erosion (Robinson et al., 2002; Hanley et al., 2006a; Stithou et al., 2012) have all been included in the description of the ecology attribute in different studies. This reflects the fact that it would be highly irregular for a waterbody to have good ecology levels combined with low water clarity, a poor smell or high erosion levels.

2.3.3 *Status quo levels*

Respondents are asked to pay for improvements to each attribute usually beyond some status quo level identified in the study. Status quo levels are most commonly set to the lowest level possible for the attribute in question (i.e. worst quality levels for the attributes). This means that if respondents say they are willing to pay for an alternative with an additional cost, the result would usually represent an improvement to the waterbody beyond what is represented by the status quo alternative. However, the description of these lowest-level status quo options may differ. For example, the status quo level for the ecology attribute in Alvarez-Farizo et al. (2007) is described as ‘low’, whereas in Hanley et al. (2006b) it is ‘worsening’.

On the other hand certain authors, such as Kragt et al. (2011), set the status quo ecology level at a mid-value to best represent the real current status of the attribute. Doing this allows for consideration of the fact that respondents may not value the current ecological levels of the river and therefore may not be interested in paying for its maintenance. Authors may even set the status quo levels to represent the standard of local rivers, meaning the status quo levels vary across respondents (Bennett et al., 2008).

2.3.4 *Method of payment*

Bateman et al. (2002) outline five aspects of the method of payment that need to be considered for any SP study:

1. The definition of reference and target payment levels;
2. The timing of the payment used;
3. Estimation of individual or household payments;
4. Choice of benefit measure; and
5. Payment vehicle type.

This report is particularly concerned with the fifth issue, but any discussion of payment vehicle type requires a discussion of the first four issues because they are all interlinked. In particular, these issues need to be considered in relation to whether the final method of payment used in an SP study reflects a realistic hypothetical market for the environmental good being valued.

Reference levels are respondents’ disposable income, which may be gathered as part of the questionnaire that accompanies all SP surveys. Target levels refer to respondents’ maximum WTP or minimum WTA for a change in the provision of the environmental good. Of particular concern for researchers estimating target payment levels for CEs is the range of price vectors used in the study because variation in their values has been shown to have a significant impact on final survey outcomes (Carlsson and Martinsson, 2008). Focus groups play an intricate role in determining appropriate prices to be included in the final CE survey.

Payments may be specified for a fixed length of time (Heberling et al., 2000; Birol et al., 2008a) or in perpetuity (Glenk et al., 2011). Certain authors opt for once-off payments in their studies, usually because it is more logical given the policy being reviewed (Morrison and Bennett, 2004; Kragt et al., 2011). Split sampling approaches in the CV literature have shown that WTP estimates resulting from once-off payments are not significantly different to ongoing paying (Lindhjem and Navrud, 2009). The main concern with the choice of payment timing used in SPs is, therefore, whether it adequately reflects the hypothetical market being presented to respondents.

The majority of CE studies elicit household WTP for environmental goods (e.g. Robinson et al., 2002; Morrison and Bennett, 2004; Kragt et al., 2011) rather than individual WTP. An exception to this rule can be seen in Hynes et al. (2013), who estimated respondents' WTP using hypothetical travel costs per visit, to hypothetical beaches. The decision to use individual or household WTP is particularly important because findings from CV literature suggest that household values from individuals differ from household values calculated jointly (Bateman and Munro, 2009). In fact, respondents' aggregate welfare measures for a change in the provision of a public good are higher if the same elicited mean WTP is added up over individuals rather than households (Lindhjem and Navrud, 2009).

The two main types of benefit measure used to elicit a value for environmental goods in SPs are respondents' WTP for the provision of the good and respondents' WTA for the loss of a good (Bateman et al., 2002). The choice of benefit measure used is not addressed in this report because only WTP estimates are gathered in the survey. However, the issue requires mentioning because the impact of the choice of benefit measure used in a CE on respondents' values for environmental goods is linked to the type of payment vehicle used in the study. Namely, it is well documented that a disparity exists between the amounts that respondents are willing to accept and willing to pay for the same good (see Horowitz and McConnell (2002) for an overview). Included in the many reasons given for this disparity are respondents' familiarity with the payment vehicle in the survey (Georgantzis and Navarro-Martinez, 2010) and the use of voluntary versus collective payments (Sayman and Onculer, 2005). These findings suggest that individuals' benefit values vary according to how the welfare measure fits with the payment vehicle, which, again, highlights the importance of the choice of payment vehicle type in a CE. The vast majority of CE surveys on waterbody valuation employ WTP as a benefit measure. One exception to this rule is Birol et al. (2008b) who ask respondents if they are willing to accept reductions in current taxation levels in return for declines in the environmental standard of their local river.

The fifth issue related to the method of payment used in an SP outlined by Bateman et al. (2002), and the one most pertinent to this report, is payment vehicle type. A number of split sample CV studies have shown how the use of different payment vehicles can impact on the values elicited from participants for environmental goods. For example, Ivehammar (2009) showed that using a payment vehicle for the redistribution of local taxes produced higher estimates than an increase in local taxes. Many of these split sample studies are particularly interested in how the use of coercive and voluntary payment vehicles impacts on welfare measures (Champ et al., 2002; Ivehammar, 2009). Findings generally indicate that estimate values from coercive sources are higher than those from donations. An explanation for this finding is provided by Champ and Bishop (2001) who, during a pretest focus group, found that respondents believed all individuals should jointly share the expense associated with the provision of public goods. However, a more recent paper by Stithou and Scarpa (2012) found that collective values for the protection of marine biodiversity were lower than voluntary values. Consequently, the influence of payment vehicle type on respondents' preferences varies across studies, meaning that it is likely to be influenced by spatial, temporal and individual-specific factors. For example, Wiser (2007) showed that collective WTP estimates were only significantly higher than voluntary estimates if the coercive payments were given to private companies rather than the government. Hence, belief in the government's ability to produce the good being offered may affect how payment vehicle type influences respondents' WTP for the hypothetical good on offer. Similarly, Vondolia (2011) shows that respondents' experiences of payment vehicles can affect their WTP estimates for the hypothetical good being valued.

Payment vehicles presented to respondents in CE literature on waterbody valuation can be both voluntary (Poirier and Fleuret, 2010) and coercive. Coercive payments appear as government payments, such as additional levies on council rates (Robinson et al., 2002), or private, e.g. payments to local sewage operators (Hanley et al., 2006a).

2.4 Studies in Ireland

Using CEs to estimate economic values for ecosystems requires information on the current status of the ecosystem in question. Thus far, a comprehensive assessment of all waters in Ireland has been prepared as part of Ireland's requirements under the Water Framework Directive's (WFD) implementation timetable. Characterisation reports for each of the river basin districts (RBDs) in the country provide information on their baseline ecological status and priority actions for subsequent stages in the river basin planning cycle (ERBD, 2005). An assessment of Ireland's environment, which was carried out by the Environmental Protection Agency (EPA) in 2012, confirms that, whilst water quality for the country in general compares favourably with that of other countries, Ireland faces considerable challenges to meet the objectives of the WFD by the given deadlines (EPA, 2012).

To achieve a proper estimate of the value of Irish waterbodies, it is necessary to collate data on the Irish situation specifically. This is because values accrued from studies in other countries do not map directly onto water status levels for Ireland as defined in the WFD (Goodbody, 2008). A number of studies in Ireland involve some form of economic appraisal of water-based activities but do not directly value water-related benefits. For example, Lawlor et al. (2007) conducted an economic evaluation of selected water investment projects in Ireland, part of which involved the estimation of required WTP estimates for local populations. Whilst an apportionment of benefits was made between local and non-local beneficiaries, based on the relative importance or popularity of the waterbody in question, the study did not provide benefit values of use in the appraisal of water resource initiatives.

Bullock et al*.* (2008) carried out an economic assessment of the value of biodiversity in Ireland, which involved consideration of the economic and social benefits of biodiversity across a range of sectors, including water. In this report, consumer surplus figures were produced for specialist and general users of rivers and lakes based on certain population assumptions. However, the findings were indicative only and not based on any original analysis. In late 2003, the Department of the Environment, Heritage and Local Government commissioned research in relation to the evaluation of water supply and waste water schemes in Ireland (DKM, 2004), although no valuations on the external costs and benefits of these schemes were produced. The Economic and Social Research Institute (ESRI) has conducted a number of studies over the years providing an economic evaluation on certain aspects of the Irish fishing industry. Finally, Indecon (2003) produced an economic evaluation of the salmon industry in Ireland based on actual revenues accruing to commercial salmon fishermen from fish sales and average expenditure incurred by salmon rod anglers in Ireland.

The number of studies that have been carried out to estimate the values of improvements to Irish waterbodies is limited. A baseline economic analysis, containing a preliminary assessment of the value and costs associated with water resources in Ireland, was completed as part of the 2005 National Summary Report for Ireland (EPA, 2005). Aside from this study, the majority of non-market valuations for Irish waterbodies focus on estimating benefits from water-based leisure activities on rivers. The travel cost method has been used to estimate the demand for, and economic value of, salmon angling in Co. Donegal (Curtis, 2002), as well as the mean WTP of the average kayaker using the Roughty River in Co. Kerry (Hynes and Hanley, 2006). Curtis (2003) used a nationally representative survey to examine Irish demand for water-based leisure activities and Hynes et al. (2009) used RP data to examine values for a range of river attributes relevant to kayaking. In addition, Norton et al. (2012) explored the use of benefit transfer techniques to calculate the economic value of Irish waterbodies achieving good environmental status (GES) under the WFD.

The number of papers using CEs to estimate values for Irish ecosystems has increased in recent years. Examples include evaluations of improvements to Irish agricultural landscapes (Hynes and Campbell, 2011), walking sites (Doherty et al., 2012) and coastal waters

(Hynes et al., 2013). However, whilst Doherty et al. (2012) include river walks as an alternative for respondents, none of these papers specifically estimates the values for improvements to Irish freshwater bodies. To date, the only study that used a CE to estimate values for Irish rivers was carried out by Stithou et al. (2012). The authors interviewed a total of 252 respondents in the Boyne River Catchment area to estimate their WTP for improvements to the river. Estimated implicit prices for the river attributes indicate that respondents assigned the highest value to improvements to river ecology, followed closely by the appearance of the waterbody.

2.5 Summary

Waterbodies increase human welfare through use values in the form of provisional, cultural and supporting goods and services and through non-use values in the form of supporting services. A number of methodologies exist for the valuation of these ecosystem goods and services. Of these, CE is the most appropriate for estimating generic values of Irish waterbodies for a number of reasons. Firstly, CEs belong in the category of SP methods, which means that they can be used to estimate both use and non-use values. Secondly, they are the most appropriate type of CM model for estimating monetary values of ecosystem goods and services. Finally, unlike CVs, one CE is capable of providing information on respondents' preferences for different levels of use and non-use values over a range of payment amounts. Consequently, one CE can be used to estimate welfare values for a number of policy changes to Irish waterbodies.

Other literature using CEs to value waterbodies can be divided into those that take a holistic and those that take a multidimensional approach. Within the latter category, there is a large degree of variation in the area, spatial scale and time frame addressed by studies. In addition, the description of attributes and their levels, as well as status quo levels and payment vehicles used, differs substantially throughout the literature. The overview of studies on Irish waterbodies provided in this literature review has shown that, to date, CEs have not been used to estimate generic values for Irish waterbodies, despite the requirements contained under the WFD.

3 The Design of the Discrete Choice Experiment Survey

The main aim of the CE design phase in this report was to create a survey that correctly identified and captured Irish citizens' preferences for quality improvements to Irish waterbodies in line with requirements laid down by the WFD and the EPA. Designing a CE survey is a cyclical process involving several stages. This chapter describes how these stages were approached for the design of this CE study. Section 3.1 provides details on the focus group that, along with a literature review, advised on which attributes and levels were to be used in the final survey. Section 3.2 gives details on these attributes and levels. Sections 3.3 and 3.4 provide details on the experimental design phase and sampling procedure, used in the report, respectively. Section 3.5 provides an overview of the statistical analysis used to obtain generic values for Irish waterbodies in this report. The chapter concludes with a final summation of the CE design phase of the study.

3.1 Focus Group

The focus group used for this report was conducted in July 2012 and included eight individuals from a variety of backgrounds. The meeting lasted just under 2 h and followed the guidelines set by Krueger (1997) for moderating focus groups. Individuals were asked to discuss a CE questionnaire on Irish waterbodies that was created using input from the CE literature described in Chapter 2, particularly the study carried out by Stithou et al. (2012) which estimated Irish citizens' values for rivers in the Boyne Catchment area. The required outputs from the focus group with regard to the CE survey were threefold. Firstly, it was used to ensure that the attributes on the choice cards correctly identified the systematic components of respondents' preferences for the good in question. Secondly, it was used to ask individuals whether they felt that the combinations of attributes, levels and prices presented on the cards were realistic and logical. Finally, it was to gauge whether any aspects of the survey were problematic for, or unclear to, respondents.

Discussions showed that individuals agreed that the attributes and levels identified in the questionnaire were the most important for describing Irish waterbodies. A number of individuals suggested that the name and description of the health of ecosystems attribute needed to be rewritten for clarification purposes. Visual aids were tested for the levels of the recreational activities and waterbody-type attributes in the focus group. Overall, the main difficulty identified in the focus group concerning the definition of the attribute and levels was conceptualisation of the waterbody-type attribute. For this reason, the status quo alternative was set to 'no improvements to any waterbody' to emphasise that the other alternatives on the choice cards were targeting specific waterbody types under the hypothetical policy change.

The combinations of attributes, levels and prices were deemed appropriate by the focus group in general. However, certain participants made it clear that they would not expect to be offered an alternative that provided access to primary recreational activities alongside poor water clarity. This comment was noted for the experimental design phase of the survey.

Initially, the upcoming introduction of water charges in Ireland was thought to be an important factor influencing whether respondents would be willing to pay for changes to Irish waterbodies. This is because it is a contentious issue and individuals may have expressed their distaste for it by refusing to bid anything in the CE. For this reason, the original draft of the questionnaire asked focus group participants how they felt about the possibility of being charged for water in the future. Interestingly, participants in the focus group unanimously agreed that the question should be removed from the survey because it made them suspicious of the intentions of the study.

3.2 Attributes and Levels

Identification of individuals' preferences for any good requires an understanding of the utility functions underlying the choices that they make when they are asked to choose from a selection of alternatives. Some influences on individuals' preferences are unobservable and therefore cannot be measured, meaning the CE design process is concerned with the measurable, or deterministic, part of respondents' utility functions. Therefore, the attributes and levels used in any CE must capture as much of the deterministic part of the utility function as possible. The choice of attributes and attribute levels used in this report was greatly aided by findings from related literature, especially Stithou et al. (2012), and comments made during the focus group discussions.

Table 3.1 shows the attributes and levels included in the final CE survey. Three levels were selected for each of the non-monetary attributes in the CE. The health of ecosystem attribute was included to account for the non-use values of, or supporting services

Table 3.1. Attributes and levels.

Attribute name	Levels	Status quo
Health of ecosystems (fish, insects, plants, wildlife on shoreline or banks)	Poor (60% of endangered aquatic species are present) Moderate (80% of endangered aquatic species are present) Good (100% of endangered aquatic species are present)	Poor (60% of endangered aquatic species are present)
Water clarity and smell	Poor (low water clarity, excessive algae, smell noticeable) Moderate (slightly murky water, some algae noticeable, no smell) Good (good water clarity, no algae, no smell)	Poor (low water clarity, excessive algae, smell noticeable)
Access to recreational activities	 Visual amenity only (access for walking or cycling along banks or shoreline)  Secondary contact recreation also possible (e.g. fishing, sailing)  All types of recreation possible (including primary contact, swimming, kayaking)	 Visual amenity only (access for walking or cycling along banks or shoreline)
Condition of banks or shoreline	High levels of erosion and damage (possibility of extreme flooding event once every 5 years) Moderate levels of erosion (possibility of extreme flooding event once every 10 years) Low levels of erosion (possibility of extreme flooding event once every 20 years)	High levels of erosion and damage (possibility of extreme flooding event once every 5 years)
Type of waterbody affected	 River  Sea  Lake	No improvements to any waterbody
Annual increase in personal income tax	€0 €5 €10 €20 €30 €45 €70	€0

provided by, Irish waterbodies in the form of the number of endangered species present at the waterbody. Levels for this attribute were set at poor, moderate and good, which were defined as 60%, 80% and 100% of endangered species being found at the waterbody, respectively. In this case, endangered species are those that are published under the national red lists as being extinct, endangered, vulnerable or rare (NPWS, 2013).

The water clarity and smell attribute captures regulatory services provided by Irish waterbodies in terms of waste regulation. It is also associated with cultural use values because it is capturing the aesthetic value of the ecosystems. The description of the attribute used is similar to that of Stithou et al. (2012), although the attribute levels are described differently. These are given as poor, moderate and good. Respondents are also provided with an outline of the degrees of clarity and smell provided from each level to ensure that they understand what each alternative is offering them.

Recreational cultural services were specifically addressed with the access to recreational activities attribute. The levels used for this attribute were primary, secondary and visual recreational activities. Primary activities are those that involve submersion of the individual into the water. Secondary activities involve being on, but not in, the water. Finally, visual recreational activities are those that concern being by, but not on or in, the water. Graphic aids were used for this attribute to remind respondents what each level meant.

The condition of banks and shoreline attribute was, again, similar to an attribute included in Stithou et al. (2012) because it addressed the level of erosion on the banks or shoreline. In doing so, it captured some of the aesthetic value of Irish waterbodies. However, unlike Stithou et al. (2012), the condition of banks and shoreline attribute used in this study included a description of the flood protection regulatory service provided by waterbodies. This change was made in response to focus group comments, which reflected the fact that flooding is a growing concern amongst Irish citizens. The three levels of the condition of banks and shoreline attribute are described in terms of both erosion and the possibility of an extreme flooding event occurring.

The type of waterbody affected attribute had three levels: river, sea or lake. Each level was accompanied by a small graphic to ensure clarity for respondents. The final attribute contained in Table 3.1 is the payment, which was given as an annual increase in personal income tax for 10 years. Prices offered to individuals ranged from €0 to €70.

The status quo alternative was set to the lowest levels for each of the first four attributes listed in Table 3.1, to ‘no improvements to any waterbody’ for the type of waterbody affected attribute and to €0 for the payment.

3.3 Experimental Design

An important part of CEs is the construction of an experimental design. This entails assigning the combinations of alternatives, attributes and their levels into a manageable number of choice tasks for respondents. Only where the number of attributes, levels and alternatives are small can all combinations be given to respondents. Therefore, an experimental design is typically necessary to derive combinations of alternatives, attributes and their levels from the full set of possibilities. A number of designs can be used to achieve this goal. While there are a number of benefits and drawbacks associated with alternative approaches, a Bayesian efficient design was chosen for this study (see Bliemer and Rose (2006) for a detailed discussion on experimental designs).

