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Working Paper Series

Working Paper 13-WP-SEMRU-01

Are similar ecosystem services valued differently across different water body types: A discrete choice analysis of rivers, lakes and sea attributes?

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Abstract

As demands on the environment and associated ecosystem services increase, the need for a more integrated approach to managing the exploitation of these natural resources also increases. This is particularly true for the alternative types of water bodies such as a sea, river and/or a lake. The purpose of this paper is to explore the preferences of residents in the Republic of Ireland for a number of ecosystem services provided by Irish water bodies. In particular the paper examines whether, and how, preferences for the same ecosystem services differ when the public is asked to consider the alternative water body types (sea, river and lake). This is relevant as the ecosystem services' economic benefits are not necessarily uniform across water bodies, a factor that has not been explored in detail previously.

Keywords: ecosystem services, water bodies; non-market valuation; willingness to pay

This study has been funded as part of the Science, Technology, Research and Innovation for the Environment (STRIVE) Programme 2007–2013. The programme is financed by the Irish Government under the National Development Plan 2007–2013. It 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 environmental research.

This work was also funded through the Beaufort Marine Research Award, which is carried out under the Sea Change Strategy and the Strategy for Science Technology and Innovation (2006-2013), with the support of the Marine Institute, funded under the Marine Research Sub-Programme of the National Development Plan 2007–2013.

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1. Introduction

The assignment of economic values to ecosystem services requires an understanding of how human welfare is affected by change in those ecosystem services. Humans use a variety of goods and services provided by ecosystems, which may be classified as provisional, regulatory or cultural services (UKNEA, 2011a). In addition to producing goods and services for human use, ecosystems also provide supporting services. Water bodies supply, for example, resistance and resilience to surrounding ecosystems, wild species diversity and biogeochemical cycling. They also contribute to biological and genetic diversity (UKNEA, 2011b). Although these services are not used directly by humans, they nonetheless increase human welfare (Bateman *et al.*, 2002).

The Millennium Ecosystem Assessment (MA), which was initiated by the United Nations and took place between 2001 and 2005, provides evidence of interest at the supra-national level of establishing frameworks for better management of ecosystem services. The findings of the MA highlighted that over the past 50 years, humans have changed ecosystems more rapidly and extensively than in any other period in history, showing the need for strong action to combat irreversible changes to ecosystems. With regard to European Union (EU) policy, in 2012 the EU adopted the 'EU Biodiversity Strategy to 2020', which aims to halt the loss of biodiversity and the degradation of ecosystem services in the EU by 2020.

Within the context of water policy the implementation of the Water Framework Directive (WFD) in 2000 laid the foundations for European action in the specific area of water-based ecosystem management (OJEC, 2000). The WFD aimed at a minimum for a 'good' and 'non-deteriorating status' for all freshwater bodies in EU member states. Thus it provides a framework to achieve '*good ecological status'* (GES) in all EU waters by 2015. The directive takes a 'source to sea' approach in assessing freshwater ecosystems, defining planning, management and reporting on River Basin Districts rather than administrative regions, and it calls for social participation and transparency in the implementation of each step of the directive (WFD, 2013). Unlike previous narrowly-defined water directives, the WFD is concerned with estimating the impact of all human activity on biological, hydro-morphological and physio-chemical elements on water bodies (Norton *et al*., 2012).

The objectives of a more recent marine waters related directive, the Marine Strategy Framework Directive (MSFD) 2008 (OJEC, 2008), are also complementary with those laid down by the WFD. The MSFD requires that "*good environmental status*" be achieved based

on 11 indicators encompassing an ecosystems approach to management. Broadly, the WFD applies to freshwater and transitional water while the MSFD applies to deep water and there is overlap between the WFD and the MSFD in respect to coastal waters. One of the key aspects of these directives from an environmental economics perspective is that they call for full consideration of the economic costs and benefits arising from the impact of the proposed environmental protection measures on the water bodies' ecosystem service provision. This is challenging, particularly from the environmental benefits perspective, because assessing the benefits arising from changes in complex ecosystem services is not a straightforward task. Nevertheless, various methods exist for the purposes of valuing such benefits.