Efficient designs are those that attempt to maximise sampling efficiency. The designs are generated on the basis of the variance covariance matrix. In practice, however, since it is not possible to know the variance covariance matrix the asymptotic variance covariance (AVC) matrix is used. The generation of the AVC matrix requires some prior parameter values. These are usually obtained from focus groups, pilot studies, a literature review or expert judgement. If the prior parameter values are incorrect, then this can lead to a loss of efficiency. Paradoxically, however, if the prior parameter values were known with certainty, then no experimental design or study would be required. Therefore, for most designs aimed at collecting data based on a real world population, it is likely that most priors are at best approximations to the true values. Bayesian efficient designs can be used to accommodate this. Bayesian efficient designs allow for the fact that the prior parameters may not be exact. The primary benefit of using such an approach is that Bayesian efficient designs are more robust to misspecification of the priors. For this report, priors were taken from Stithou et al. (2012) to inform the initial pre-pilot construction of the experimental design. After the pilot, the results were analysed and priors were used from this to inform the construction of the experimental design for the main study.

A consideration when constructing the experimental design is not to provide respondents with combinations of attribute levels that are illogical to them. This will compromise the realism of the study. Findings from related literature and the focus group highlighted a number of incompatible attribute level interactions. For this reason, three restrictions were included in the experimental design used so that respondents answering the choice cards could not be presented with alternatives that offered them:

1. Poor water clarity and smell combined with good health of ecosystem;

2. Poor water clarity and smell combined with access to primary recreational activities; and

3. Poor health of ecosystems combined with access to primary recreational activities.

To ensure that respondents understood what was required of them in the CE, a detailed sample choice card was included in the survey similar to Fig. 3.1. Each option of the sample choice card was described to respondents in detail. Respondents were told that Option A is associated with poor health of ecosystems, poor water clarity and smell, access to secondary and visual recreation, low levels of erosion on banks and shorelines on all Irish rivers for €5 extra in annual personal income tax for 10 years. Option B is associated with moderate health of ecosystems, good

	Option A	Option B	Option C
Health of ecosystems: fish, insects, plants, wildlife on shoreline or banks	Poor (60% of endangered aquatic species are present)	Moderate (80% of endangered aquatic species are present)	Poor (60% of endangered aquatic species are present)
Water clarity and smell	Poor (Low water clarity, excessive algae, smell noticeable)	Good (Good water clarity, no algae, no smell)	Poor (Low water clarity, excessive algae, smell noticeable)
Access to recreational activities	Secondary contact recreation also possible (e.g. fishing, sailing)	All types of recreation possible (including primary contact, swimming, kayaking)	Visual amenity only (access for walking or cycling along banks or shoreline)
Condition of banks or shoreline	Low levels of erosion and damage (possibility of extreme flooding event once every 20 years)	High levels of erosion and damage (possibility of extreme flooding event once every 5 years)	High levels of erosion and damage (possibility of extreme flooding event once every 5 years)
Type of waterbody affected	River	Lake	No improvements to any waterbody
Annual increase in personal income tax	€5	€45	€0

Figure 3.1. Sample choice card.

water clarity and smell, all types of recreational activities, high levels of erosion on banks and shorelines for every lake in Ireland for a €45 increase in annual personal income tax. Finally, Option C is the status quo option. It is associated with poor health of ecosystems, poor water clarity and smell, access to visual recreation only, high levels of erosion on banks and shorelines for no increase in their annual personal income tax. Respondents were asked to choose their preferred option out of each choice card.

In total, respondents were asked to answer six choice cards. The combination of attribute levels on Options A and B varied for each card and always incurred a cost. Option C remained unchanged for each of the six choice cards. There were two blocks of six choice cards used in this experimental design.

Respondents' preferences for different waterbody attributes are expected to vary according to a number of individual-specific factors. These include their socio-economic and demographic status and their level of interest in the CE survey. As a result, those who participated in the study were asked a variety of questions relating to their demographic status, such as their age, education level and marital status. Information was gathered on whether they used Irish waterbodies and their opinions of the current environmental status of rivers, lakes and seas. Respondents were asked to rank their preferences for different waterbody attributes and to provide details on their underlying decision-making processes whilst they were completing the CE survey. Finally, the questionnaire accompanying the CE survey asked respondents to give their preference for the type of payment vehicle used to improve the status of waterbodies in Ireland.

3.4 Sampling Procedure

A market research company was employed to collect the data for this report. The company followed a quota control sampling system based on respondents' location and socio-demographic profile to ensure that the sample was representative of the general population of Ireland. Interviewers from the survey company collected the data face-to-face with respondents in their home. They were instructed to go through the survey carefully with respondents to ensure that they fully understood what was required of them.

There were two stages of data collection. The first was the pilot survey, which took place in September 2012 and involved surveying 50 respondents. Results from the pilot survey showed that generally the survey was well understood by those answering it. Some concern was expressed by interviewers regarding the type of waterbody attribute, which resulted in a rewrite of the description of the attribute to clarify its meaning for respondents. Interviews for the main survey were carried out in November 2012. A total of 800 surveys were collected during this time, meaning the analysis for this report is based on responses from 850 respondents in total (pilot + main study).

Table 3.2 shows how the survey sample compares with the 2011 Irish census for the main demographic variables used to meet the sample quotas. The sample has a higher proportion of Irish residents, of individuals with more than primary school education and of married people than the national average. Table 3.2 also shows that the sample used for this report has fewer individuals whose highest education level is primary school and a lower proportion of urban dwellers than the Irish population. Average income from the survey sample is substantially lower than average income reported in the 2011 Irish Census (CSO, 2013a). This is almost certainly a consequence of the high refusal rate for reporting income amongst respondents (399 individuals did not report their income). Despite these minor disparities, overall Table 3.2 indicates that the sample of individuals interviewed for this report aptly represents the general population of Ireland.

3.5 Statistical Analysis of Results

When respondents are presented with a choice card, they are expected to choose the alternative that provides them with the greatest amount of utility, subject to constraints. Utility from each alternative can be derived from observed or unobserved sources but, by definition, researchers are not privy to information on the unobserved sources. The economic model that was used to link information on respondents' observable sources of utility with a statistical model of human behaviour is the RUM. RUMs do this by treating

Table 3.2. Sampling breakdown of the survey.

Variable	Survey (n = 850)	Irish Census 2011[1]
Age (years)	45	45
Gender (% male)	49	49
National (% Irish)	90	86
Education (% to primary)	10	16
Education (% to secondary)	57	53
Education (% to tertiary)	33	31
Marital status (% single)	27	27
Marital status (% married)	55	51
Marital status (% other)	18	22
Urban (% urban)	59	62
Income (€/year)[2]	27,350	36,138

[1]Data compiled from CSO (2013).
[2]For the income variable: n = 455.

unobserved sources of utility as random components. The type of distribution that is used to describe unobserved sources of utility dictates which econometric model is used for the choice analyses. In this report, two models were used to estimate respondents' preferences for the management of generic waterbody attributes. The first was a CL, which is the product of assuming that the random components are independently and identically distributed (IID) following a Type 1 extreme value distribution. Whilst the CL is considered the 'workhorse' of discrete choice modelling, these assumptions can be somewhat limiting. For this reason, the second model used for this report is the MXL, which accounts for heterogeneity in respondents' preferences by assuming that the parameters estimated for each attribute level are randomly distributed rather than fixed. For this reason, the MXL is capable of overcoming a number of the limitations associated with the CL (Train, 2003).

Parameter estimates from the CL and MXL were converted into monetary values, or implicit prices, for each attribute level in the survey. Then, the TEV of policy changes for Irish waterbodies was calculated by estimating the compensation surplus (CS) value of improvements to the first four attributes in Fig. 3.1 from their lowest to their highest levels. These CS values were calculated separately for improvements to rivers, lakes and seas. Finally, average individual estimates were aggregated upwards to create values for each of these waterbody types for the entire Irish population (for more information on the statistical analysis used in this report, refer to Appendix 2).

3.6 Summary

This chapter describes the stages of the CE design used for this survey. The CE design phase was informed by the literature review, a focus group discussion and a large pilot study. The final choice cards that resulted from the CE design process contained five non-monetary attributes. Of these, four were related to the goods and services provided by Irish waterbodies and one investigated whether respondents had preferences for the type of waterbody affected by policy changes. Each of these non-monetary attributes had three levels. The monetary attribute, or payment, was given as an increase in personal income tax for 10 years.

Each choice card used in the CE contained three alternatives. The status quo option (Option C) had all of the non-monetary goods and services attributes set to their lowest level, the type of waterbody attribute set to 'no improvements to any waterbody' and the payment set to €0. The remaining two options (Option

A and Option B) had improved levels for the goods and services non-monetary attributes, a waterbody type targeted for the fifth attribute and a non-zero price. Each respondent was asked to choose their preferred alternative on six choice cards.

A quota control sampling system was used to identify respondents for this study and to ensure that the preferences of those interviewed aptly represented members of the Irish population. Two models were used in this report to estimate Irish citizens' generic values for waterbodies: a CL model and an MXL model. Parameter estimates from these models were used to separately estimate the Irish populations' values for improvements to rivers, lakes and seas.

4 Factors Influencing Irish Citizens' Preferences for the Management of Waterbodies

This chapter presents summary statistics from the questionnaire used in this report that help to describe respondents' preferences for the management of Irish waterbodies. Section 4.1 provides an overview of how respondents rank the attributes in the CE and how their use of waterbodies is expected to influence this decision. In addition, it describes how waterbody use varies by certain socio-economic, demographic and regional criteria. Section 4.2 looks specifically at respondents' expected preferences for the type of waterbody attributes in the CE. These are expected to be influenced by how respondents' use the different waterbody types and by their opinions on the environmental quality of each. Both topics are discussed in relation to Irish seas, lakes and rivers. Section 4.3 looks at three issues that are expected to impact on the actual values that respondents assign to improvements in Irish waterbodies. These issues are the reasons for zero bidding (i.e. always choosing the status quo option, which is associated with zero cost in return for the lowest waterbody quality levels), socio-economic, demographic and regional variation in maximum WTP, and the impact of payment vehicle type on the amount that respondents are willing to pay in the CE. Finally, Section 4.4 provides a brief summary of the chapter.

4.1 Waterbody Use

The generic attributes of Irish waterbodies used for this report are the health of ecosystems, water clarity and smell, access to recreational activities, condition of banks or shorelines and the type of waterbody affected by the hypothetical policy change. Respondents' preferences for these attributes are expected to be largely influenced by whether or not they use waterbodies. This section briefly provides a preliminary overview of respondents' preferences for the five attributes and whether their use of waterbodies is associated with these preferences. It also provides details on the type of respondent who is most likely to visit Irish waterbodies in terms of socio-economic status, demographics and geographical location.

4.1.1 Preferences for waterbody attributes

In a question that was presented to respondents before the CE exercise, they were asked to rank five water management issues according to what they considered was important to them personally. These issues corresponded to the five attributes that appeared in the CE. Figure 4.1 shows the average value of the rankings assigned to each issue, where 1 and 5 are the least and most important to the respondent, respectively.

The average rankings displayed in Fig. 4.1 show that the most important attribute for respondents is water clarity and smell and the one that concerns them least is the type of waterbody affected by the proposed policy change. A number of statistical tests were implemented to find associations between these rankings and individual-specific factors, such as socio-economic status and location, to gain further insights into what influences respondents' preferences for various waterbody issues. The one factor that varied significantly with the ranking of each of the five waterbody attributes was the number of times a respondent visited a waterbody in the past 12 months.

A graphical representation of this relationship is displayed in Fig. 4.2. It shows that neither the type of waterbody affected nor access to recreational activities is a priority for individuals who visit waterbodies regularly. Condition of banks and shoreline and water clarity and smell are both issues that are of mid-importance to regular visitors to waterbodies. However, the most striking finding in Fig. 4.2 is that the health of ecosystems ranking increases with the number of visits made by respondents, which implies that the more a person visits waterbodies, the more highly they value the biodiversity found there.

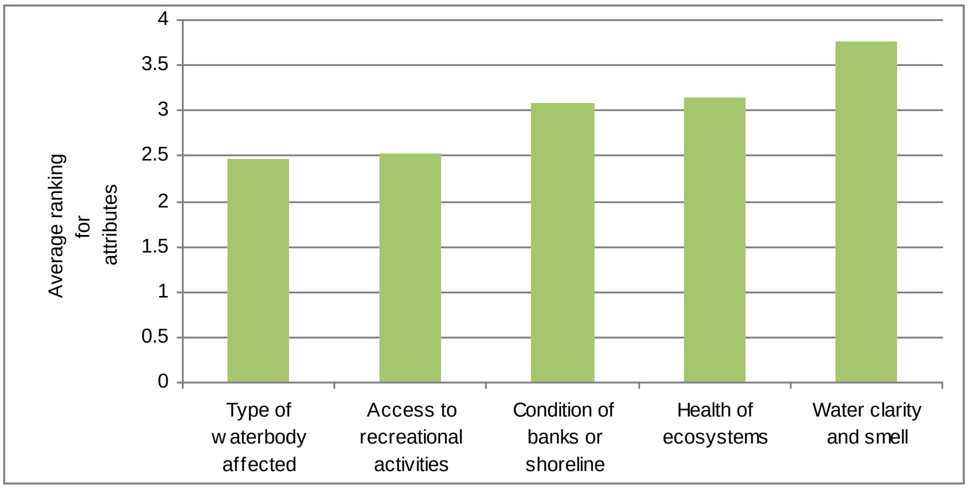


Figure 4.1. Rankings for attributes where 5 is most and 1 is least important.

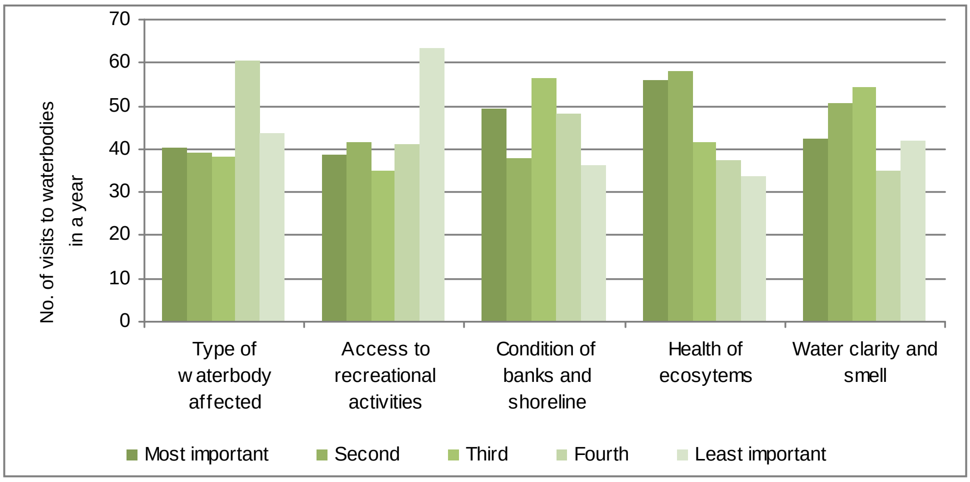


Figure 4.2. Average number of visits to waterbodies for each attribute ranking.

Kruskal–Wallis test tied/untied – Health of ecosystems: 135.73/138.07, df = 4, p = 0.001; Water clarity and smell: 15.14/15.40, df = 4, p = 0.004; Access to recreational activities: 81.24/82.65, df = 4, p = 0.001; Condition of banks and shoreline: 65.96/67.10, df = 4, p = 0.001; Waterbody affected: 50.74/51.62, df = 4, p = 0.001.

4.1.2 Socio-economic and demographic status and waterbody use

Whilst factors relating to respondents' socio-economic and demographic status do not vary significantly with their rankings for each of the waterbody attributes in this study, a number of these factors do vary significantly according to whether or not respondents visited a waterbody in the past year. The likelihood that an individual visited a waterbody varies according to his/her income level, social class and the hours that he/she works, as well as educational and marital status.

Figure 4.3 demonstrates how likely it is that individuals earning various income levels, from different social classes and working a variety of hours visited a waterbody in the previous 12 months. It shows that the likelihood of individuals visiting waterbodies consistently increases with income. In fact, the likelihood of those earning less than €10,000 and €10,000–20,000 per annum visiting a waterbody is far below the sample average (0.74) at 0.58 and 0.63, respectively (Fig. 4.3a). Respondents who belong to Category B of the listed social classes are the most likely of all to visit Irish waterbodies, followed by

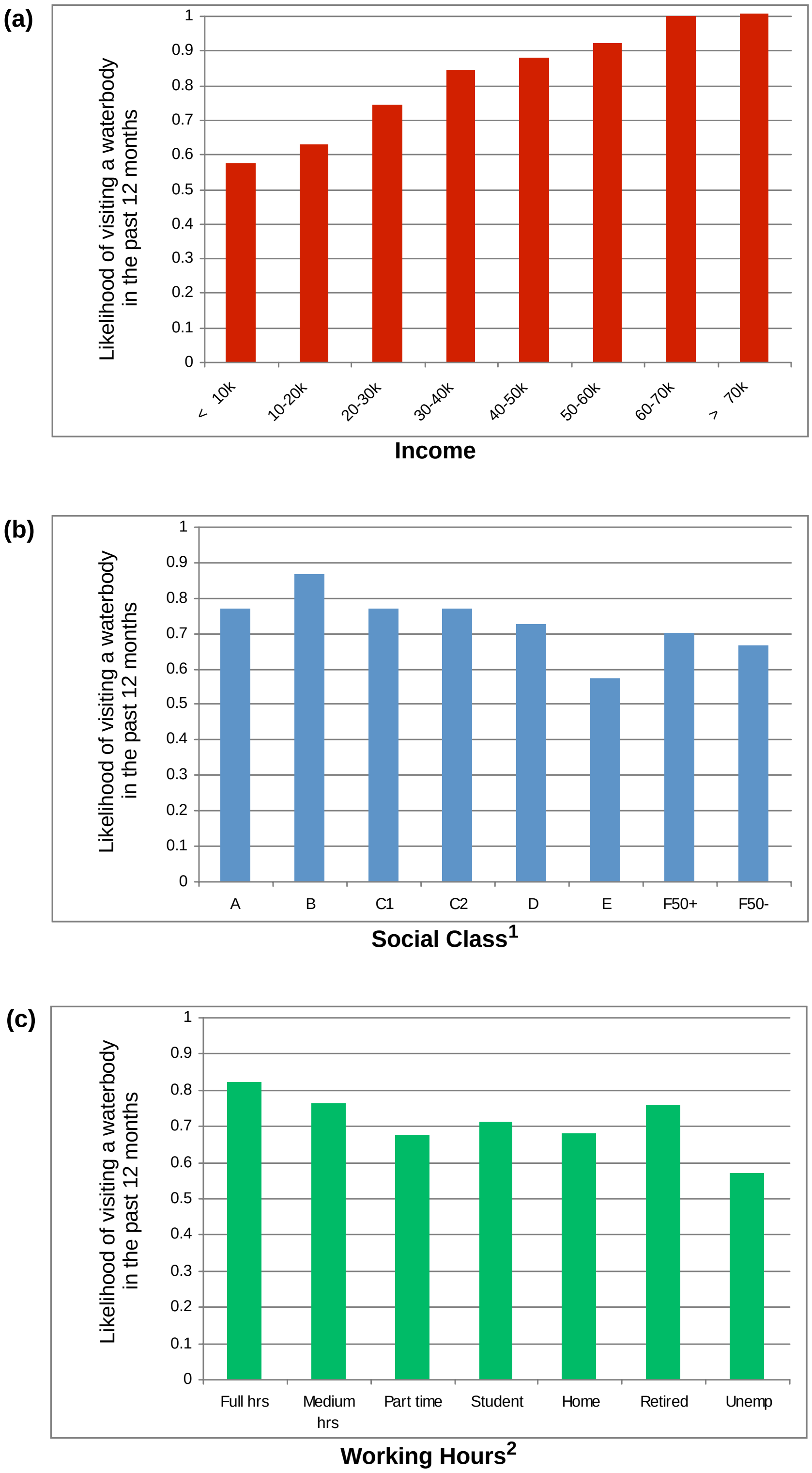


Figure 4.3. Likelihood that individuals from different income, social class and working categories visited an Irish waterbody in the past 12 months.

[1]*Class categories – A: Higher managerial, administrative or professional; B: Intermediate managerial, administrative or professional; C1: Supervisory or clerical and junior managerial, administrative or professional; C2: Skilled manual worker; D: Semi- and unskilled manual worker; E: Casual or lowest grade workers, pensioners and others depending on the State; F1: Farmers with 50+ acres; F2: Farmers with less than 50 acres.*

[2]*Pearson chi*^{2} *– (a) 41.79, df = 9, p = 0.001; (b) 22.65, df = 7, p = 0.002; (c) 4.05, df = 8, p = 0.001.*

Categories A, C1 and C2, whilst the least likely are Category E (Fig. 4.3b). Finally, the first three columns in Fig. 4.3c show that the least likely to visit waterbodies, with likelihoods of 0.57, 0.67 and 0.68, respectively, are unemployed persons, part-time workers and home makers. Overall, the results in Fig. 4.3 suggest that respondents with higher earnings and a full-time wage are more likely to visit waterbodies than not.

The likelihood of visiting a waterbody does not vary significantly by sex or age categories (see Section A3.2 in Appendix 3 for how they significantly vary by type of use). Demographic variables that are significantly associated with whether a respondent visited a waterbody or not in the past 12 months include educational status and marital status.

Figure 4.4a shows that the likelihood that an individual visited a waterbody in the past 12 months increases with the individual's minimum education level. This finding may be linked to those shown in Fig. 4.3 – namely, individuals with higher minimum educational levels may have higher earnings and are therefore less constrained by income. It may also be that individuals with a tertiary education get more opportunities to

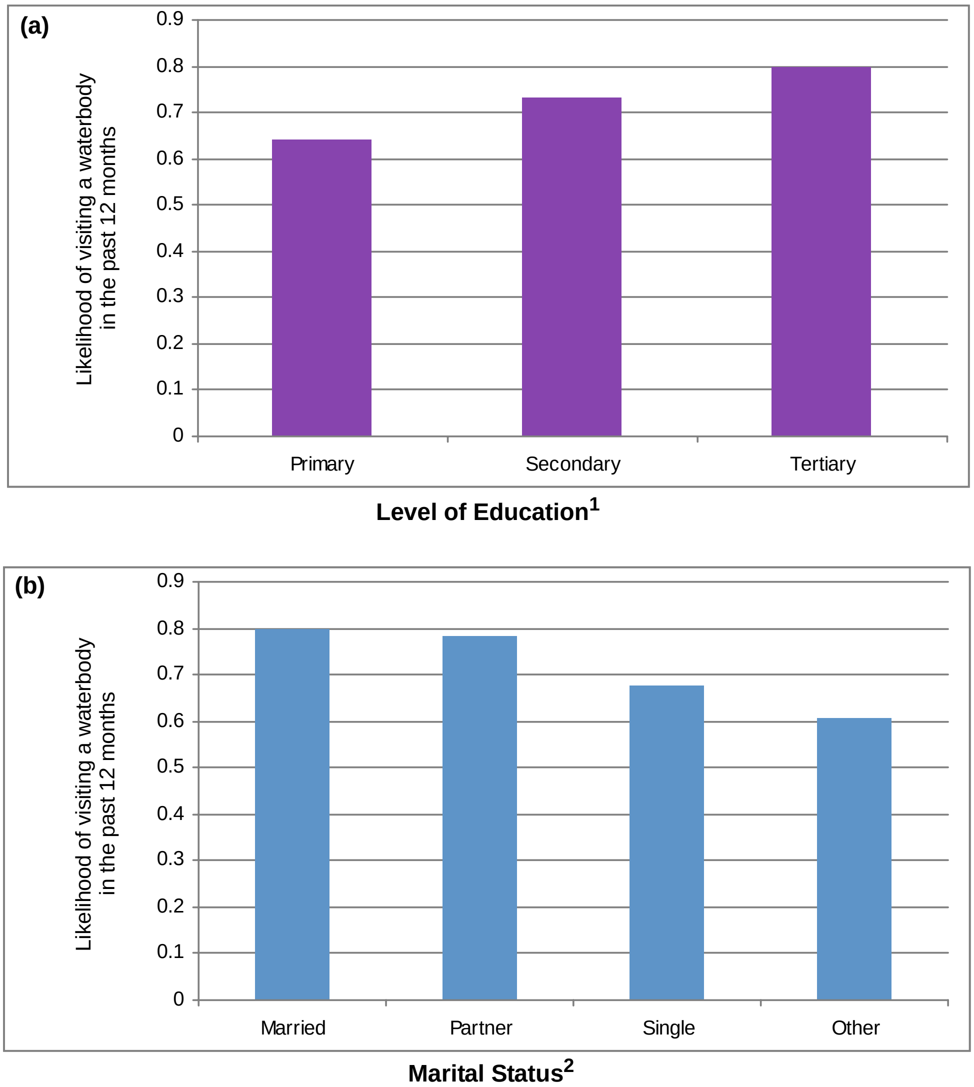


Figure 4.4. The likelihood of visiting a waterbody in the past 12 months by (a) educational status and (b) marital status.

[1]*Respondents' maximum level of education.*

[2]*Pearson chi*^{2} *– (a) 8.82, df = 2, p = 0.012; (b) 22.62, df = 3, p = 0.001.*

participate in water-based recreational activities, such as surfing or swimming clubs, than those who did not go to college. If so, it is reasonable to assume that they continue to pursue these sports later in life. A similar argument can be made for the fact that those with secondary level education are more likely to visit waterbodies than those with just primary education. This may be a consequence of experiencing water-based recreation as part of school tours or with clubs.

Figure 4.4b shows that individuals who are married, or who live with their partner, are the most likely individuals to visit waterbodies of all the marital status categories. This may be because individuals who are married or living with their partners enjoy participating in recreational activities together, or they may have children and therefore take them out for family days (see Appendix 3 for more information on family structure and waterbody use).

4.1.3 Geographical location and waterbody use

Waterbodies are spread generously throughout Ireland, which means that there are no regions in the country that are devoid of them. In addition, the overall environmental quality of Irish waterbodies is good, with non-polluted waters being within driving distance of every person in the country. Consequently, in terms of availability, there is no obvious reason for regional variation in general waterbody use throughout the country.

Nonetheless, Fig. 4.5 shows that individuals in the south-west, south-east and south are significantly more likely to have visited a waterbody in the past 12 months than those in any other region of the country. This may be because the south of Ireland is sunnier than the remainder of the country, but weather does not explain all the variation in Fig. 4.5. For example, the north, west and midlands of Ireland all have higher rainfall than the east, yet the likelihood that someone in the east visited a waterbody is the lowest of all seven regional categories.

The finding for eastern regions may be due to the fact that Dublin is located in the east and, as Fig. 4.6 shows, the likelihood that an individual from an urban setting visited a waterbody in the past 12 months is lower than that of a rural dweller. This may be a consequence of perceived distance from the waterbody, where living in a built-up area and the resulting traffic means that average distances (in terms of time) from a waterbody is further for urbanites than for those in the countryside.

However, Fig. 4.6 also shows that people living in county boroughs are the most likely of all three location variables to visit waterbodies, which is an unexpected result given that they too will experience the impacts of

Figure 4.5. The likelihood that individuals from different regions visited an Irish waterbody in the past 12 months.

Pearson chi^2: 36.39, df = 6, p = 0.001.

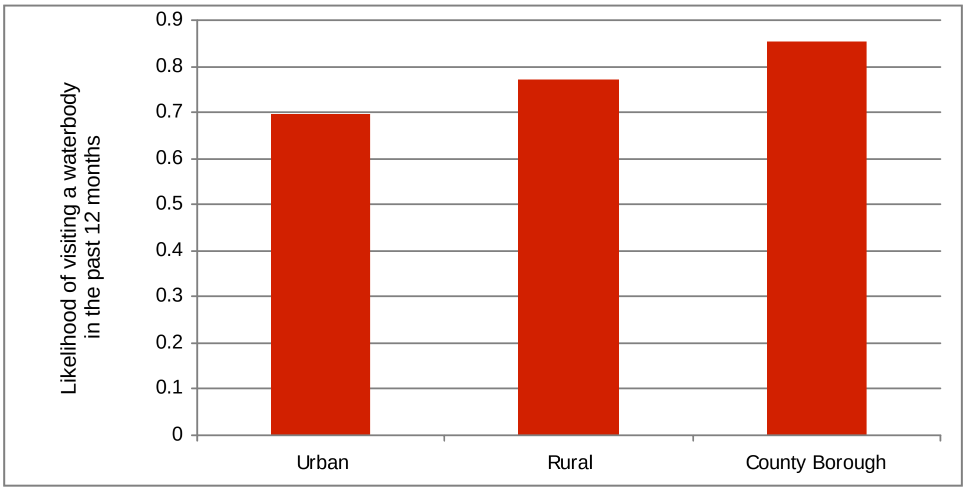


Figure 4.6. The likelihood that individuals from different locations visited an Irish waterbody in the past 12 months.

Pearson chi^2 – 12.63, df = 2, p = 0.002.

living in a built-up area. The higher likelihood of finding an individual from a county borough at a waterbody than an individual from a rural area may be because individuals from the countryside do not feel the need to travel to visit any one particular landscape feature given that they are surrounded by many.

4.2 Waterbody Type

A central point of interest for this study is whether individuals show preferences for improvements to one particular waterbody type, as it would suggest that they are likely to place a higher value on it than on other waterbody types. This section looks at reasons for potential differences in respondents' preferences for different rivers, lakes and seas. In particular, it shows which waterbody type respondents were most likely to visit in the past 12 months, differences in the types of recreational activity pursued at rivers, lakes and seas, and respondents' opinions of the environmental quality of all three.

4.2.1 Use of different waterbody types

The Venn diagram in Fig. 4.7 shows that in the past 12 months respondents are most likely to have visited no waterbodies (25.64%), followed by the sea alone (22.37%) and all three waterbody types (17.10%). Overall, the most popular waterbody to visit is the sea (55.90%), followed by rivers (43.92%) and, finally, lakes (27.76%). In fact, individuals are substantially more likely to have visited both a river body and the sea in the previous 12 months (11.59%) than they are to have visited just a lake (3.28%). A possible reason for these findings is the availability of different waterbodies throughout the country. For example, individuals located in the midlands are often the furthest in the country from the sea but the number of lakes nearby is plentiful. The opposite often may be said for those living near the coast. Rivers, on the other hand, tend to be distributed evenly throughout the countryside.

Respondents who claimed to have visited the sea, a lake or river in the past 12 months were asked two follow-up questions. The first was how many times during this period they had participated in one of six types of recreation at each type of waterbody. Secondly, interviewers enquired how far, on the previous occasion, visitors had travelled to seas, lakes or rivers for each of these six recreational pursuits. Responses to these questions are displayed in Fig. 4.8.

Perhaps the most striking finding in Fig. 4.8 is the degree of variation between the number of times individuals visited, as well as the distance they travelled, for a seemingly similar recreational pursuit but at different waterbody types. Visitors most regularly go to the sea for nature and bird watching, wind, board or kite surfing and swimming; to rivers for walking,

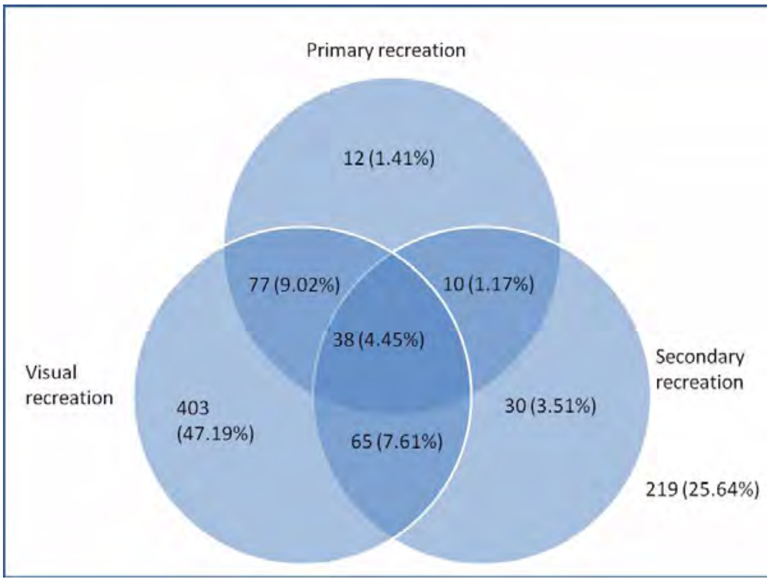


Figure 4.7. Breakdown of uses of the different waterbody types in the sample.

running and jogging, as well as fishing; and almost equally as often to lakes and rivers for rowing, boating, canoeing or cruising (1.65 and 1.63 times per year, respectively). The furthest distances travelled by visitors were to the sea in order to swim or wind, board or kite surf; and to a lake in order to walk, jog or run, nature or bird watch, row, boat, canoe or cruise and to fish.

A conclusion that can be made from this large amount of variation is that participating in a form of recreational activity at one waterbody type is not necessarily equivalent to doing it at others. This may be because the sport itself differs according to the environment of the specific waterbody, e.g. waves are required for board surfing. A second reason may be that individuals use different waterbodies for different experiences. For example, respondents who walked, ran or jogged at a lake did so approximately 14.79 times in the past 12 months and travelled an average of 23.74 miles to do so. In contrast, those who walked, ran or jogged at a river did so 41.36 times in a year and travelled 7.63 miles (Fig. 4.8a). These descriptions imply that there is more effort required to visit a lake over a river for walking, running or jogging. For respondents to have put in the extra effort to go to a specific waterbody type implies that it has a unique appeal over other waterbody types, which is expected to be reflected in respondents' preferences for waterbody management.

4.2.2 Opinions of environmental quality

Individuals may also prioritise the management of a specific waterbody type over others because they feel it is in greatest need of improvement or protection from environmental damage. Respondents were presented with three Likert scale questions asking them to separately describe the general environmental quality of rivers, lakes and seas in Ireland. Any differences in respondents' opinions of the environmental standards of different waterbodies can be ascertained by looking at the number of people who claimed to be very unsatisfied, unsatisfied, neither, satisfied or very satisfied with each.

In general, respondents' opinions of the quality of Irish waterbodies are positive (Fig. 4.9). For seas, lakes and rivers, the majority of respondents claimed to be satisfied with the environmental quality. The most positive results are for seas, with 65.65% of respondents claiming to be very satisfied or satisfied with their quality. This can be compared with 56.74% and 57.66% of respondents claiming to be satisfied or very satisfied with lakes and rivers, respectively. In addition, the number of respondents who claim to be unsatisfied or very unsatisfied with the status of the seas is the lowest of all three at 14.54% of the sample.

A total of 22.79% of the sample claimed to be unsatisfied or very unsatisfied with the status of rivers. It is the only category of waterbody that has a higher

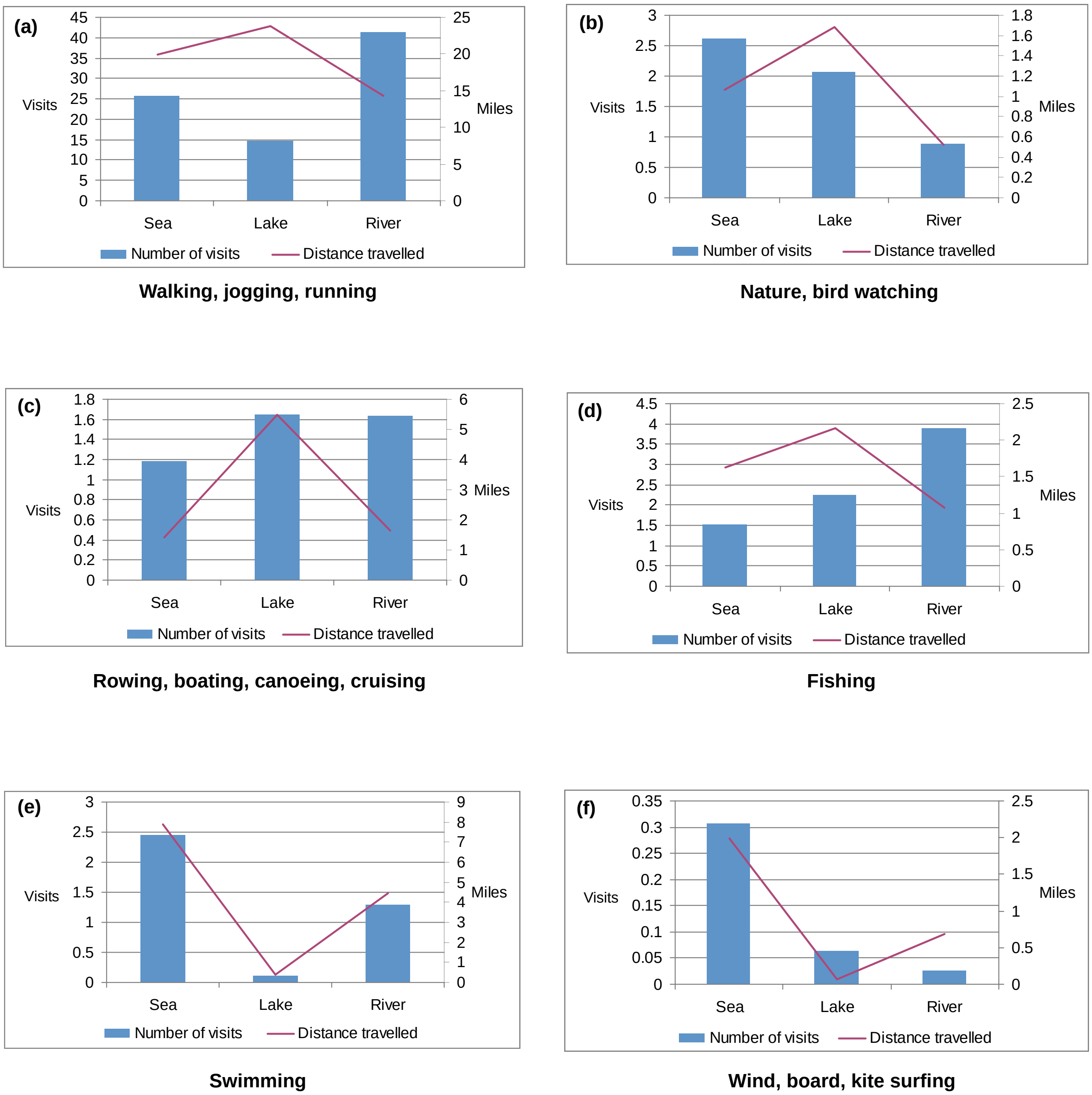
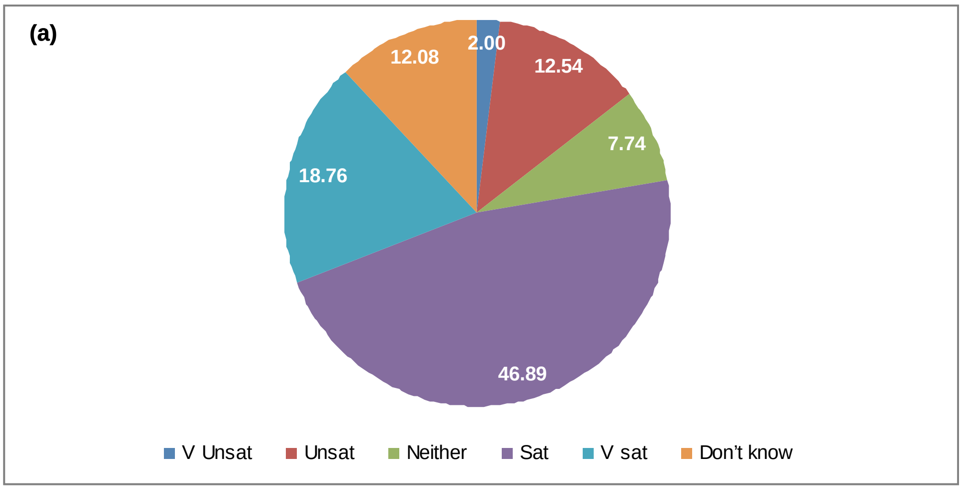


Figure 4.8. Recreation at different waterbody types showing average number of visits in a year (blue bars) and average number of miles travelled (red lines).