Within this context, this paper aims to assess the economic values of Irish residents' for a number of ecosystem services from Irish water bodies as identified though focus group discussions and by the Environmental Protection Agency in Ireland (EPA, 2012). This study uses the method of discrete choice experiments (DCEs) which can represent the multifaceted and complex nature of ecosystems and therefore makes them capable of estimating how a combination of changes to one or more ecosystem services affects human welfare. Broadly speaking, this study adheres to the objectives of the WFD by modelling members of the publics' preferences with regard to different management scenarios for a variety of Irish water bodies. The choices presented to individuals within the DCE remain true to the holistic concept of ecosystem assessment required under the directive. A particular aim of this study is to understand if and how, preferences for the main ecosystem services provided differ across rivers, lakes and sea. This is an important consideration since the value of ecosystem services may not be uniform across different water bodies.

In what follows, the next section reviews the international literature on water body ecosystem service valuation as well as provides an overview of previous valuation studies conducted in Ireland. This is followed by an outline of the econometric methodology employed in the study and a description of the survey design. We then present a number of results and conclude the paper with a discussion of the implications of our findings.

2. Review of the water valuation literature

The DCE literature evaluating ecological improvements in water bodies as a consequence of the introduction of policy differ in terms of the purpose of the study and hence the affected population. Authors may solely be interested in ascertaining the perceptions of users of the water body (Can *et al.,* 2012, Hynes et al, 2008) or of those residing near the water body (Kataria *et al.,* 2012, Stithou *et al.,* 2012). They may also be interested in estimating the value of improvements to water bodies for an entire region or country (Kataria, 2009, Metcalfe *et*

al., 2012), in which case a nationally representative sample is required. They may address the impact of changes to different water body types at many geographic scales. The majority of the literature focuses on singular water body types, particularly rivers. Within this category, 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, Brouwer *et al.*, 2010, Poirier *et al.*, 2010). DCEs focussing on the evaluation of ecosystem services provided by lakes or coastal waters are less common than those for rivers. Exceptions include evaluations 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), coastal waters off the west coast of Ireland (Hynes et al., 2013) and Gocek Bay in Turkey (Can *et al.*, 2012). Even fewer papers combine the evaluation of more than one water body type into one study. Metcalfe et al. (2012) carried out a large-scale investigation of the value of the implementation of the WFD for all water bodies in the UK, which included a DCE. However, the authors did not differentiate between varying water body types in their survey but kept them as one combined entity. Glenk et al. (2011), on the other hand, kept their description of the impact on rivers and lochs separate when they investigated the impact of the WFD in Scotland.

Both Metcalfe *et al*. (2012) and Glenk et al. (2011), use an ecological status approach to ecological water valuation in their studies. The four attributes used in their DCEs' are descriptions of the potential status of the water body in a number of years' time. For example, Glenk et al. (2011) include two variables for lochs, as well as two for rivers, each described as having differing environmental standards in 7 and 20 years' times, respectively. The levels for the attributes in both studies are varying quantities of the water bodies that will be at the achieved environmental standard by the end of the given time frame. A consequence of focusing on just the ecological status of the water bodies being analysed is that the marginal value of a specific characteristic of a water body (e.g. the marginal value of a change in the recreational, aesthetic or ecological attribute) cannot be estimated. Conversely, in accordance with Lancaster's characteristics theory of demand (Lancaster, 1966), the total value of water bodies may be viewed as the sum of the marginal values of their many attributes, and, combined with welfare theory and consumer theory, DCEs may be used to elicit the marginal benefit of the many characteristics of water bodies separately. In this paper, we use this multidimensional approach to water body valuation to estimate, amongst other things, the preference parameters for attributes such as recreational potential, ecosystem health and the state of banks or shoreline across rivers, lakes and seas separately.