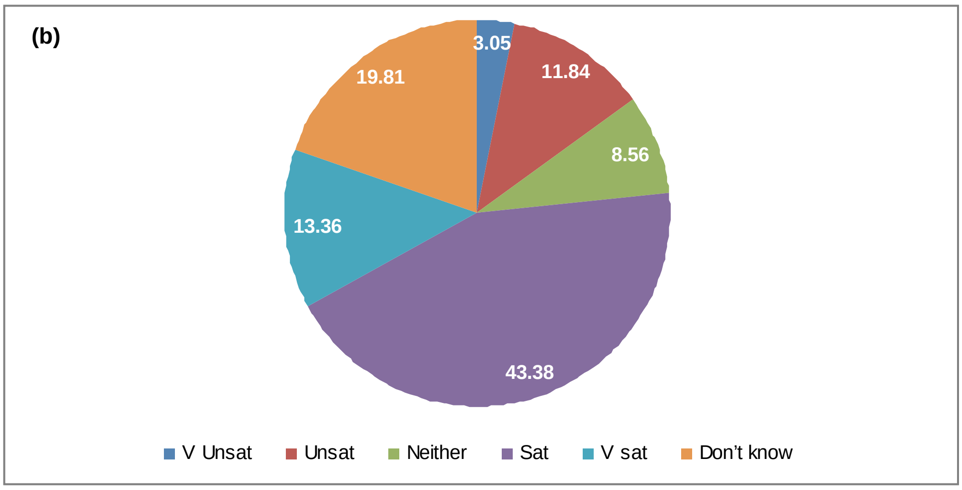
number of interviewees expressing dissatisfaction (17.12%) than extreme satisfaction (12.66%) with its environmental quality. Only 14.89% of respondents said they are unsatisfied or very unsatisfied with the quality of Irish lakes, although a total of 19.81% claim to not know the answer to this question. This latter finding is likely to be due to the fact that only 27.76% of the population visited lakes in the past 12 months (Appendix A3.1).

4.3 Valuation of Irish Waterbodies

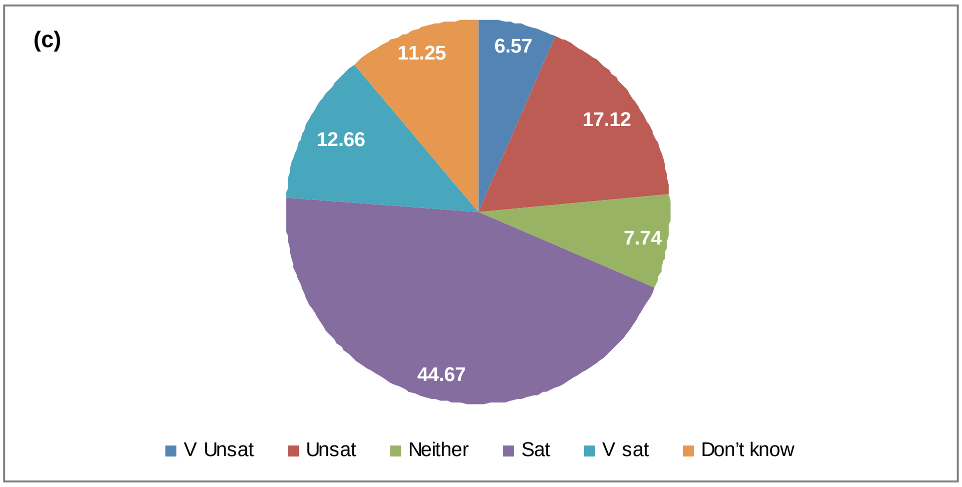
Respondents' preferences for alternatives on each choice card are expected to be influenced by a number of individual-specific factors. This section is concerned with outlining what these influences may be. Section 4.3.1 looks at the reasons why a number of individuals were not willing to pay for any improvements to Irish waterbodies. Section 4.3.2 investigates whether the maximum amount that respondents were willing to pay



Seas



Lakes



Rivers

Figure 4.9. Respondents' description of the environmental quality of (a) seas, (b) lakes and (c) rivers in Ireland.

varied significantly according to their socio-economic and demographic status. Section 4.3.2 also looks at whether individuals' preferences for the type of payment vehicle used in the study is likely to have impacted on the amount that they were willing to pay in the CE.

4.3.1 Zero bidders

A total of 43.85% of respondents in the CE chose the status quo option on every choice card. These individuals are referred to as zero bidders. Each zero bidder was asked a follow-up question to ascertain their reasons for being unwilling to pay for improvements to Irish waterbodies. The results from this question are displayed in Fig. 4.10.

According to Fig. 4.10, the majority of zero bidders were unwilling to pay for improvements to Irish waterbodies because they disagree with the concept of paying for them. A total of 47.33% of zero bidders comprised protesters, claiming that the government should pay and not them, that they object to paying tax, that they do not believe it will happen or that they pay enough tax already. The second most common type of zero bidder is the respondent who cannot afford to pay for changes to Irish waterbodies (44.92% of zero bidders). Finally, 7.75% of zero bidders claim to not value changes to the ecosystems. These respondents are not concerned with the issues, could not decide what the best options were, do not use waterbodies and claim that no change to waterbodies is fine. Zero bidders who were deemed protest responses were excluded from the sample used to model the preferences for waterbody attributes.

4.3.2 Payment vehicles and WTP

Of particular interest to this study is whether respondents' preferences for different payment vehicle types impacted on their WTP for improvements to Irish waterbodies. The payment vehicle used in the CE was an increase in annual income tax. Respondents were asked to make these payments for 10 years. They were informed that the payments would be exclusively used for improvements to waterbodies. After completing the CE survey, individuals who were willing to pay for changes to Irish waterbodies were asked to identify their preferred method of payment from a list. The results from this question are shown in Fig. 4.11.

Respondents' preferred method of payment for improvements to Irish waterbodies was through a once-off lump sum (38.83%). The payment vehicle specified for this study (income tax) is only the second most popular method of payment chosen by respondents (22.34%). The reasons for this are likely to be twofold. Firstly, increases in tax may be associated with a mistrust of the government and its ability to deliver on the promised improvements. Secondly, taxes (or rates) tend to be paid on an ongoing basis, which may be unappealing for certain individuals.

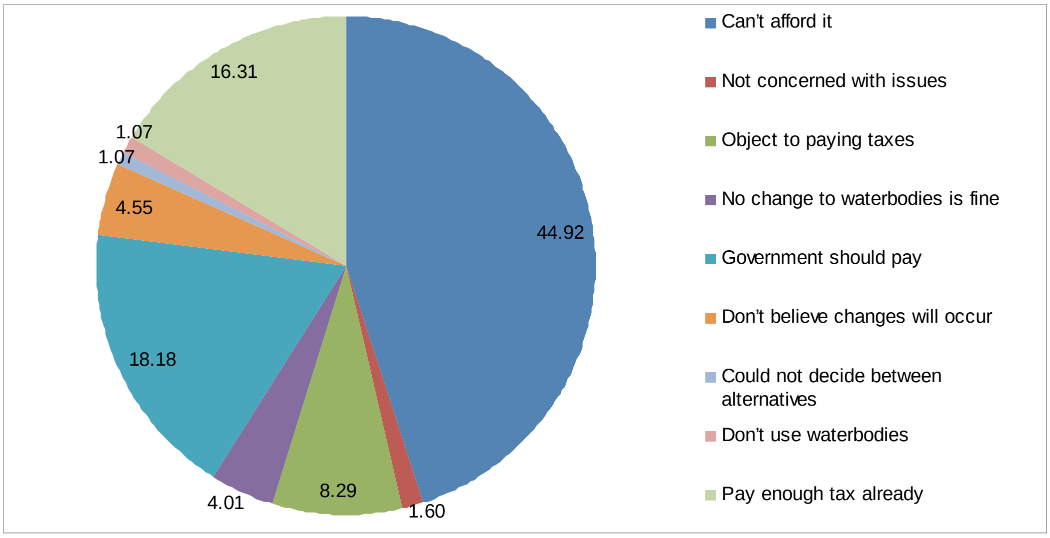


Figure 4.10. Reasons given for choosing all zero values on the choice cards.

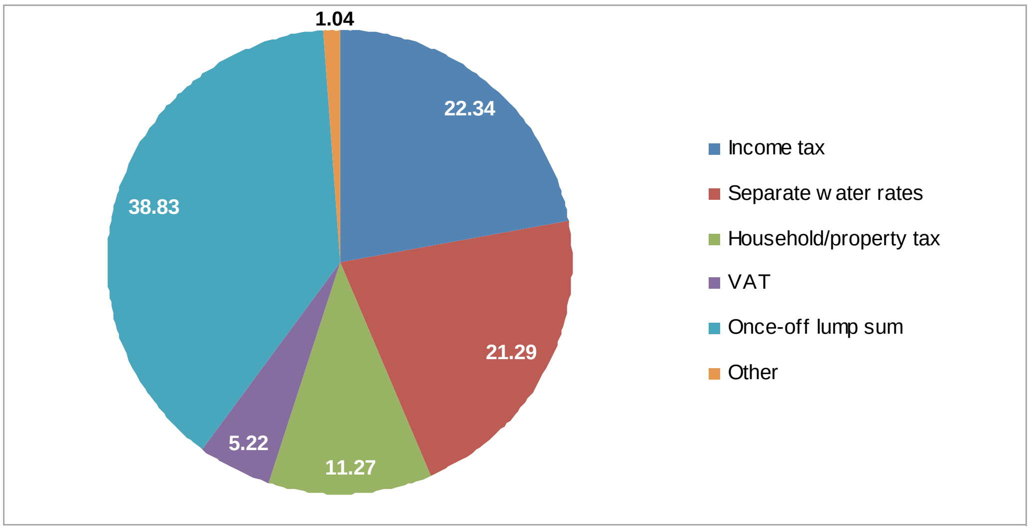


Figure 4.11. Bidders' preferences for payment vehicle type.

Figure 4.12 shows that respondents are significantly more likely to have higher maximum WTP levels if they identified an increase in income tax as their preferred payment vehicle type[3]. Therefore, despite the fact that payment vehicle type is not expected to influence individuals' preferences for improvements to Irish waterbodies, it is expected to influence the amount that they are willing to pay for these changes.

3. The alternatives presented to respondents in the CE had various prices from €0 (status quo) to €5, €10, €20, €30, €45 or €70.

4.4 Summary

This summary statistics chapter outlined which individual specific factors are expected to influence respondents' preferences for, and valuation of, different attributes contained in the CE. In Section 4.1, respondents were found to rank water clarity and smell most highly and waterbody type least highly of the five attributes used in the CE survey. This section also outlined how waterbody use captures some of the variation in respondents' preferences for these waterbody attributes.

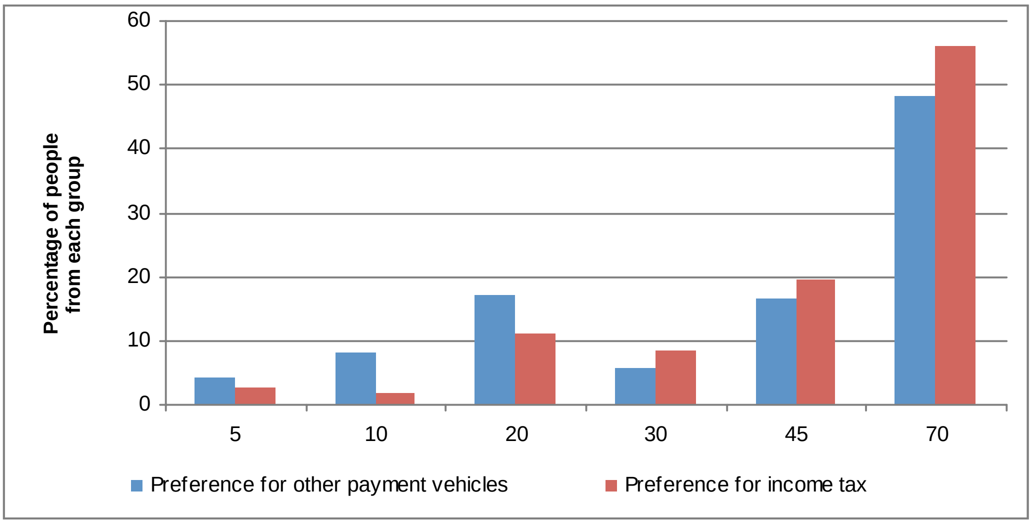


Figure 4.12. Respondents' preferences for different payment vehicles by maximum willingness to pay. *Pearson chi^2 – 9.61, df = 5, p = 0.087.*

Section 4.2 looked specifically at respondents' expected preferences for the type of waterbody attribute in the CE. It showed that visiting the sea, a lake or a river is a unique experience in itself. Section 4.2.2 demonstrated that there are a number of disparities between respondents' levels of satisfaction with the environmental quality of each waterbody type. For these reasons, respondents are expected to have different preferences, and values, for changes in the management of seas, lakes and rivers.

Finally, Section 4.3 identified three issues that are expected to impact on the actual values that respondents assign to improvements in Irish waterbodies. These are zero bidding, the influences of socio-economic, demographic and regional variation on respondents' WTP for improvements to Irish waterbodies and the type of payment vehicle used in the CE. Any values derived by the CE in this report need to account for these issues.

5 Irish Citizens' Preferences for Waterbody Management

This chapter provides details on the results from the statistical models that were used to analyse the CE data in this report, which show individuals' preferences, and WTP, for changes in the levels of each waterbody attribute. Outputs from the CL and MXL models on Irish citizens' preferences for generic waterbody attributes are discussed in Section 5.1. Section 5.2 provides estimates for respondents' MWTP values for the first four attributes on the choice cards. These are health of ecosystems, water clarity and smell, access to recreational activities and condition of banks and shorelines. It also discusses welfare values for improvements to seas, lakes and rivers separately. In doing so, Section 5.2 investigates whether respondents value improvements to different waterbody types differently. It also provides aggregate values for the three waterbody types for the entire Irish population. Finally, Section 5.3 provides a brief summary of the chapter.

5.1 Preferences for Attributes

Both a CL and an MXL model were used to model respondents' preferences for waterbody attributes in this report. For these analyses, the sample was restricted to those respondents who did not serially choose the status quo alternative. In both models, the base level with which the health of ecosystems and water clarity and smell coefficients were compared was low. Secondary and primary levels for access to recreational activities were assessed against visual amenities only. The base level for condition of banks or shoreline was high levels of erosion or damage. Finally, the base level for the type of waterbody affected attribute was *no targeting of any waterbody*. Each of these base levels is associated with the status quo alternative.

The magnitude and signs of the coefficients in Table 5.1 show that the results of the CL model are in

Table 5.1. Conditional logit (CL) model results.

Variable	Coefficient	Standard error
Health of ecosystems: moderate	0.359***	(0.060)
Health of ecosystems: good	0.591***	(0.076)
Water clarity and smell: moderate	0.832***	(0.085)
Water clarity and smell: good	1.069***	(0.091)
Access to recreational activities: secondary	0.308***	(0.055)
Access to recreational activities: primary	0.335***	(0.072)
Condition of banks or shoreline: moderate erosion	0.373***	(0.062)
Condition of banks or shoreline: low erosion	0.512***	(0.068)
Type of waterbody affected: sea	0.079	(0.117)
Type of waterbody affected: lake	0.342***	(0.108)
Type of waterbody affected: river	0.516***	(0.109)
Visits to seas × status quo	–0.013***	(0.003)
Visits to lakes × status quo	–0.002	(0.002)
Visits to rivers × status quo	–0.001	(0.001)
Preference for income tax vehicle × status quo	–0.443***	(0.156)
Price	–0.023***	(0.002)
Log likelihood function	–2,660***	

***p < 0.01.

line with prior expectations. Respondents associate each of the water-related attribute levels with positive utility and price with disutility (this means that respondents dislike higher prices). Results show that the two highest coefficient values are for water clarity and smell at good (1.069) and moderate (0.832) levels, respectively. Following this, the next most highly ranked attribute levels are a good level of ecosystem health (0.591), targeting rivers (0.516) and obtaining low levels of erosion (0.512), respectively. Overall, respondents assigned the lowest value to the access to recreational activities attributes.

These findings are similar to the results shown in Fig. 4.1, which displays respondents' stated ranking for the five attributes included in the CE. However, the results in Table 5.1 provide more detail on the underlying preferences respondents have for waterbody attributes particularly in relation to access to recreational activities and type of waterbody affected. Figure 4.1 shows that the average rankings for access to recreational activities and waterbody type were similar (2.52 and 2.47, respectively). Results from the CL model show that respondents' preferences for waterbody type are not evenly assigned. In particular, high and significant levels of utility are associated with improvements to rivers but the coefficient for the targeting of seas attribute level is not significant. On the other hand, preferences for access to primary and secondary recreational activities are both significant, but the magnitudes of the coefficients for these attribute levels are lower relative to the other attributes.