The majority of multidimensional DCE surveys contain attributes that relate to the ecology of the water body, to recreational opportunities and to the aesthetics of the water body, although the manner by which these categories are included in studies varies greatly throughout the literature. Ecology may be described solely in terms of the type of biodiversity found in the water body. The former typology may include attributes for specific groups of species, such as native fish, whose levels are described quantitatively (Morrison *et al.*, 2004, Kragt *et al.*, 2011). Alternatively, they may include attributes that are more general in their description of the biodiversity on the water body and are qualitative in their measurement of change (Hanley *et al.*, 2005, Alvarez-Farizo *et al.*, 2007, Birol *et al.*, 2008a). Similarly, recreational activities may be included in DCEs as solo attributes, such as angling (Kataria *et al.*, 2012) or as attributes for recreation in general. In this latter case, levels tend to be defined as different combinations of the possible activities (Morrison *et al.*, 2004, Stithou *et al.*, 2012). The most commonly used attribute for estimating values for regulatory services provided by water bodies, as defined by the UKNEA (Assessment, 2011), is water flow (Willis *et al.*, 2002, Hanley *et al.*, 2006b, Tait *et al.*, 2012). An exception to this is the inclusion by Biorol et al. (2008a) of an attribute for the likelihood that flooding will occur in Sosnowiec, Poland, in the next ten years. Aesthetics is often described as a conglomerate of the effects of litter, smell and clarity (Alvarez-Farizo *et al.*, 2007), sewage (Hanley *et al.*, 2006a) and pollution (Stithou *et al.*, 2012) on water body status. Additionally previous studies have used overlapping characteristics to describe particular attributes. Examples include the use of water clarity (Alvarez-Farizo *et al.*, 2007), smell (Hanley *et al.*, 2006b) or erosion (Robinson *et al.*, 2002, Hanley *et al.*, 2006a, Stithou *et al.*, 2012) to denote the ecological attribute. Some studies have used potential threats to human health in their description of the recreation attribute (Bennett *et al.*, 2008, Smyth *et al.*, 2009). Consequently, the previous DCE literature also highlights the potential interaction between different water bodies attributes.

Valuation studies with a specific focus on water body improvements in Ireland are limited. The majority focus on valuing 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 willingness to pay (WTP) of the average kayaker using the Roughty River in Co. Kerry (Hynes *et al.*, 2006). Elsewhere Curtis (2003) uses a nationally representative survey to examine Irish demand for water-based leisure activities and Hynes *et al.* (2008) use revealed preference data to examine values for a range of river attributes relevant to kayaking. These papers provide important information on the use values

of water bodies, particularly in relation to leisure activities, but they do not capture the total economic value (TEV) of the resource.

To date, only one Irish study has estimated the TEV of a water body using CE. Stithou *et al.* (2012) calculate the value of achieving GES in the Boyne River Catchment using 252 face-to-face interviews in the Boyne catchment area. Based on the Stithou et al. estimates, Norton et al. (2012) examined a number of alternative benefit transfer (BT) techniques that may be used to calculate the benefit value of Irish water bodies achieving GES as specified under the WFD. They concluded that comparing BT estimates across water bodies could allow policy-makers in different river basin districts to assess which river might receive the highest or the least amount of benefits from any policy intervention aimed at achieving GES. In the cases where policy-makers feel that the costs of achieving GES may be higher than the aggregate benefits (in terms of the change in the water body's ecosystem services) from such a policy intervention then the authors recommended that a primary survey should be carried out. To estimate the value of a number of key ecosystem services from Irish water bodies, we follow this advice and use a primary survey instrument to assess the preferences of the Irish general public directly.

3. Methodology

DCEs involve the generation and analysis of choice data through the construction of a hypothetical market using a survey. DCEs present respondents with several choice sets, each of which contains a number of mutually exclusive hypothetical alternatives that relate to potential outputs as a consequence of a change in policy. Alternatives are described by a set of attributes, each of which is set to a specific level, and respondents are asked to choose their preferred alternative in each choice set. Every choice set contains an alternative that reflects the current status (status quo) of the good being evaluated. A price is included as an attribute in each alternative to reflect the cost of the policy change to the respondent (usually, the status quo option incurs no cost). This DCE format allows marginal utility estimates for changes in the level of each attribute to be easily converted to WTP estimates. In addition, given that compensating variation measures may be obtained, the total value of improvements to the public good as a consequence of the policy change may be calculated (Hoyos, 2010).