Some interaction terms within the model were included. In particular, the status quo alternative coefficient was interacted with the number of visits respondents made to waterbodies in the previous 12 months. The purpose of this was to determine whether respondents who visited waterbodies were more or less likely to choose the status quo option (which is associated with the lowest quality levels of the attributes). An interaction term between the status quo alternative and preferences for paying for water quality improvements through income tax was also included. The study found that respondents' likelihood of choosing the status quo alternative did not significantly change with the number of visits that they paid to either rivers or lakes in the past 12 months. However, it did change with the number of visits they paid to seas, meaning the more regularly individuals visited the sea the more likely they were to choose a non-status quo alternative on the choice cards. This finding is especially interesting when it is combined with the fact that the 'affecting seas' attribute is the only insignificant attribute level in Table 5.1. Together these findings suggest that, whilst visiting seas has a positive impact on respondents' likelihood of paying for improvements to Irish waterbodies in general, overall respondents do not associate the targeting of seas by policy makers with significant additional utility or benefit.

The MXL model used for this report is specified to allow for random heterogeneity in the health of ecosystems, water clarity and smell, access to recreational activities and condition of banks or shoreline attributes. Coefficients for the type of waterbody targeted are fixed to facilitate the calculation of welfare measures. Given some well-known difficulties surrounding a random cost coefficient (Doherty et al., 2012), the price attribute is also specified as fixed. This will enable more straightforward computation of welfare effects and reduce the possibility of retrieving extreme welfare estimates.

As outlined in Table 5.2, for each of the random attribute level coefficients there is an estimated coefficient for the mean of the distribution and one for the standard deviation of the distribution. Associated with each of these is an estimate of the standard error so one can determine the statistical significance of these coefficients. If the estimate of the standard deviation is not statistically significant but the mean coefficient is, then one can infer that the preference parameter is constant across the population (i.e. everybody attaches the same value to a particular attribute level). If the mean coefficient is not significant but the standard deviation estimate is significant, one can infer that there is a diversity of preferences, both positive and negative, for the attribute (i.e. almost an equal proportion of people both like and dislike the attribute). In order to understand whether there is any behaviour that may explain differences in preferences, the authors explore whether the number of trips made to the waterbodies is a significant predictor for the heterogeneity in preferences surrounding the waterbody attributes.

Table 5.2. Mixed logit (MXL) model results.

Variable	Mean		Standard deviation	
	Coefficient	SE	Coefficient	SE
Random parameters in utility function				
Health of ecosystems: moderate	0.374***	(0.102)	0.778***	(0.119)
Health of ecosystems: good	0.481***	(0.123)	0.791***	(0.172)
Water clarity and smell: moderate	0.756***	(0.139)	0.879***	(0.157)
Water clarity and smell: good	1.167***	(0.143)	0.911***	(0.165)
Access to recreational activities: secondary	0.290***	(0.109)	1.341***	(0.148)
Access to recreational activities: primary	0.281**	(0.117)	0.631***	(0.211)
Condition of banks or shoreline: moderate erosion	0.408***	(0.100)	0.797***	(0.152)
Condition of banks or shoreline: low erosion	0.493***	(0.106)	0.241	(0.222)
Heterogeneity in mean of random parameters				
Visits to waterbodies × Health of ecosystems: moderate	0.002**	(0.001)		
Visits to waterbodies × Health of ecosystems: good	0.005***	(0.001)		
Visits to waterbodies × Water clarity and smell: moderate	0.002*	(0.001)		
Visits to waterbodies × Water clarity and smell: good	0.001	(0.001)		
Visits to waterbodies × Access to recreational activities: secondary	0.001	(0.001)		
Visits to waterbodies × Access to recreational activities: primary	0.002*	(0.001)		
Visits to waterbodies × Condition of banks: moderate erosion	–0.001	(0.001)		
Visits to waterbodies × Condition of banks: low erosion	0.002*	(0.001)		
Non-random parameters in utility function				
Type of waterbody affected: sea	0.373**	(0.161)		
Type of waterbody affected: lake	0.648***	(0.144)		
Type of waterbody affected: river	0.818***	(0.145)		
Price	–0.029***	(0.002)		
Preference for income tax vehicle: status quo	–0.410**	(0.180)		
Visits to seas × status quo	–0.009**	(0.003)		
Visits to lakes × status quo	0.001	(0.002)		
Visits to rivers × status quo	0.002	(0.001)		
Log likelihood function			–2,587	
Log likelihood chi^2 stat (29 df)			419.44***	

***p < 0.01, **p < 0.05, *p < 0.1.
SE, standard error.

The mean coefficient results of the MXL model, which are displayed in Table 5.2, are similar to those shown in Table 5.1. Again, water clarity and smell and access to recreational activities have the highest and lowest coefficient values, respectively. The reported standard deviations provide information on the heterogeneity or diversity in respondents' preferences for the randomly specified attributes in the model. Aside from the exceptions of the standard deviation for the low erosion attribute level, the standard deviations for each of the other random attribute levels are significant, which suggests that the MXL model has revealed more about respondents' preferences for improvements to Irish waterbodies than the CL model (i.e. by highlighting the extent of the diversity in preferences for each of the water quality attribute coefficients).

Findings showing respondents' preferences towards secondary recreational activities in Table 5.2 are particularly interesting. The mean values indicate that the mean levels of utility associated with each recreational activity are similar. However, the standard deviations associated with secondary and primary levels of recreation are quite different. In particular, the standard deviation associated with access to secondary recreation is much larger, meaning that certain individuals value this attribute highly but others may associate it with disutility. This indicates that there is a much larger degree of preference heterogeneity or diversity for this attribute level compared with access to primary recreation. It is possible that, whilst the 16.74% of respondents who participate in secondary recreational pursuits value access to secondary recreation highly, certain other recreational users would rather the shorelines were not disturbed to improve access for secondary recreationalists.

In both the CL and MXL models, the likelihood that respondents chose the status quo alternative was reduced if they favoured income tax over other payment vehicle options for financing improvements to Irish waterbodies. This demonstrates that the type of payment vehicle used in a CE can potentially impact on the WTP – a positive value – and on the actual amount that respondents' bid for an alternative, a finding that is in line with other research exploring payment vehicle effects.

5.2 Monetary Values

Table 5.3 presents mean MWTP estimates retrieved from the CL and MXL models[4]. In the case of the MXL model, these marginal values have been estimated using the Krinsky and Robb procedure (Krinsky and Robb, 1986)[5]. The estimates produced by the two models are similar albeit, aside from the MWTP value for a moderate health of ecosystem level, the estimates provided by the MXL are slightly lower.

Table 5.3 shows MWTP values for the means calculated by the CL and the MXL models. Confidence interval (CI) values show that the mean values estimated by the two models are not significantly different. The highest retrieved MWTP figure is for a good level of water clarity and smell, followed by the moderate level of water quality and smell (€45.64 and €35.53, respectively) in the CL model. These findings imply that respondents value highly the aesthetics of waterbodies. The condition of banks or shoreline and health of ecosystem attributes may also be valued by individuals for aesthetic reasons. Low erosion levels and high levels of biodiversity are more visually pleasing than high erosion levels and low biodiversity levels, respectively. Table 5.3 shows that respondents placed high values on the upper levels of these attributes, with MWTP values for good health of ecosystems at €25.26 per year in the CL model and €24.90 per year in the MXL model and low erosion conditions at €21.89 per year in the CL model and €19.90 per year in the MXL model. It is important to note, however, that both good health of ecosystems and low erosion provide other ecosystem goods and services in addition to aesthetics. The occurrence of an extreme flooding event is only once every 20 years for the low erosion level of the condition of banks and shoreline attribute. Similarly, the good level of the health of ecosystems attribute is associated with supporting biodiversity for the sake of its existence and

4. It is important to note that these values represent MWTP for non-zero bidders only (n = 479).
5. The Krinsky–Robb procedure estimates the empirical distribution of the WTP estimates based on n random drawings from the multivariate normal distribution defined by the coefficients and covariance matrix estimated from the model (Krinsky and Robb, 1986). This technique is used as it allows for the skewness of the distribution of the marginal WTP estimates.

Table 5.3. Marginal willingness to pay (MWTP) across models.

Variable	Mean MWTP values (€/person/year)	
	CL mean (CI)	MXL mean (CI)
Health of ecosystems: moderate	15*** (10, 20)	17*** (10, 23)
Health of ecosystems: good	25*** (19, 31)	25*** (17, 33)
Water clarity and smell: moderate	36*** (28, 42)	30*** (22, 38)
Water clarity and smell: good	46*** (38, 53)	42*** (32, 51)
Access to recreational activities: secondary	13*** (9, 18)	11*** (4, 18)
Access to recreational activities: primary	14*** (8, 20)	13*** (5, 21)
Condition of banks or shoreline: moderate erosion	16*** (11, 21)	14*** (7, 21)
Condition of banks or shoreline: low erosion	22*** (17, 27)	20*** (13, 27)

Estimates are rounded to nearest whole number. 95% confidence interval (CI) in parentheses.
*** indicates significant at 95% level.
CL, conditional logit; MXL, mixed logit.

suggests that some of the values respondents assign to waterbodies are altruistically motivated.

The values in Table 5.4 represent estimates of welfare values associated with a waterbody moving from the lowest ecosystem service levels of the first four attributes in the study (health of ecosystems, water clarity and smell, access to recreational activities, and condition of banks and shoreline) to the highest level of the attributes.[6] The results in Table 5.4 show that the estimated CS measures are higher for the CL compared with the MXL model. This is because a proportion of the value that respondents assign to waterbodies is assigned to the distribution surrounding the mean in the MXL model.

The CS values of these improvements are estimated separately for seas, lakes and rivers, thereby deciphering whether preferences for the ecosystem services vary depending on the type of waterbody considered. In all cases, the values for improvements to rivers are the highest of all three waterbody types, followed by lakes and, finally, seas (Table 5.5). For example, mean results from the MXL model suggest that on average individuals obtain welfare benefit equivalent to €110.22 for an improvement from poor to good health of ecosystems, from poor to good levels of water quality and smell, from access to visual-only recreation to all types of recreation and from high to low levels of erosion on banks and shorelines at every river in Ireland. This can be compared with only €95.26 and €104.58 for equivalent improvements to all Irish seas and lakes, respectively. At first glance, this result seems surprising because, in terms of use of waterbodies, residents in Ireland show a higher propensity to visit the seaside compared with lakes, which is likely to be in part due to greater accessibility to the seaside (Fig. 4.7). A possible explanation for this is that residents believe that rivers and lakes are in greater need of improvement than seas and therefore obtain higher welfare from improving the quality of river and lake ecosystem services (see Fig. 4.9). It may also be the case that this finding reflects a belief amongst

6. The values in Table A4.1 in Appendix 4 present estimates of compensating surplus measures and aggregate values associated with the value of medium improvements in the attributes to Irish waterbodies.

Table 5.4. Compensation surplus (CS) values for different waterbody types and scenarios.

Attribute	Levels		
Health of ecosystems (fish, insects, plants, wildlife on shoreline or banks)	Good		
Water clarity and smell	Good		
Access to recreational activities	All, including primary contact recreation: e.g. swimming and kayaking		
Condition of banks or shoreline	Low erosion and damage (extreme flooding event once every 20 years)		
	CS (€/person/year)		
	River	**Lake**	**Sea**
Conditional logit	129***	122***	110***
Confidence interval	(117, 140)	(110, 133)	(99, 121)
Mixed logit (mean)	110***	105***	95***
Confidence interval	(97, 124)	(92, 118)	(83, 108)

Estimates are rounded to nearest whole number. 95% confidence interval in parentheses.
***p < 0.011.

Table 5.5. Total yearly value of improvements to Irish waterbodies.

	Aggregated values (€/year)		
Model estimate	**Rivers**	**Lakes**	**Seas**
CL mean (CI)	250,470,786	236,879,348	213,579,740
MXL mean (CI)	213,579,740	203,871,570	184,455,230

CI, confidence interval; CL, conditional logit; MXL, mixed logit.

residents that improved quality levels are more difficult to achieve for seas compared with smaller and more defined waterbodies such as rivers and lakes.

According to figures from the Central Statistics Office (CSO, 2013b), the total Irish population in 2011 aged 18 and over was 3,439,000. Given that 43.55% of the sample surveyed for this report was not willing to pay for improvements to Irish waterbodies, the total number of people for which the values in Table 5.4 may be applied is 1,941,634. Based on this information, the resulting total value of changes to Irish waterbodies per year are presented in Table 5.5. The lowest amount estimated is €184 million per year for seas (MXL) and the highest is €250 million per year for Irish rivers (CL).

5.3 Summary

This chapter provided outputs from the CL and MXL models used to estimate Irish residents' values for improvements in waterbodies in Ireland. The preference rankings for attribute levels calculated by both models are similar, although the mean parameter values for the CL model are generally higher than the MXL model. In both models, the likelihood that respondents chose the status quo alternative was reduced if they favoured income tax over other payment vehicle options for financing improvements to Irish waterbodies. Hence, results from this chapter show that the type of payment vehicle used in a CE can potentially impact on the amount that respondents potentially bid for an alternative.

Respondents displayed preferences for, and had the highest MWTP values for, a good level of water quality and smell and the second highest MWTP was associated with the moderate level of this attribute. This suggests that the visual aspect of waterbodies is important to Irish residents. The next most valued attribute is the health of the ecosystems, followed closely by condition of banks and shoreline. The lowest valued attribute is access to recreational activities. These results show that respondents had greater preferences for actual quality improvements of the waterbodies compared with improvements in their recreational potential. This finding may be reflecting the fact that a higher proportion of the population is more likely to pursue visual-only recreational activities than secondary or primary activities on Irish waterbodies.

Finally, outputs from this chapter demonstrated that the highest welfare levels are associated with improvements to rivers, followed by those at lakes and, finally, improvements at sea. This finding may be caused by the fact that respondents perceive the need for improvements to the environmental quality of rivers and lakes to be more pressing than that of seas.

6 Conclusions

Ecosystems play a vital role in preserving and promoting human and economic well-being. Aquatic ecosystems provide provisional, regulatory and cultural goods and services, which provide economic benefits in the form of use values. Furthermore, they provide supporting services, which are not directly used by humans but are nonetheless highly valued by individuals. Given the importance of ecosystems to human and economic well-being, there has been a growing interest at supra-national level in protecting and promoting these services. Also, valuing the benefits derived from these ecosystem services allows those managing waterbodies (i.e. regional policy makers and related stakeholders) to make more informed decisions about best management practices for the future.

Waterbodies may be valued by humans for a number of reasons. They provide use values in the form of provisional, supporting and cultural goods and services as well as non-use values in the form of supporting services. Given the multifaceted nature of the benefits that waterbodies provide, their valuation is a complex task. Despite this, there has been a strong desire nationally and internationally to value water and its characteristics. This is reflected by the growing number of non-market studies that have attempted to put a monetary value on the environmental, health and/or recreational benefits associated with water. As discussed, these studies range from exploring preferences for specific features of particular waterbodies to studies that explored preferences for wide-scale changes to different waterbodies. The multi-attribute nature of water is also reflected in the changing and growing emphasis of legislation. An examination of water policy through previous EU water directives, including the Nitrates Directive and the Bathing Water Quality Directive, demonstrates how it evolved from the emphasis on public health protection to environmental protection and, finally, as formed today, to the notions of ‘sustainable use’ of water and an integrating ecosystem-based approach to water management. Although in the past EU legislation on water was focused on specific environmental problems related to water quality as far as, for example, drinking, bathing or freshwater fishing activities are concerned, emphasis is now placed on the improvement of the ecological quality of water and its eco-system functions, by using a broader, more integrated approach. Greater emphasis has also been put on the value of ‘healthy’ waterbodies within these directives.

This report used the CE approach to estimate the generic values that the Irish public associate with Irish waterbodies. The CE was used to estimate the Irish public’s value for attributes representing the health of ecosystems, water clarity and smell, access to recreational activities and the condition of banks and shorelines. Also, individuals may not view different waterbody types (coastal, lakes, rivers) as holistic management units but as waterbodies with similar ecosystem services being provided. For this reason, this report also investigated whether Irish citizens have different benefit values associated with alternative waterbody types. Special attention was also given in this report to whether respondents’ preferences for alternative means of paying for water management impacted on the values they assigned to Irish waterbodies.

A review of findings from the survey showed that respondents’ concern for the five waterbody attributes varied significantly according to the number of times they visited waterbodies in the past 12 months. There is also evidence that individuals’ use of rivers, lakes and seas differs substantially. This is apparent when viewing the types of recreational activities that respondents pursue at, the regularity of respondents’ visitation to, and the distances that respondents travel towards each of the three waterbody types. In addition, respondents displayed mainly positive opinions on the environmental quality of Irish waterbodies, but the extent of this positivity varied somewhat across waterbody type. A total of 43.85% of respondents were zero bidders, meaning they were unwilling to pay for improvements to Irish waterbodies. The preferred payment vehicle identified by the survey was a once-off lump sum (33.83% of bidders) whilst the vehicle used in the survey (an increase in personal income tax for 10 years) was only the second most popular payment type listed in the survey (22.34% of bidders).

The results from the CE exercise highlighted that the most important attribute for respondents was water clarity and smell. On average, respondents were willing to pay approximately €42 per person per year to achieve good water clarity and smell and they were willing to pay approximately €30 to achieve a moderate level of this attribute. The third and fourth most important attributes for respondents were the good level for the health of ecosystem attribute followed by the low erosion level for the condition of banks or shoreline attribute. The respective MWTP for these attribute levels was €25 and €20 per person per year. The moderate levels of these attributes were associated with MWTP amounts of €17 and €14, respectively. The least valued attribute among respondents was the recreation attribute; respondents were only willing to pay €13 to access waterbodies for primary recreation contact and they were willing to pay €11 to access waterbodies for secondary recreational activities. This latter finding may be due to the fact that the majority of respondents in the survey participated in visual-only recreational activities.

This report had a number of specific objectives in terms of its contribution to the wider literature on valuing aquatic ecosystem services. The first looked at whether the type of payment vehicle used in a CE has the potential to impact on the amounts that respondents are willing to pay for alternatives on a choice card. In both models, the likelihood that respondents chose the status quo alternative was reduced if they favoured income tax over other payment vehicle options for financing improvements to Irish waterbodies. Hence, the type of payment vehicle used in a CE needs to be considered in light of respondents' payment preferences.

The second key objective of this report was to assess if and how preferences for the environmental improvements differed by types of waterbodies. This is a useful question for policy makers as it established whether priority should be given for improvements of certain types of waterbodies over other types. Furthermore, this is highly relevant in the current European and Irish economic climate as economic resources to implement environmental changes are severely restricted. As a consequence, a case could be made that, in such a climate, investigation of how preferences differed by types of waterbodies was particularly warranted to establish a ranking of benefits arising from ecosystem services from the public's viewpoint. The report found that societal welfare was increased the most by improvements at river bodies followed by improvements at lakes and finally improvements at the sea. However, the results were not statistically different. Overall, it can be said that, based on the results of the CE exercise, improving the quality of waterbodies to the best levels of the attributes considered in this study would result in aggregate welfare gains to the Irish public worth €214–250 million for river bodies, €204–237 million for lakes and €184–214 million for seas.