As is standard practice with DCE data, the random utility model (RUM) as developed by McFadden (1974) is used to analyse the choices made by the respondents. The RUM model is

based on the premise that utility for an individual is composed of an observable component $\beta' x_{nt}$ and a random component ε_{nt}, which leads to the following representation of utility:

$$U_{nt} = \beta' x_{nt} + \varepsilon_{nt}$$

Where β' represents a vector of parameter coefficients used to describe preferences for the *x* attributes. The starting point for most analysis of DCE data is the conditional logit (CL) model. Under the CL model, the choice probability for individual n can be represented as follows:

$$Prob_{nt} = \frac{\exp(\beta' x_{nt})}{\sum_j \exp(\beta' x_{nj})}$$

The popularity of the model arises from the fact that it is associated with a number of convenient properties. However, the assumptions underlying the CL model are restrictive. For instance, the model is underpinned by the "*independence and identical distribution*" condition of the error terms. As a result, it is now commonplace to estimate more flexible specifications. One of the more flexible model specifications used in the literature is the random parameters logit (RPL) model. In the RPL model, the parameters vary over decision-makers in the population with density $f(\beta)$. Therefore, the unconditional choice probability represents the integral of the logit probabilities over all possible values of β_n. As a result the choice probability can be represented by a product of logits:

$$Prob_{yn} = \int \prod_{t=1}^{T} \left(\frac{\exp(\beta' x_{nt})}{\sum_j \exp(\beta' x_{nj})} \right) f(\beta) d\beta$$

where T is the number of choices observed for each respondent and represents the fact that the model is estimated to account for the panel nature of the data. An important decision in the RPL model is what distribution to use to represent the tastes associated with the random parameters. In this paper, the heterogeneity in the non-cost random coefficients is modelled assuming a Normal distribution. The model is further specified to enable observed factors to enter as explanatory variables for the random heterogeneity in the parameter estimates. The distribution of the parameters is simulated using 300 Halton draws.

4. Survey design and data description

The survey design was informed by prior research conducted in Ireland (Stithou et al., 2012), by focus group discussions and through the reported importance of a number of key water body features by the Irish Environmental Protection Agency (EPA, 2012). This study differs

from previous research in Ireland as it is generalised to apply to all water bodies in Ireland rather than specific rivers. Furthermore, it also ascertains preferences for the ecological improvements from a sample of Irish residents rather than those who are located close to specific water bodies. Additionally, the study contains an added attribute to denote the type of water body associated with the ecosystem service attribute levels. This is specified with three possible types of water bodies which include rivers, lakes and the sea. For the status quo or no change option this attribute is specified to suggest that no water bodies will be targeted with ecological and water quality improvements. We specified the status quo option like this so that we could value improvements over a situation where the resources would not be managed. Since we were interested in exploring preferences for generic features of water bodies rather than valuing improvements to one particular water body, we felt that this was an acceptable status quo option to use. In terms of the actual quality of water bodies in Ireland, there is quite a large variation. For instance, the EPA suggests that 71 percent of rivers, 45 percent of lakes and 64% of transitional or coastal water are of high or good status (EPA, 2013). Therefore, our status quo option represents a situation in which no management of water bodies would lead to a decline in the quality of the bodies. While this may raise concerns that the status quo would not be realistic for respondents, our focus group discussions did not raise this as an issue. Table 1 depicts the attributes and levels chosen for the study. The ecosystem health, water clarity and smell and the conditions of banks or shorelines attributes can be thought of as ecological non-use services provided by water bodies. On the other hand the recreational goods provided by ecosystem services represent a form of use value.