Ecosystems and the services that flow from them play a vital role in preserving and promoting human and economic well-being. Aquatic ecosystems in particular provide provisional, regulatory, and cultural goods and services, which provide economic benefits in the form of use values. Furthermore, they provide supporting and regulating services that are not directly used but which are still critically important to societal welfare as they involve climate control, waste assimilation, etc. Given the importance of ecosystem services to human and economic well-being, there has been a growing interest at supra-national level in protecting and promoting these services. Also, valuing the benefits derived from key ecosystem services, as was done in this report, allows those managing waterbodies (e.g. government departments, regional policy makers and catchment managers) to make more informed decisions related to best management practices for the sustainable use of Ireland's water resources. Furthermore, the information gathered from the CE carried out in this project should also enable those responsible for setting policy in the area to prioritise funding for features that are most highly valued among the general population of Ireland. In this regard, the CE results may facilitate managers to make decisions that reflect the preferences of the Irish public.

References

Alvarez-Farizo, B., Hanley, N., Barberan, R. and Lazaro, A., 2007. Choice modeling at the “market stall”: individual versus collective interest in environmental valuation. *Ecological Economics* **60:** 743–751.

Bateman, I. and Munro, A., 2009. Household versus individual valuation: what's the difference? *Environmental Resource Economics* **43:** 119–135.

Bateman, I., Carson, R., Day, B., Hanemann, M., Hanley, N., Hett, T., Jone-Lee, M., Loomes, G., Mourato, S., Ozdemiroglu, E., Pearce, D., Sugden, R. and Swanson, J., 2002. *Economic Valuation with Stated Preference Techniques: a Manual.* Edward Elgar Publishing Limited, Cheltenham, UK.

Bennett, J., Dumsday, R., Howell, G., Lloyd, C., Sturgess, N. and Van Raalte, L., 2008. The economic value of improved environmental health in Victorian rivers. *Australasian Journal of Environmental Management* **15:** 138–148.

Birol, E., Koundouri, P. and Kountouris, Y., 2008a. Using the choice experiment method to inform river management in Poland: flood risk reduction versus habitat conservation in the upper Silesia Region. *In:* Birol, E. and Koundouri, P. (Eds) *Choice Experiments Informing Environmental Policy.* Edward Elgar Publishing Limited, Cheltenham, UK.

Birol, E., Karousakis, K. and Koundouri, P., 2008b. Using a choice experiment to inform implementation of the European Union Water Framework Directive: the case of Cheimaditida wetland in Greece. *In:* Birol, E. and Koundouri, P. (Eds) *Choice Experiments Informing Environmental Policy.* Edward Elgar Publishing Limited, Cheltenham, UK.

Bliemer, M. and Rose, J., 2006. *Designing Stated Choice Experiments: “State-of-the-Art”.* 11th International Conference on Travel Behaviour Research, Kyoto, Japan. Available at: http://www.ivt.ethz.ch/news /archive/20071205_seminar_rose.pdf.

Bockstael, N. and Opaluch, J., 1983. Discrete modeling of supply response under uncertainty: the case of the fishery. *Journal of Environmental Economics and Management* **10(2):** 125–137.

Boyle, K.J., 2003. Chapter 9: Revealed preference methods. *In* P. Champ, K. Boyle and T. Brown (Eds) *A Primer on Nonmarket Valuation.* Kluwer Academic Publishers, Netherlands.

Brouwer, R., Martin-Ortega, J. and Berbel, J., 2010. Spatial preference heterogeneity: a choice experiment. *Land Economics* **86:** 552–568.

Bullock, C., Kretsch, C. and Candon, E., 2008. *Benefits and Costs of Biodiversity in Ireland.* Report to Government of Ireland. Available at: http://www.cbd.int/doc/case-studies/inc/cs-inc-ireland-en.pdf.

Can, O. and Alp, E., 2012. Valuation of environmental improvements in a specially protected marine area: a choice experiment approach in Gocek Bay, Turkey. *Science of the Total Environment* **439:** 291–298.

Carlsson, F. and Martinsson, P., 2008. How much is too much? An investigation into the effect of the number of choice sets, context dependence and the choice of bid vectors in choice experiments. *Environmental Resource Economics* **40:** 165–176.

Champ, P. and Bishop, R., 2001. Donation payment mechanisms and contingent valuation: an empirical study of hypothetical bias. *Environmental and Resource Economics* **19:** 383–402.

Champ, P., Flores, T. and Chivers, J., 2002. Contingent valuation and incentives. *Land Economics* **78:** 591–604.

CSO, 2013a. *Census 2011* [online]. Central Statistics Office. Available at: http://www.cso.ie/en/statistics [Accessed: March 2013].

CSO, 2013b. *Population by Age. Data from 2011 Census* [online]. Central Statistics Office. Available at: http://www.cso.ie/Quicktables/GetQuickTables.aspx?FileName=CNA15.asp&TableName=Population+by+Age+2011&StatisticalProduct=DB_CN [Accessed: 5th of July 2013].

Curtis, J., 2002. Estimating the demand for salmon angling in Ireland. *Economic and Social Studies* **33:** 319–332.

Curtis, J., 2003. Demand for water-based leisure activity. *Journal of Environmental Planning and Management* **46:** 65–77.

DKM, 2004. *Economic Evaluation of Water Supply and Waste Water Projects, Cost-benefits Analysis Methodology Paper (Final report).* Aquavarra Research Ltd and ESRI. Available at: http://www.environ.ie/en/Publications/Environment/Water/FileDownLoad,1543,en.doc.

Doherty, E., Campbell, D. and Hynes, S., 2012. Models of site-choice for walks in rural Ireland: exploring cost heterogeneity. *Journal of Agricultural Economics* doi: 10.0000/1477-9552.12002.

EPA, 2005. *Article 5, The characterisation and analysis of Ireland’s River Basin Districts. In accordance with Section 7(2&3) of the European Communities (Water Policy) Regulations 2003(SI 722 of 2003).* Available at: http://www.wfdireland.ie/Documents/

Characterisation%20Report/Background%20Information/Compendium%20of%20Public%20submissions.pdf.

EPA, 2012. *Ireland's Environment: An Assessment 2012. Chapter 4: Water.* Environmental Protection Agency, Johnstown Castle Estate, Wexford, Ireland. Available at: http://www.epa.ie/media/00061_EPA_SoE12_Chp04.pdf.

ERBD, 2005. *Final Characterisation Report.* Dublin, Ireland. Available at: http://www.erbd.ie/characterisation-report.html.

Georgantzis, N. and Navarro-Martinez, D., 2010. Understanding the WTA-WTP gap: attitudes and feelings, uncertainty and personality. *Journal of Economic Psychology* **31:** 895–907.

Glenk, K., Lago, M. and Moran, D., 2011. Public preferences for water quality improvements: implications for the implementation of the EC Water Framework Directive in Scotland. *Water Policy* **13:** 645–662.

Goodbody, 2008. *Review of Water Resource Benefit Values. Report Draft Copy.* Dublin, Ireland. Available at: http://www.wfdireland.ie/docs/35_Economics/Review%20of%20Water%20Resource%20Benefit%20Values%20-%20Draft%20Reportv5.pdf.

Greene, W., 2003. *Econometric Analysis.* 5th Edition. Prentice Hall, New Jersey, USA.

Hanley, N. and Barbier, E., 2009. *Pricing Nature: Cost-benefit Analysis and Environmental Policy.* Edward Elgar Publishing Limited, Cheltenham, UK.

Hanley, N., Mourato, S. and Wright, R., 2001. Choice modelling approaches: a superior alternative for environmental valuation? *Journal of Economic Surveys* **15:** 435–462.

Hanley, N., Adamowicz, W. and Wright, R., 2005. Price vector effects in choice experiments: and empirical test. *Resource and Energy Economics* **27:** 227–234.

Hanley, N., Wright, R. and Alvarez-Farizo, A., 2006a. Estimating the economic value of improvements in river ecology using choice experiments: an application to the water framework directive. *Journal of Environmental Management* **78:** 183–193.

Hanley, N., Colombo, S., Tinch, D., Black, A. and Aftab, A., 2006b. Estimating the benefits of water quality improvements under the Water Framework Directive: are benefits transferable? *European Review of Agricultural Economics. Oxford University Press for European Association of Agricultural Economists* **33:** 391–413.

Heberling, M., Shortle, J. and Fisher, A., 2000. *The Effect of the Number of Choice Sets on Responses in a Stated Choice Survey.* Annual meeting American Agricultural Economics Association, July 30–August 2. No. 21832. Tampa, Florida, USA.

Hensher, D., Rose, J. and Greene, W., 2006. *Applied Choice Analysis: A Primer.* Cambridge University Press, New York, USA.

Hime, S., Bateman, I., Posen, P. and Hutchins, M., 2009. A transferable water quality ladder for conveying use and ecological information within public surveys. *CSERGE Working Paper EDM,* No. 09–01**:** http://hdl.handle.net/10419/48821.

Horowitz, J. and McConnell, K., 2002. A review of WTA/WTP studies. *Journal of Environmental Economics and Management* **44:** 426–447.

Hoyos, D., 2010. The state of the art of environmental valuation with discrete choice experiments. *Ecological Economics* **69:** 1595–1603.

Hynes, S. and Campbell, D., 2011. Estimating the welfare impacts of agricultural landscape change in Ireland: a choice experiment. *Journal of Environmental Planning and Management* **54:** 1019–1039.

Hynes, S. and Hanley, N., 2006. Preservation versus development on Irish rivers: whitewater kayaking and hydro power in Ireland. *Land Use Policy Journal* **23:** 170–180.

Hynes, S., Hanley, N. and Scarpa, R., 2008. Effects on welfare measures of alternate means of accounting for preference heterogeneity in recreational demand models. *American Journal of Agricultural Economics* **90:** 1011–1027.

Hynes, S., Hanley, N. and O'Donoghue, C., 2009. Alternative treatments of the cost of time in recreational demand models: an application to whitewater kayaking in Ireland. *Journal of Environmental Management* **90(2):** 1014–1021.

Hynes, S., Campbell, D. and Howley, P., 2011. A holistic vs. an attribute-based approach to agri-environmental policy valuation: do welfare estimates differ? *Journal of Agricultural Economics* **62:** 305–329.

Hynes, S., Tinch, D. and Hanley, N., 2013. Valuing improvements to coastal waters using choice experiments: an application to revisions of the EU Bathing Waters Directive. *Marine Policy* **40:** 137–144.

Indecon, 2003. *An Economic/Socio Economic Evaluation of Wild Salmon in Ireland.* Submitted to the Central Fisheries Board, Dublin, Ireland. Available at: http://www.fisheriesireland.ie/fisheries-research-1/10-an-economic-socio-economic-evaluation-of-wild-salmon-in-ireland-1.

Ivehammar, P., 2009. The payment vehicle used in CV studies of environmental goods does matter. *Journal of Agricultural and Resource Economics* **34:** 450–463.

Kataria, M., 2009. Willingness to pay for environmental improvements in hydropower regulated rivers. *Energy Economics* **31:** 69–79.

Kataria, M., Bateman, I., Christensen, T., Dubgaard, A., Hasler, B., Hime, S., Ladenburg, J., Levin, G., Martinsen, L. and Nissen, C., 2012. Scenario realism and welfare estimate in choice experiments – a non-market valuation study on the European Water Framework Directive. *Journal of Environmental Management* **94:** 25–33.

Kragt, M., Newham, L., Bennett, J. and Jakeman, A., 2011. An integrated approach to linking economic valuation and catchment modelling. *Environmental Modelling and Software* **26:** 92–102.

Krinsky, I. and Robb, R., 1986. On approximating the statistical properties of elasticities, *Review of Economics and Statistics* **68:** 715 – 719.

Krueger, R., 1997. *Moderating Focus Groups.* Sage Publications.

Lancaster, K., 1966. A new approach to consumer theory. *Journal of Political Economy* **74:** 132–157.

Lawlor, J., McCarthy, C. and Scott, S., 2007. Investment in water infrastructure: findings from an economic analysis of a national programme. *Journal of Environmental Planning and Management* **50:** 41–63.

Lindhjem, H. and Navrud, S., 2009. Asking for individual or household willingness to pay for environmental goods. *Environmental Resource Economics* **43:** 11–29.

Metcalfe, P., Baker, W., Andrews, K., Atkinson, G., Bateman, I., Butler, S., Carson, R., East, J., Gueron, Y., Sheldon, R. and Train, K., 2012. An assessment of the nonmarket benefits of the Water Framework Directive for households in England and Wales. *Water Resource Research* **48:** doi: 1029/2010WR009592.

Moran, D. and Dann, S., 2008. The economic value of water use: implication from implementing the Water Framework Directive in Scotland. *Journal of Environmental Management* **87:** 484–496.

Morrison, M. and Bennett, J., 2004. Valuing New South Wales rivers for use in benefit transfer. *The Australian Journal of Agricultural and Resource Economics* **48:** 591–611.

Norton, D., Hynes, S., Doherty, E., Buckley, C. and Campbell, D., 2011. Valuing the non-market benefits of the WFD implementation in Ireland. *3rd Annual Beaufort Marine Socio-Economic Workshop.* Galway, Ireland.

Norton, D., Hynes, S., Doherty, E., Buckley, C., Campbell, D. and Stithou, M., 2012. *Benefit Transfer for Irish Water: Using Benefit Transfer Techniques to Estimate the Value of Achieving 'good Ecological Status' in Irish Water Bodies.* Environmental Protection Agency, Johnstown Castle Estate, Wexford, Ireland. Available at: http://www.epa.ie/pubs/reports/research/water/strivereport94.html.

NPWS, 2013. *Red Lists* [online]. National Parks and Wildlife Services. Available at: http://www.npws.ie/publications/redlists/ [Accessed: 2013 July].

Poirier, J. and Fleuret, A., 2010. *Using the Choice Experiment Method for Valuing Improvements in Water Quality: A Simultaneous Application to Four Recreation Sites of a River Basin.* 59th Conference of Association Francaise de Science Economique 9–10 September 2010, Nanterre Université, Paris, France. Available at: www.webmeets.com/Files/papers/SAEE/2010/papier multisite nov2010.pdf.

Robinson, J., Clouston, B. and Suh, J., 2002. *Estimating Consumer Preferences for Water Quality Improvements Using a Citizens' Jury and Choice Modelling.* Brisbane, Australia. Available at: http://www.coastal.crc.org.au/pdf/citizen_jury.pdf.

Sayman, S. and Onculer, A., 2005. Effects of study design characteristics on the WTA-WTP disparity: a meta analytical framework. *Journal of Economic Psychology* **26:** 289–312.

Smyth, R., Watzin, M. and Manning, R., 2009. Investigating public preferences for managing Lake Champlain using a choice experiment. *Journal of Environmental Management* **90:** 615–623.

Stithou, M. and Scarpa, R., 2012. Collective versus voluntary payment in contingent valuation literature for the conservation of marine biodiversity: and exploratory study from Zakynthos, Greece. *Ocean and Coastal Management* **56:** 1–9.

Stithou, M., Hynes, S., Hanley, N. and Campbell, D., 2012. Estimating the value of achieving "Good Ecological Status" in the Boyne River Catchment in Ireland using choice experiments. *The Economic and Social Review* **43:** 397–422.

Tait, P., Baskaran, R., Cullen, R. and Bicknell, K., 2012. Nonmarket valuation of water quality: addressing spatially heterogeneous preferences using GIS and a random parameter logit model. *Ecological Economics* **75:** 15–21.

Train, K., 2000. *Halton Sequences for Mixed Logit.* Working Paper. Department of Economics, UC Berkeley, CA, USA. Available at: http://escholarship.org/uc/item/6zs694tp.

Train, K., 2003. *Discrete Choice Methods with Simulation.* Cambridge University Press, Cambridge, UK.

UKNEA, 2011. *Chapter 9: Freshwater – Openwaters, Wetlands and Floodplains.* UK National Ecosystem Assessment, UNEP-WCMC, Cambridge, UK. Available at: http://uknea.unep-wcmc.org/Home/tabid/38/Default.aspx.

van Bueren, M. and Bennett, J., 2004. Towards the development of a transferable set of value estimates for environmental attributes. *The Australian Journal of Agricultural and Resource Economics* **48(1):** 1–32.

Vondolia, G., 2011. *What do Respondents Bring into*

Contingent Valuation? A Comparison of Monetary and Labour Payment Vehicles. School of Business University of Gotenburg, Economics and Law. Working Paper no 508. Gotenburg, Sweden. Available at: https://gupea.ub.gu.se/bitstream/2077/25682/1/gupea_2077_25682_1.pdf.

WFD, 2013. *Water Matters. Our Plan. EU Water Framework Directive* [online]. Available at: http://www.wfdireland.ie/ [Accessed: 5 March 2013].

Willis, K., McMahon, P., Garrod, G. and Powe, N., 2002. Water companies' service performance and environmental trade-offs. *Journal of Environmental Planning and Management* **45:** 363–379.

Wiser, R., 2007. Using contingent valuation to explore willingness to pay for renewable energy: a comparison of collective and voluntary payments vehicles. *Ecological Economics* **62:** 419–432.

Young, R.A., 2005. *Determining the Economic Value of Water: Concepts and Methods.* Resources for the Future, Washington DC, USA.

Acronyms

AVC	Asymptotic variance covariance
CE	Choice experiment
CI	Confidence interval
CL	Conditional logit
CM	Choice model
CS	Compensation surplus
CSO	Central Statistics Office
CV	Contingent valuation
EPA	Environmental Protection Agency
ESRI	Economic Social Research Institute
EU	European Union
GEP	Good ecological potential
GES	Good ecological status
HP	Hedonic pricing
IIA	Independent of irrelevant alternatives
IID	Independently and identically distributed
IUF	Indirect utility function
MEA	Millennium ecosystem assessment
MSFD	Marine Strategy Framework Directive
MSLE	Maximum simulated likelihood estimator
MWTP	Marginal willingness to pay
MXL	Mixed logit
RBD	River basin district
RP	Revealed preference
RUM	Random utility model
SD	Standard deviation
SLL	Simulated log likelihood
SP	Stated preference
TC	Travel cost
TEV	Total economic value
WFD	Water Framework Directive
WTA	Willingness to accept
WTP	Willingness to pay

Appendix 1 Attributes and Levels Used to Estimate Generic Values for Waterbodies in Other CE Studies

This appendix provides additional information on the attributes and levels used to estimate generic values for waterbodies in other multidimensional CE studies. In each of the tables that follow, the first three columns refer to the authors' name(s), the location of the study and whether or not the study was concerned with evaluating the impact of the WFD, respectively. The fourth column gives the name of the attribute as it was displayed to the respondent. The final column gives an outline of how the levels of the variables are described to respondents. Where present, semicolons are used to separate different variable levels. For each attribute, the status quo level is placed next to its value (separated by a forward slash).

Table A1.1 shows attributes for ecology that contained biotic descriptors alone, while Table A1.2 displays those that accounted for abiotic factors too. Table A1.3 outlines studies that linked recreational attributes with aesthetic values, whereas the attributes in Table A1.4 describe recreational activity in isolation. Table A1.5 shows a limited number of studies that incorporated regulatory services (aside from those underpinning water clarity) into their CE. Finally, Table A1.6 identifies a number of other attributes of interest that have been used in the evaluation of waterbodies in the CE literature.