Table 1. Attributes and Levels used in the DCE

Attributes	**Levels**
Aquatic Ecosystem Health: Abundance and variety of 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)
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)
Access to Recreational Activities	Visual amenity only (access for walking or cycling along banks or shoreline) Secondary contact recreation possible (e.g. fishing, boating) All types of recreation possible (including primary contact; swimming, kayaking)
Condition of Banks or Shoreline	High levels of erosion and damage (extreme flooding event once every 5 years) Moderate levels of erosion and damage (extreme flooding event once every 10 years) Low levels of erosion and damage (extreme flooding event once every 20 years)
Water Body Type Targeted	Lake, Sea, River, None Targeted
Annual household income tax	€0, €5, €10, €20, €30, €45, €70

As shown in the attributes table above; aquatic ecosystem health, water clarity and smell, access to recreational activities and condition of banks or shoreline are specified with three levels to depict the range of quality levels that could apply to these attributes. The health of ecosystem attribute was included to account for the non-use values of, or supporting services, provided by Irish water bodies in the form of the number of endangered species present at the water body. 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 water body, 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 water bodies 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 this attribute is similar to that of Stithou *et al*. (2012) although the attribute levels are described differently. They 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 conditions 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 water bodies. However, unlike Stithou *et al.* (2012), the conditions of banks and shoreline attribute used in this study included a description of the flood protection regulatory service provided by water bodies. 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 conditions of banks and shoreline attribute are described in terms of both erosion and the possibility of an extreme flooding event occurring.

The type of water body affected attribute had three levels: river, sea or lake. Each level was accompanied by a small graphic to ensure clarity for respondents. As with all environmental valuation studies a cost attribute is also included to allow post-survey welfare analysis to be elicited. This attribute is specified with six levels and an additional zero cost level for the status quo option. As previously mentioned, the levels of the attributes were informed by focus group discussions and previous research conducted within Ireland (Stithou et al., 2012) and the EPA. To generate the choice cards, following Ferrini and Scarpa (2009), a Bayesian efficient design was employed and each respondent was given a total of 6 choice cards to complete. A pilot study was conducted with 50 respondents to ensure that there were no problems with the survey instrument and to obtain prior estimates for the experimental design used in the main survey. The design for the main survey was generated using the NGENE software and the value of the D-Error for the main design was 0.47 (mean value).

A market research company was employed to collect the data during 2012 (both pilot and main survey). The survey company collected the data face-to-face with respondents in their home. The surveyors were instructed to go through the survey carefully with respondents and to ensure that the proper explanations of the attributes were given. The market research company followed a quota control sampling system based on respondents' location and

socio-demographic profile to ensure the sample was representative of the general population in Ireland. In total, information was collected from 853 respondents. Table 2 depicts one of the choice cards used in the survey.

Table 2. Example Choice Card

	Option A	**Option B**	**Option C**
Health of ecosystems: fish, insects, plants, wildlife on shoreline or banks	Good	Moderate	Poor
Water Clarity and Smell	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	 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	Moderate levels of erosion (extreme flooding event once every 10 years)	High levels of erosion and damage (extreme flooding event once every 5 years)	High levels of erosion and damage (extreme flooding event once every 5 years)
Type of water body targeted	 River	 Sea	No improvements to any water body
Annual increase in personal income tax	€20	€45	€0

5. Results

Table 3 provides an overview of the mean summary statistics for the sample along with the characteristics of the Irish population taken from the 2011 census. The sample has a marginally higher proportion of individuals with higher than primary school education, of

married people and of residents of Irish nationality than the national average. Table 3 also shows that the sample has a slightly 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, 2013). 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 indicates that the sample is broadly representative of the general population of Ireland based on these demographic characteristics.

It is interesting to note that among our sample the mean number of visits to rivers for recreational purposes is 22 visits per year, this is followed closely by visits to the seaside. These estimates may seem high, but rivers are widely distributed throughout Ireland. Similarly, a large proportion of the population in Ireland are located within a relatively short distance to the sea, which likely explains the high annual seaside visitation rates at approximately 18 mean visits per year. For lakes, there are a much smaller mean number of visits at approximately 6 visits per year, which could reflect that fact that lakes are found in fewer geographical locations in Ireland. Figure 1 (in the appendix) highlights that by far the most common recreational reason that people visit any of the water bodies is for walking or jogging activity and only a small proportion of the sample used the water bodies for primary contact recreational activities (such as fishing, surfing or swimming activities).