Table A1.1. Ecology attributes with biotic descriptors alone

Author(s)	Location	WFD	Attribute	Levels
Alvarez-Farizo et al. (2007)	Cidacos River, Navarra, Spain	Yes	River ecology	Low/Status quo; high diversity (variety of aquatic plants, fish and birds)
Bennett et al. (2008)	Three rivers, Victoria, Australia	No	Native fish	Four levels that vary according to the river in question (percentage of pre-settlement species and population levels)
			Native waterbirds and animals	Four levels that vary according to the river in question (number of native waterbirds and other animal species with sustainable populations)
Birol et al. (2008a)	Five rivers, Sosnowiec, Poland	No	Biodiversity	Low/Status quo; high (number of different species of plants and animals, their population levels, number of different habitats and their size in the river ecosystem in the next 10 years)
Birol et al. (2008b)	Cheimaditida wetlands (including Lake Cheimaditida), Greece	Yes	Biodiversity	Low/Deterioration/Status quo; high/10% increase (number of different species of plants, animals, their population levels, the number of different habitats and their size)
Can and Alp (2012)	Gocek Bay, Turkey	No	Marine life	Gets better or stays the same/status quo (bio-physical, i.e. habitats)
Hanley et al. (2005)	River Wear, Co. Durham	Yes	Ecology	Fair/Status quo; good (range of coarse fish, water plants, insects and birds)
Hanley et al. (2006a)	Two rivers, UK	Yes	Ecology	Good, fair and status quo levels (salmon, trout and coarse fish, range of water plants, insects and birds)

Table A1.1 *contd*

Author(s)	Location	WFD	Attribute	Levels
Kataria (2009)	Nationally representative survey in Sweden	Yes	Birds	Improved conditions for the bird life or status quo
			Fish	15, 25 and 0/Status quo increase (percentage in fish stock)
			Benthic invertebrates	High, moderate and considerably reduced/status quo (species richness)
Kataria et al. (2012) Survey 2	Odense River, Denmark	Yes	Water quality	Water quality ladder. Yellow/Moderate/Status quo; green/good; blue/very good
Kragt et al. (2011)	George Catchment (river and estuary), Tasmania	No	Rare native animal and plant species	35, 50, 65, 80/Status quo (number of native flora and fauna species listed as vulnerable, endangered or critically endangered)
			Seagrass area	420, 560, 690/Status quo, 815 (ha of dense seagrass beads mapped in the estuary)
Morrison and Bennett (2004)	Five rivers, NSW, Australia	No	Native fish	15/Status quo, 18, 21 and 25 (number of native species present)
			Water birds and other fauna	48/Status quo, 59, 72, 88 (number of species present)
Robinson et al. (2002)	Bremer River Catchment, Queensland, Australia	No	Aquatic vegetation in moderate condition	Four levels, lowest level 5/status quo (percentage of the total length of the river)
Smyth et al. (2009)	Lake Champlain Basin, USA and Canada	No	Water clarity	No algal blooms with surface scum, 10 days of algae with some surface scum, 10 days of algal bloom with thick surface scum
			Spread of invasive water chestnut	Extent of water chestnut reduced by 10 miles; extent of water chestnut not changed/status quo; extent of water chestnut increases by 10 miles
Stithou et al. (2012)	River Boyne, Ireland	Yes	River life: fish, insects, plants	Poor/Status quo, moderate, good (composition and abundance of biological elements: fish, plants, invertebrates, mammals and birds)
van Bueren and Bennett (2004)	Two river basins as well as national, Australia	No	Species protected	Four levels that vary according to the river in question (number of endangered native species of animal protected)
Willis et al. (2002)	Sussex, UK	No	Wildlife in Pulborough and Amberley Brooks	No change, up to 10% decrease and up to 5% increase (bird numbers and plant diversity)

Table A1.2. Ecology attributes with biotic and abiotic descriptors.

Author(s)	Location	WFD	Attribute	Levels
Alvarez-Farizo et al. (2007)	Cidacos River, Navarra, Spain	Yes	Surroundings of the river	Low/Status quo; high (presence of litter and bad smells, visual quality of the water, abundance of trees, riverside vegetation and erosion of river banks)
Bennett et al. (2008)	Three rivers, Victoria, Australia	No	Riverside vegetation	Four levels that vary according to the river in question (percentage of river's length with healthy vegetation on both banks)
Hanley et al. (2005)	River Wear, Co. Durham, UK	Yes	Bankside conditions	Fair/Status quo; good (number of trees and plants and natural or accelerated erosion)
Hanley et al. (2006a)	Two rivers, UK	Yes	River banks	Good; fair; status quo levels (trees, plants, degree of erosion)
Hanley et al. (2006b)	Two rivers, Scotland	Yes	Ecological condition	Worsening/Status quo; slight improvement; big improvement (mammals, plants, fish, smell)
Kataria (2009)	Sweden	Yes	River margin vegetation and erosion	Broad beach with high amount of plant species and biomass growth; broad beach with somewhat reduced amounts of plant species and biomass growth; narrow beach with somewhat reduced plant species and biomass growth/status quo
Kataria et al. (2012) Survey 2	Odense River, Denmark	Yes	Character of surroundings	Primary cultivated/status quo; primary uncultivated
Kragt et al. (2011)	George Catchment (river and estuary), Tasmania	No	Native riparian vegetation	35% (40 km), 50% (56 km), 65% (74 km)/status quo, 75% (84 k m) (river length with intact vegetation, of which at least 70% is native vegetation)
Morrison and Bennett (2004)	Five rivers, NSW, Australia	No	Healthy riverside vegetation and wetlands	30/Status quo, 40, 60, 80 (percentage of river)
Robinson et al. (2002)	Bremer River Catchment, Queensland, Australia	No	Riparian vegetation in moderate or better condition	Four levels, lowest level 5%/status quo (percentage of the total length of the river)
Smyth et al. (2009)	Lake Champlain Basin, USA and Canada	No	Land use change	Current land use distribution/status quo; increase urban/suburban, decrease agricultural; increase urban/suburban, decrease natural
Stithou et al. (2012)	River Boyne	Yes	Condition of river banks	Visible erosion that needs repairs/status quo; natural-looking banks (level of erosion and presence of vegetation (scrubs, trees) and animals (mammals and birds))
van Bueren and Bennett, 2004	Two river basins as well as national, Australia	No	Hectares of farmland repaired or bush protected	Four levels that vary according to the river in question (millions of ha rehabilitated)

Table A1.3. Recreational attributes with aesthetic descriptors.

Author(s)	Location	WFD	Attribute	Levels
Alvarez-Farizo et al. (2007)	Cidacos River, Navarra, Spain	Yes	Aesthetics of the river	Low; high; status quo (litter, smell, visual quality of water, riverside vegetation, erosion)
Birol et al. (2008b)	Cheimaditida wetlands (including Lake Cheimaditida), Greece	Yes	Open water surface area	Low/Decrease in 20%/status quo; high/increase by 60% (surface area of the lake that remains uncovered by reed beds)
Hanley et al. (2006a)	River Wear, Durham, England and River Clyde, Central Scotland	Yes	Aesthetics/ Appearance	Good and fair level (sewage or litter)
Hanley et al. (2005)	River Wear, Co. Durham	Yes	Aesthetics	Fair/Status quo; good (some or no sewage or litter)
Robinson et al. (2002)	Bremer River Catchment, Queensland, Australia	No	Good or very good appearance	Four levels, lowest level 55/status quo (percentage of the total length of the river)
Stithou et al. (2012)	River Boyne	Yes	Water appearance	No improvement/Status quo; some improvement; a lot of improvement (clarity, plant growth, visible pollution, noticeable smell)

Table A1.4. Recreational attributes alone.

Author(s)	Location	WFD	Attribute	Levels
Bennett et al. (2008)	Three rivers, Victoria, Australia	No	Water quality	Four levels that vary according to the river in question (percentage of river suitable for primary contact recreation without threat to public health)
Birol et al. (2008a)	Five rivers, Sosnowiec, Poland	No	River access	Easy; difficult/status quo (public's access to the river for recreational purposes in the next 10 years)
Heberling et al. (2000)	Pennsylvania, USA	No	Water quality	Able to swim/status quo; able to fish and swim; able to fish, swim and drink
Kataria et al. (2012) Survey 2	Odense River, Denmark	Yes	Access	Restricted/Status quo; good (for recreational purposes)
			Angling	Good/Status quo; improved (fishing opportunity)
Morrison and Bennett (2004)	Five rivers, New South Wales, Australia	No	Recreational uses	Picnics and boating/Status quo; picnics, boating and fishing; picnics, boating, fishing and swimming
Smyth et al. (2009)	Lake Champlain Basin, USA and Canada	No	Use of beach	Never closed, closed 7 days a year on average/status quo, closed 14 days a year on average
Stithou et al. (2012)	River Boyne	Yes	Recreational activities	No fishing or swimming/Status quo; no swimming; all available (availability of the recreational activities walking, boating, fishing, swimming)
van Bueren and Bennett (2004)	Two river basins as well as national, Australia	No	Waterway health	Four levels that vary according to the river in question (km of waterways restored for fishing or swimming)

Table A1.5. Regulatory attributes (aside from those associated with water clarity).

Author(s)	Location	WFD	Attribute	Levels
Birol et al. (2008a)	Five rivers, Sosnowiec, Poland	No	Flood risk	Low, high/status quo (risk of flooding in the area in the next 10 years)
Hanley et al. (2006b)	Two rivers, Scotland	Yes	Flow rate	2, 3, 4, 5/Status quo (months of the year that the river is in a low-flow condition)
Tait et al. (2012)	Canterbury, New Zealand	No	Flow	1, 3, 5/Status quo (months of low flow per year)
Willis et al. (2002)	Sussex, UK	No	Change in the flow of water in rivers around the waterworks	No change/Status quo; small increase; small decrease (flow of water in rivers around the area)

Table A1.6. Other attributes of interest.

Author(s)	Location	WFD	Attribute	Levels
Alvarez-Farizo et al. (2007)	Cidacos River, Navarra, Spain	Yes	Supplies of water	Subject to fluctuations/Status quo; guaranteed (urban and agricultural purposes)
Birol et al. (2008b)	Cheimaditida wetlands (including Lake Cheimaditida), Greece	Yes	Research and education	Low/Deterioration/Status quo; high/10% increase (educational, research and cultural information that may be derived from the existence of the wetland, including visits by scientists, students and schoolchildren to learn about ecology and nature)
Hanley et al. (2006b)	Two rivers, Scotland	Yes	Employment	Local agricultural jobs lost; local agricultural jobs gained; no change/status quo
Tait et al. (2012)	Canterbury, New Zealand	No	Health risk	10, 30, 60/Status quo (number of people per 1,000 who get sick yearly from pathogens in animal waste ending up in waterways)
van Bueren and Bennett, 2004	Two river basins as well as national, Australia	No	People leaving country areas every year	Four levels that vary according to the area in question (thousands of people leaving annually)

Appendix 2 Statistical Analyses

Appendix 2 provides details on the types of statistical procedures that were used to estimate values for generic waterbody attributes in this report. When respondents were presented with a choice card, they were expected to choose the alternative that provided them with the greatest amount of utility or benefit, subject to constraints. Utility from each alternative can be derived from observed or unobserved sources but, by definition, researchers are not privy to information on the unobserved sources. Appendix 2 outlines the methods used in this report for overcoming this problem. Section A2.1 introduces a RUM, which can be used to link information on the observable sources with a statistical model of human behaviour. RUMs do this by treating unobserved sources of utility as random components. The type of distribution that is used to describe unobserved sources of utility dictates which econometric model is used for choice analyses. Section A2.2 introduces a CL model, which is the product of assuming that the random components are IID following a Type 1 extreme value distribution. Whilst the CL model is considered the 'workhorse' of discrete choice modelling, these assumptions can be somewhat limiting. For this reason, Section A2.3 presents the MXL model, which accounts for heterogeneity in respondents' preferences by assuming that the parameters estimated for each attribute level are randomly distributed rather than fixed. For this reason, the MXL model is capable of overcoming a number of the limitations associated with the CL model. Finally, Section A2.4 outlines how the parameter estimates from the CL and MXL models can be converted into monetary values for individual attributes and the TEV of policy changes.

A2.1 Random Utility Model

The behavioural choice rule says that individuals compare the utility (U) that they get from each alternative (j = 1,..., J) on a choice card and, subject to their personal budget and the variety of prices presented to them, choose the alternative that provides them with the highest level of utility:

$$Max(Uj) \qquad \text{Eqn A2.1}$$

The decision-making process underlying Eqn A2.1 is referred to as respondents' indirect utility function (IUF). It is not visible to researchers but discrete outcomes of respondents' choices are:

$$Prob_i = Prob(U_i \geq U_j) \qquad \text{Eqn A2.2}$$

Equation A2.2 says that the probability of an individual choosing alternative i is equal to the probability that the utility he/she gets from i is greater than (or equal to) the utility he/she gets from each of the other alternatives on the choice card. The utility respondents get from each can be derived from observable (V) and unobservable (ε) sources:

$$U_j = f(V_j, \varepsilon_j) \qquad \text{Eqn A2.3}$$

To achieve estimates for U_j in Eqn A2.3, the presence of ε_j must be accounted for, despite the fact that virtually nothing is known about it. To begin with, a decision needs to be made regarding the specification of ε_j in the utility function. Most models assume it is additive:

$$U_j = V_j + \varepsilon_j \qquad \text{Eqn A2.4}$$

Combining Eqns A2.3 and A2.4 gives:

$$Prob_i = Prob[(V_i + \varepsilon_i) \geq (V_j + \varepsilon_j)] \qquad \text{Eqn A2.5}$$

Rearranging Eqn A2.5 gives:

$$Prob_i = Prob[(V_i - V_j) \geq (\varepsilon_i - \varepsilon_j)] \qquad \text{Eqn A2.6}$$

Equation A2.6 states that the probability of an individual choosing alternative i is equal to the probability that the difference in the observed sources of utility associated with alternative i compared with alternative j is greater than (or equal to) the unobserved sources of utility of alternative i compared with j after evaluating each alternative on the choice card. It is referred to as the modified behavioural rule and is the model that is estimated by the RUM.

The value of the differences between the unobservable components in the IUF in Eqn A2.6, $\varepsilon_i - \varepsilon_j$, differs for each respondent participating in the CE. The RUM assumes that the utility values for the unobserved components are located on some unknown distribution and are randomly allocated to each respondent. This assumption is untestable.

Equation A2.3 shows that each alternative has its own unobserved component. Each of these unobserved components has a unique mean. Differences between their utility values can be randomly assigned to respondents to represent $\varepsilon_i - \varepsilon_j$ in Eqn A2.6. Although the distribution of these random components is unknown, it can be assumed. The choice of distribution for the random unobserved components dictates which econometric model is used to estimate respondents' IUF (Hensher et al., 2006).

A2.2 Conditional Logit

For this report, the observable components of U_j were represented by the attributes on the choice card. Hence, Eqn A2.4 may be rewritten as:

$$U_{nj} = \beta'_n x_{nj} + \varepsilon_{nj} \qquad \text{Eqn A2.7}$$

where x_{nj} represents the attributes of alternative j for individual n and β'_n is a vector of coefficients used to describe the linear relationship between x_{nj} and U_{nj}. The use of double subscripts in Eqn A2.7 denotes the fact that each individual made six choices in the CE survey. The decision maker knows the value of his/her own ε_{nj} and β'_n. By assuming that ε_{nj} are IID and follow a Type 1 extreme value distribution, the researcher is committing to using a logit model. If the researcher specifies β'_n to be fixed (or known), then a CL model is used and the probability of individual n choosing alternative i over all other alternatives j, conditional on knowing β'_n, is given as:

$$P_{ni} = \frac{\exp(\beta' x_{ni})}{\sum_j \exp(\beta' x_{nj})} \qquad \text{Eqn A2.8}$$

Equation A2.8 shows the probability of individual n choosing alternative i over all other alternatives j.

Since logit probabilities take a closed form, classical maximum-likelihood procedures can be applied to estimate β' in Eqn A2.8. The probability of individual n choosing the alternative he/she actually chose on any one choice card is:

$$\prod_i (P_{ni})^{y_{ni}} \qquad \text{Eqn A2.9}$$

where y_{ni} = 1 if person n chose i and zero otherwise. Simply put, Eqn A2.9 represents the probability of the chosen alternative (Train, 2003). The joint density, or likelihood function, of all the observations in the sample (assuming that each respondent's choice is independent of all other respondents' choices) is given as:

$$L(\beta|y) = \prod_{n=1}^{N} \prod_i (P_{ni})^{y_{ni}} \qquad \text{Eqn A2.10}$$

where y is used to indicate the collection of sample data and β is a vector of unknown parameters, which are assumed to be fixed constants that can be learned about from the data (Greene, 2003). For simplicity of estimation, Eqn A2.10 is converted to a log-likelihood function:

$$LL(\beta|y) = \sum_{n=1}^{N} \sum_i y_{ni} \ln P_{ni} \qquad \text{Eqn A2.11}$$

where $LL(\beta \mid y)$ is globally concave for linear-in-parameters coefficients. The estimators are the values for β that maximise Eqn A2.11. They are the values for which the predicted average of each explanatory variable is equal to the observed average of the sample.

Whilst CL models are considered computationally simple 'workhorses' of discrete choice models, there are a number of issues with their design. They have restrictive substitution patterns for alternatives because the ratio of the logit probabilities of two alternatives is always independent from all others. This property is referred to as being independent of irrelevant alternatives (IIA). Combined with the fact that all probabilities must sum to 1 over alternatives, the IIA property implies that introducing or changing one alternative impacts on the ratio of every probability combination on the choice card, regardless of whether it is logical or not. A manifestation of the IIA property is proportional substitution, whereby an improvement in the attributes of an alternative reduces the probabilities for the other alternatives by the same percentage. In addition, the fact that CL models are incapable of representing taste variation caused by unobserved components can be restrictive for a study describing human behaviour (Train, 2000).

A2.3 Mixed Logit

The second model used to estimate respondents' preferences for Irish waterbodies in this report is an MXL model. MXL models are more flexible than CL models because they allow for random taste variation towards different attributes, unrestricted substitution patterns and correlation in unobserved components (Hoyos, 2010).