Table 3. Summary Statistics of the sample compared with the Irish Census 2011

Variable	***Survey Mean***	***Irish Census 2011***
Age (Years)	44.8	44.8
Primary Education (%)	10	16
Secondary Education (%)	57	53
Third level Education (%)	33	31
Married (%)	55	51
Male (%)	49	49
Urban (%)	59	62
National (% Irish)	90	86

Gross Income (€/YR)	27350	36138
Visits to Rivers per Year for Recreation	21.6	
Visits to Lakes per Year for Recreation	5.9	
Visits to Sea per Year for Recreation	18.2	

The results from the CL model are presented in Table 4. For the analysis, we restricted the sample to those respondents who did not serially choose the status quo option; this left a sample size of 479 respondents. A total of 47% of zero bidders comprised of protestors, claiming that the government should pay, 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 water bodies (45% of zero bidders). Finally, approximately 8% 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, and do not use water bodies. Therefore over 47 percent of these respondents were seen as protest bid and the majority of the remainder were individuals who could not afford to pay. While the latter is a legitimate reason to choose the status quo option including these individuals, who serially choose this option for this reason, could lead to an underestimate of the true WTP in the population. These individuals are being forced to choose a zero cost response due to their economic circumstances not due to the value they may actually place on the environmental service[1].

For the health of ecosystems and the water clarity attributes the level against which these estimates are compared is the poor level. In terms of the recreational attribute the base level is access for visual amenity recreation only. In the case of conditions of banks or shoreline the base level is a high level of erosion or damage. For the type of water body targeted the base level is targeting of no water body, which is associated with the status quo option.

Table 4. Conditional logit model results

[1] In Ireland, there has been a large scale economic crisis which has resulted in substantial unemployment, large increases in taxes and a cut in public spending. This will have impacted on people's ability to pay for environmental goods and services.

Variable	*Coefficient*	*Standard Error*
Health of ecosystems: moderate	0.359***	-0.06
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
Conditions of banks or shoreline: moderate erosion	0.373***	-0.062
Conditions of banks or shoreline: low erosion	0.512***	-0.068
Type of water body affected: sea	0.079	-0.117
Type of water body affected: lake	0.342***	-0.108
Type of water body 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	-2660.297***	
McFadden Pseudo R-squared	0.06	

Notes: Figures in parenthesis indicate the values of the standard errors. *** indicates significant at 1%, ** indicates significant at 5%, * indicates significant at 10%.

The magnitude and signs of the coefficients are in line with expectations. In particular respondents show a stronger preference for better levels of water quality and ecological improvements. Respondents value the good level of this attribute most highly, followed by the moderate level of this attribute over all other attribute levels. In terms of which water bodies respondents would like to see these improvements being implemented at, improvements at rivers are most preferred followed by lakes. The lowest values are for attribute improvements at sea, however, the coefficient is still positive and significant. As expected the coefficient on cost is negative and significant, suggesting that *ceteris paribus*,

respondents prefer lower prices. We interacted the number of reported trips to water bodies with the experimentally designed alternatives. Our results highlight that the number of trips is a positive and significant predictor of choosing one of the experimentally designed alternatives relative to the status quo option, which is associated with the base case in all the water body attribute levels. We also included an interaction term between the status quo alternative and preferences for paying for water quality improvements through income tax. Our results highlight, as expected, that respondents who show a preference for paying for improvements through income tax are less likely to choose the status quo option in the choice cards.

Table 5 presents the results from the RPL model. The model is specified to allow for random heterogeneity in the attribute parameters. We specified the parameters for the type of water body targeted as fixed to facilitate the calculation of compensating variation measures. Given the well-documented difficulties surrounding a random cost coefficient (Doherty et al. 2013), we also specify this as fixed. This will enable more straightforward computation of welfare effects and reduce the possibility of retrieving extreme welfare estimates. However, we acknowledge that we are making a very restrictive assumption when we have a fixed cost as it implies that the marginal disutility of income is the same for all respondents (Thiene and Scarpa, 2009). We tried a number of alternative model specifications which included having interactions with other socio-demographic variables to test whether these were significant predictors of the heterogeneity observed in the model. We found, however, that only the number of visits to the water bodies was significant and therefore, we include this as an interaction term to explain the heterogeneity in the random parameters.