In an MXL model, the probability of individual n choosing alternative i over all alternatives j shown in Eqn A2.8 is no longer estimated conditional on β'_n being fixed (or known). Instead, β'_n is assumed to be randomly distributed. Broadly speaking, the choice probabilities in MXL models are expressed as:

$$P_{ni} = \int L_{ni}(\beta|y)\, f(\beta|\theta) d\beta \qquad \text{Eqn A2.12}$$

where $L_{ni}(\beta|y)$ is the logit probability, as in the right-hand side of Eqn A2.8, evaluated at parameter β, and $f(\beta|\theta)$ is the mixing distribution used to describe β in terms of the parameters of the distribution, θ. In the MXL model, $f(\beta|\theta)$ is specified to be continuous. For the model used in this report, the random parameters were all the non-monetary attributes except waterbody type. They were specified as normally distributed, meaning θ contained estimates for the distribution mean, b, and covariance, W. Specifically, the choice probabilities for the model used in this report are given as:

$$P_{ni} = \int \prod_{t=1}^{T} \left(\frac{\exp(\beta' x_{ni})}{\sum_j \exp(\beta' x_{nj})} \right) \emptyset(\beta|b, W) d\beta \qquad \text{Eqn A2.13}$$

where T is the number of choices observed for each respondent and $\phi(\beta|b,W)$ indicates a normal density function. The probabilities in Eqn A2.13 are approximated through simulations for any given value of θ. Train (2003) outlines three steps of the simulation process. Firstly, a value of β is drawn from $f(\beta|\theta)$, and labelled β^r with the superscript r = 1 referring to the first draw. In this report, values were simulated using Halton sequences, which construct numbers using number theory. They have an advantage over standard pseudo-random sequence computation because they achieve more uniform coverage over unit intervals. This means Halton sequences require far fewer draws to secure a stable set of parameter estimates (Train, 2000).

$$L_{ni}(\beta^r) = \frac{\exp(\beta^{r'} x_{ni})}{\sum_j \exp(\beta^{r'} x_{nj})} \qquad \text{Eqn A2.14}$$

Secondly, the logit formula in Eqn A2.14 is calculated using numbers from these draws. Thirdly, the first two steps are repeated many times and the results from each calculation are averaged. This results in the simulation of an unbiased estimator for P_{ni} in Eqn A2.13, which is given as:

$$\check{P}_{ni} = \frac{1}{R} \sum_{r=1}^{R} L_{ni}(\beta^r) \qquad \text{Eqn A2.15}$$

where R is the number of draws. A total of 300 Halton draws were used to simulate each of the parameters in this report. Values for $\check{P}_{ni}$ are inserted into the log-likelihood function in Eqn A2.11, providing a simulated log likelihood (SLL):

$$SLL(\theta|\beta^r) = \sum_{n=1}^{N} \sum_{j=1}^{J} d_{nj}\, \check{P}_{nj} \qquad \text{Eqn A2.16}$$

where d_{nj} = 1 if individual n chose j and zero otherwise. The resulting estimator is called the maximum simulated likelihood estimator (MSLE) and is the values for θ that maximise the SLL.

A2.4 Estimation of Monetary Values

Implicit prices, or MWTP for the mean value of each attribute i can be calculated using parameter estimates for the attributes themselves, β_i, and the parameter estimate for the price vector, β_p, in the following way:

$$MWTP_i = -\frac{\beta_i}{\beta_p} \qquad \text{Eqn A2.17}$$

To obtain the TEV of a policy change, or an average person's WTP for a package of changes to Irish waterbodies, the CS can be estimated using (Stithou et al., 2012):

$$CS = \frac{1}{\beta_p}\left[ln\left(\sum_{j=1}^{J} exp\left(V_j^1\right)\right) - ln\left(\sum_{j=1}^{J} exp\left(V_j^0\right)\right)\right]$$

Eqn A2.18

where V_j^0 and V_j^1 represent the deterministic part of the IUF before and after the policy change. CS values can be calculated from mean values of β'_n in the CL model to represent the right-hand side of Eqn A2.18. For the MXL model, 1,000 values for the right-hand side of Eqn A2.18 are simulated using estimated mean and standard deviation values for β'_n. From these simulated values, the mean, median, 25th and 75th percentile values for the CS can be reported.

Appendix 3 Respondents' Use of Waterbodies

The figures in Appendix 3 provide a more detailed breakdown of how respondents use Irish waterbodies than what is provided in the main report. Section A3.1 shows how many respondents participated in primary, secondary and visual recreational pursuits at waterbodies in the past 12 months. The type of recreational activities pursued by respondents is further explored in Section A3.2, which looks at how they differ across sex and age. Section A3.3 provides a graphical representation of how the type of people visiting Irish waterbodies varied across household structure.

A3.1 Primary, Secondary and Tertiary Recreational Use

Figure A3.1 shows how many respondents participated in different types of recreational pursuits at waterbodies in the past 12 months. The values outside the parentheses indicate how many respondents partook in visual, primary or secondary recreational activities and the values inside the parentheses show the corresponding percentages for the entire sample.

Respondents were most likely to pursue visual (68.35%), followed by secondary (16.74%) and primary (16.05%) recreational activities. In total, 38 respondents (4.45%) participated in all three recreational types in the past 12 months, whereas 219 (25.64%) participated in none.

A3.2 Type of Use by Demographic Factors

The minimum type of recreational activity carried out by respondents is the type of activity that involves the greatest level of interaction with the waterbody. For example, if an individual participated in both visual and secondary recreational activities in the past 12 months, the minimum type of recreation that he/she pursued is secondary. Whilst the likelihood of an individual visiting Irish waterbodies does not significantly differ by sex or age, the minimum type of recreational activity that is pursued does.

Figure A3.2a shows that men and women are equally likely to participate in primary recreational activities but that females opt for visual pursuits more often than secondary pursuits when compared with men. This

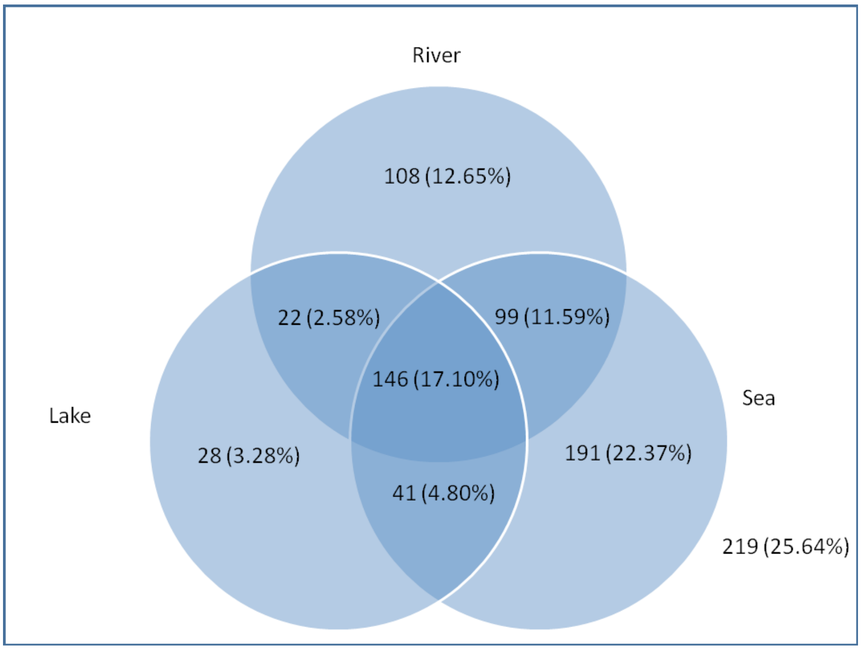
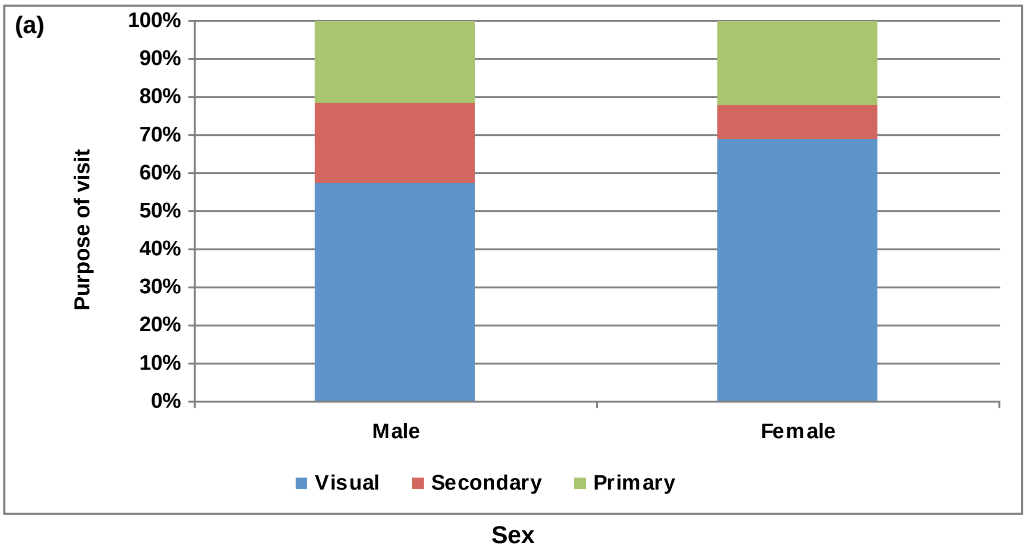


Figure A3.1. Breakdown of the types of recreational activities carried out by individuals in the sample.



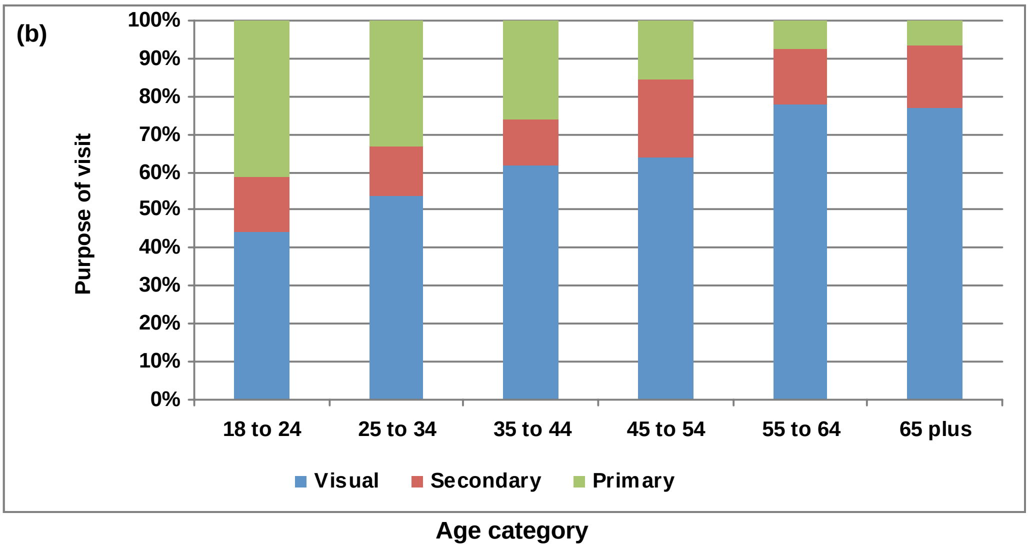


Figure A3.2. The minimum type of recreational activity pursued by respondents by (a) sex and (b) age category.

Pearson chi^2 – (a) 19.71, df = 2, p = 0.001; (b) 15.91, df = 10, p = 0.001.

may be partially explained by the fact that a total of 19.05% of men, and only 4.16%, of women surveyed went fishing in the past 12 months. It is perhaps not surprising to see that as the age categories in Fig. A3.2b increase, generally the likelihoods of individuals participating in visual and primary recreation augment and decrease, respectively. Many of the sports included in the primary recreation category have become ever more popular in recent years, e.g. board surfing. For this reason, they are expected to appeal to the younger generation. In addition, they may be more strenuous than, say, walking by a river, which helps to further explain why older people may be disinterested in them. The appeal of secondary recreational pursuits is most popular for the 45- to 54-year-old age category. Whilst a high number of individuals in this category claim to have gone fishing (11.81%) in the past 12 months, this value is mainly due to the high number of 45- to 54-year-olds who went rowing, boating, canoeing or cruising (11.11%) relative to the entire sample (7.61%).

A3.3 Waterbody Use and Household Structure

Figure A3.3 provides a graphical representation of how the type of people visiting Irish waterbodies varies across household structure. It has been created to show the breakdown of family structure versus who accompanies respondents on their visits to waterbodies. The number of children and adults in a household (household structure) is shown on the left axis and the percentage of respondents who travelled to a waterbody alone, with one or more adult(s), with one or more child(ren) or with both adults and children is shown on the right axis.

Figure A3.3 shows that only three household structures have over 20% or more observations where an individual visited a waterbody alone. These are single occupant homes, homes with three adults and homes with four adults. In addition, aside from just three household structures, all households with one or more child(ren) are most likely to bring both adults and children to the waterbody than adults only. Overall, Figure A3.3 suggests that living with children dictates the composition of who visits a waterbody and is therefore expected to influence the type of activity pursued whilst there.

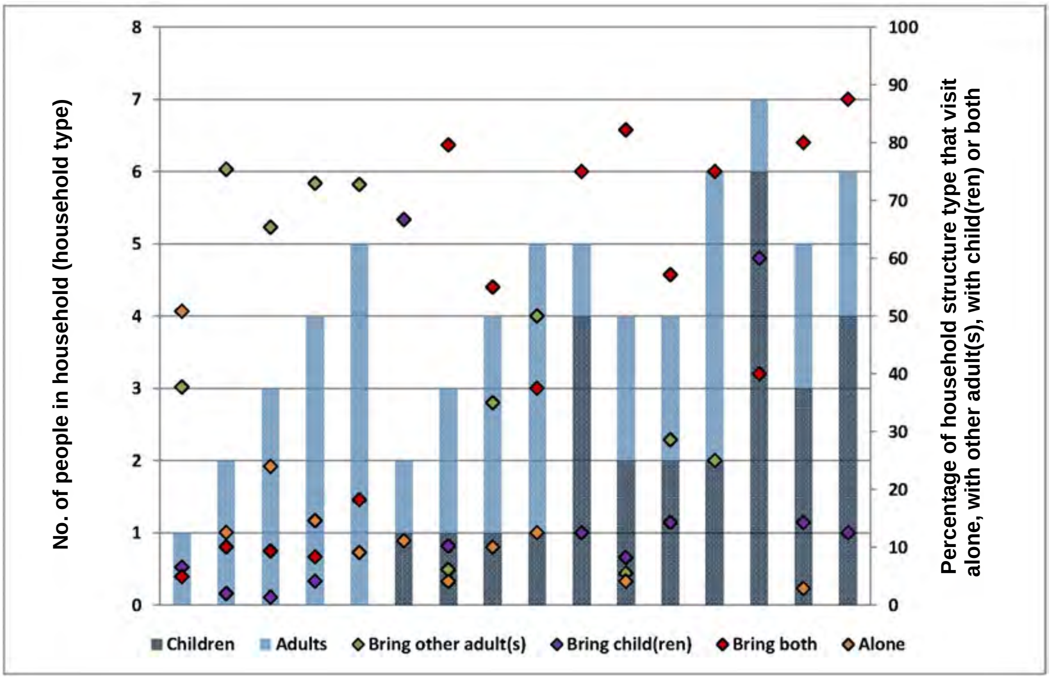


Figure A3.3. Household structure and who people bring with them to waterbodies.

Appendix 4 Compensating Surplus Measures and Aggregate Values Associated with Value of Medium Improvements to Irish Waterbodies

The values in Tables A4.1 and A4.2 present estimates of compensating surplus measures and aggregate values associated with the value of **medium** improvements in the attributes to Irish waterbodies. As expected, these values are lower than the values presented in Tables 5.4 and 5.5 where estimates of welfare values associated with a waterbody moving from the lowest ecosystem service levels of the first four attributes in the study (health of ecosystems, water clarity and smell, access to recreational activities and condition of banks and shoreline) to the **highest** level of the attributes were shown. As in the high improvement scenario the values for improvements to rivers under the medium improvement scenario are the highest of all three waterbody types, followed by lakes and, finally, seas.

Table A4.1. Compensating surplus measures for medium levels of the attributes.

Attribute	**Levels**		
Health of ecosystems (fish, insects, plants, wildlife on shoreline or banks)	Moderate		
Water clarity and smell	Moderate		
Access to recreational activities	Secondary contact recreation also possible (e.g. fishing, sailing)		
Conditions of banks or shoreline	Moderate levels of erosion (possibility of extreme flooding event once every 10 years)		
Compensating surplus (€/person/year)	**River**	**Lake**	**Sea**
Conditional logit	102***	94.55***	83.31***
Confidence interval	(90, 108)	(83, 106)	(72, 94)
Mixed logit (mean)	90***	84***	75***
Confidence interval	(75, 105)	(71, 98)	(62, 88)

Estimates are rounded to nearest whole number. 95% confidence interval in parentheses. ***$p < 0.01$.

Table A4.2. Total yearly value of medium improvements to Irish waterbodies.

Model estimate	Aggregated values (€/year)		
	Rivers	Lakes	Seas
CL mean (CI)	197,813,672	183,593,145	161,769,178
MXL mean (CI)	175,007,044.8	163,728,287.1	145,568,184.2

CI, confidence interval; CL, conditional logit; MXL, mixed logit.

EPA Research Report 127

What's our water worth?

Climate - Water - Sustainability

Identifying pressures • Informing policy • Developing solutions

Estimating the Value to Irish Society of Benefits Derived from Water-Related Ecosystem Services: A Discrete Choice Approach

Waterbodies may be valued by people for a number of reasons. In this report, a study was undertaken to determine how Irish people valued five attributes of water 1) The health of ecosystems, 2) Water clarity and smell, 3) Access to recreational activities, 4) The conditions of banks and shorelines and 5) Whether the waterbody was a river, lake or sea. This study used a discrete choice approach to determine the value a sample of 850 people placed on these five attributes.

Identifying Pressures

There are increasing pressures on all of Ireland's waters. The overriding objective of this report is to use the discrete choice method to calculate how Irish people value the 5 attributes of water studied. This report shows how much Irish citizens are willing to pay for these attributes for the first time, and also shows the differences between how much they are willing to pay for the protection of rivers, lakes and seas.

Informing Policy

Estimating the economic values and benefits of waterbodies is a key requirement under the EU Water Framework Directive (WFD) and requires the valuation of multi-dimensional features that characterise the economic values of water. This report partly addresses the knowledge gap on the general willingness of the Irish public to pay for water quality.

- People were willing to pay most for a good status of water clarity and smell, with survey respondents willing to pay €46.48 per person per year.
- The lowest value was placed on secondary access to recreational activity, which respondents were prepared to pay €11.04 per person per year.
- 43.85% of respondents were unwilling to pay for improvements to Irish waterbodies on any of the choice cards presented to them.

Developing Solutions

Aquatic ecosystems provide provisional, regulatory and cultural goods and services, which provide economic benefits in the form of use values. Furthermore, they provide supporting services, which are not directly used by humans but are nonetheless highly valued by individuals. Valuing the benefits derived from these ecosystem services allows regional policy makers and related stakeholders managing waterbodies to make more informed decisions about best management practices for the future. Results show that respondents assigned the highest value to 'water clarity and smell', and the lowest to 'access to recreational activities'.

Comhshaol, Pobal agus Rialtas Áitiúil
Environment, Community and Local Government

EPA Research: McCumiskey House, Richiew, Clonskeagh, Dublin 14.

Phone: 01 268 0100
Twitter: @EPAResearchNews
Email: research@epa.ie

Cover photo: John Doheny

www.epa.ie

EPA Research Webpages
www.epa.ie/researchandeducation/research/