Table 5. Random Parameters Logit model results

	Mean		***Standard Deviation***	
Variable	*Coefficient*	*Standard error*	*Parameter*	*Standard error*
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
Conditions of banks or shoreline: moderate erosion	0.408***	-0.1	0.797***	-0.152
Conditions of banks or shoreline: low erosion	0.493***	-0.106	0.241	-0.222
Heterogeneity in mean of random parameters				
Visits to water bodies*Health of ecosystems: moderate	0.002**	-0.001		
Visits to water bodies*Health of ecosystems: good	0.005***	-0.001		
Visits to water bodies*Water clarity and smell: moderate	0.002*	-0.001		
Visits to water bodies*Water clarity and smell: good	0.001	-0.001		
Visits to water bodies*Access to recreational activities: secondary	0.001	-0.001		
Visits to water bodies*Access to recreational activities: primary	0.002*	-0.001		
Visits to water bodies*Conditions of banks: moderate erosion	-0.001	-0.001		
Visits to water bodies*Conditions of banks: low erosion	0.002*	-0.001		
Non-random parameters in utility function				
Type of water body affected: sea	0.373**	-0.161		
Type of water body affected: lake	0.648***	-0.144		
Type of water body affected: river	0.818***	-0.145		
Price	-0.029***	-0.002		
Preference for income tax vehicle: status quo	-0.410**	-0.18		
Visits to seas*status quo	-0.009**	-0.003		
Visits to lakes*status quo	0.001	-0.002		
Visits to rivers*status quo	-0.001			
Log likelihood function			-2585.842	
McFadden Pseudo R-squared			0.18	

Notes: Figures in parenthesis indicate the values of the standard errors. *** indicates significant at 1%, ** indicates significant at 5%, * indicates significant at 10%.

As is evident from Table 5 both the mean and the standard deviation are significant for all random parameters bar low erosion of banks/shoreline where the standard deviation parameter is insignificant. For the attribute levels, examining the size of the standard deviations relative to the mean values, suggest that there is substantial heterogeneity

surrounding the attributes. The largest standard deviation is associated with secondary contact recreation. This implies that a proportion of respondents have strong preferences for this attribute level but that there may also be a proportion of respondents who wish to inhibit access to water bodies for secondary recreation. A possible explanation for this may be that some respondents believe that allowing fishing or boating activities may compromise the aesthetic or environmental quality of the water bodies. However, without additional information on this, it is difficult to provide a concrete explanation for this –albeit it seems to be consistent with findings from other studies (see Kataria et al., 2012). In terms of the non-random parameter coefficients, we find that the type of water body is significant and again with this model, the largest coefficient is associated with rivers and the lowest is for the sea. For our interactions we find that only the interaction between the number of trips and the health of ecosystems are significant at the five percent level or higher. The interaction between the number of trips and three other attribute levels are significant at the 10 percent level only. In this model also, 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 water bodies.

In Table 6 we present the marginal WTP estimates retrieved from both the CL and RPL models along with their 95% confidence intervals. In the case of the RPL model these marginal values have been estimated using the Krinsky and Robb procedure (1986)[2]. The estimates produced by the two models are similar albeit those associated with the RPL model are smaller in magnitude. The highest estimated WTP figure is for a good level of water clarity and smell followed by the moderate level of water quality and smell (€40.54 and €25.77 respectively). The relative ranking of the WTP estimates suggest that respondents have a higher preference for improvements in the water quality features denoted by the health of the ecosystems attribute, the water clarity and smell attribute and the conditions of banks or shoreline attribute compared to access to recreational activities attributes. This is likely to be indicative of the types of activities that respondents engage in with the water bodies. As Figure 1 illustrates most people visit recreational bodies for walking or jogging purposes and a much smaller proportion of people engage in actual on or in water-based activities. Therefore, having access to water bodies for water-based recreation may be less important for

[2]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.

the majority of respondents than having improved ecological quality of the water bodies. This finding is consistent with other studies. For instance, Stithou et al., (2012) found that respondents were willing to pay approximately €36 for good water clarity and appearance, €28 for good river life and approximately €23 for access for all recreational activities (walking, boating, swimming, fishing) for the Boyne Catchment in Ireland. Kataria et al., (2012) in their study of preferences for improvements to the Odense river in Denmark found that respondents were willing to pay equivalent to approximately €59 for a good quality of river compared to €20 for good access for recreational activities. They also found that improving angling potential at the river was associated with a negative value. While Hanley et al., (2006) did not examine recreation specifically they found that respondents were willing to pay approximately £18 to achieve good ecology, £16 for good aesthetics and £20 for good condition of river banks for the rivers Wear and Clyde in the United Kingdom.

Table 6. Attribute Marginal Willingness to Pay across Models (€ per Person per Year)[3]

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

[3] We have restricted our sample to those who did not always serially choose the status quo option in every choice card in our analysis. To check the sensitivity of our marginal WTP estimates to this decision we also estimated a CL model where we included the respondents who said that they could not afford to pay. We found that our marginal WTP estimates were not statistically different between the models with and without these respondents included.

Conditions of banks or shoreline: low erosion	22***	20***
	(17, 27)	(13, 27)

Estimates are rounded to nearest whole number. 95% confidence interval in parenthesis.

The results in Table 7 below present the estimates of the compensating surplus (CS) associated with a water body moving from the lowest ecosystem service levels of the attributes to the highest level of the attributes including the highest level of access for recreational activities. That is, the CS measure associated with the best standards of all the attributes. We also estimate the compensating surplus measure by the type of water body. This enables us to decipher if preferences for the ecosystem services varies depending on the type of water body considered. We develop the compensating variation measures for both the CL and RPL models. We also present the estimates for the 25th and 75th percentile for the RPL model.

Table 7: Attribute levels and compensating surplus value estimates for Policy Change Scenario (€ per person per year)

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		
Conditions of banks or shoreline	Low erosion and damage (extreme flooding event once every 20 years)		
Compensating Surplus (€/ person/year)	**River**	**Lake**	**Sea**
Conditional Logit	129***	122***	110***
Confidence Interval	(117, 140)	(110, 133)	(99, 121)
Random Parameter Logit (mean)	110***	105***	95***
Confidence Interval	(97, 124)	(92, 118)	(83, 108)

Estimates are rounded to nearest whole number. 95% confidence interval in parenthesis.

The results show that the estimated compensating surplus measures are higher for the CL model compared to the RPL model. However, the estimates are not significantly different between the models. The results indicate that on average respondents' value improvements to rivers more highly than they do to lakes and the sea. We also note that the magnitude of the CS estimates are somewhat lower for the sea compared to the other water bodies, however, they are not statistically different between the water bodies.

It may be the case that respondents 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[4] (albeit not statistically higher welfare estimates). When asked to describe the general environmental quality of water bodies in Ireland, 65.65% of respondents deemed seas to be "satisfactory" or "very satisfactory". Respondents were less generous in their descriptions of rivers and lakes with 57.33% and 56.74% of respondents giving them a "satisfactory" or "very satisfactory" ranking, respectively.

Conclusions

Ecosystems services play a vital role in preserving and promoting human and economic well-being. Aquatic ecosystem services are a key environmental resource and provide economic benefits including benefits arising from their use, such as drinking water, sanitary services and recreational use values that can be enjoyed by anyone. Furthermore, there are other services that are classified as non-use, which provides benefits to citizens. Given the importance of ecosystems to societal well-being, there has been a growing interest at the supra-national level in protecting and promoting these services. Also, valuing the benefits derived from these ecosystem services allows those managing water bodies (i.e. policy makers and related stakeholders) to make more informed decisions.

This study made several contributions to the literature on valuing the ecosystems services associated with water bodies. This was the first study to assess preferences for ecosystem services across alternative water body types in Ireland. This research built on a previously published study conducted by Stithou et al. (2012) who assessed benefits arising from implementation of the WFD at the Boyne River. However, this previous study was concerned with valuing benefits at one specific river rather than all water bodies. Furthermore, that study only asked individuals who are located close to the river catchment to participate in the valuation exercise. In the present paper, values were retrieved from a sample of Irish residents rather than to residents located near specific water catchments.

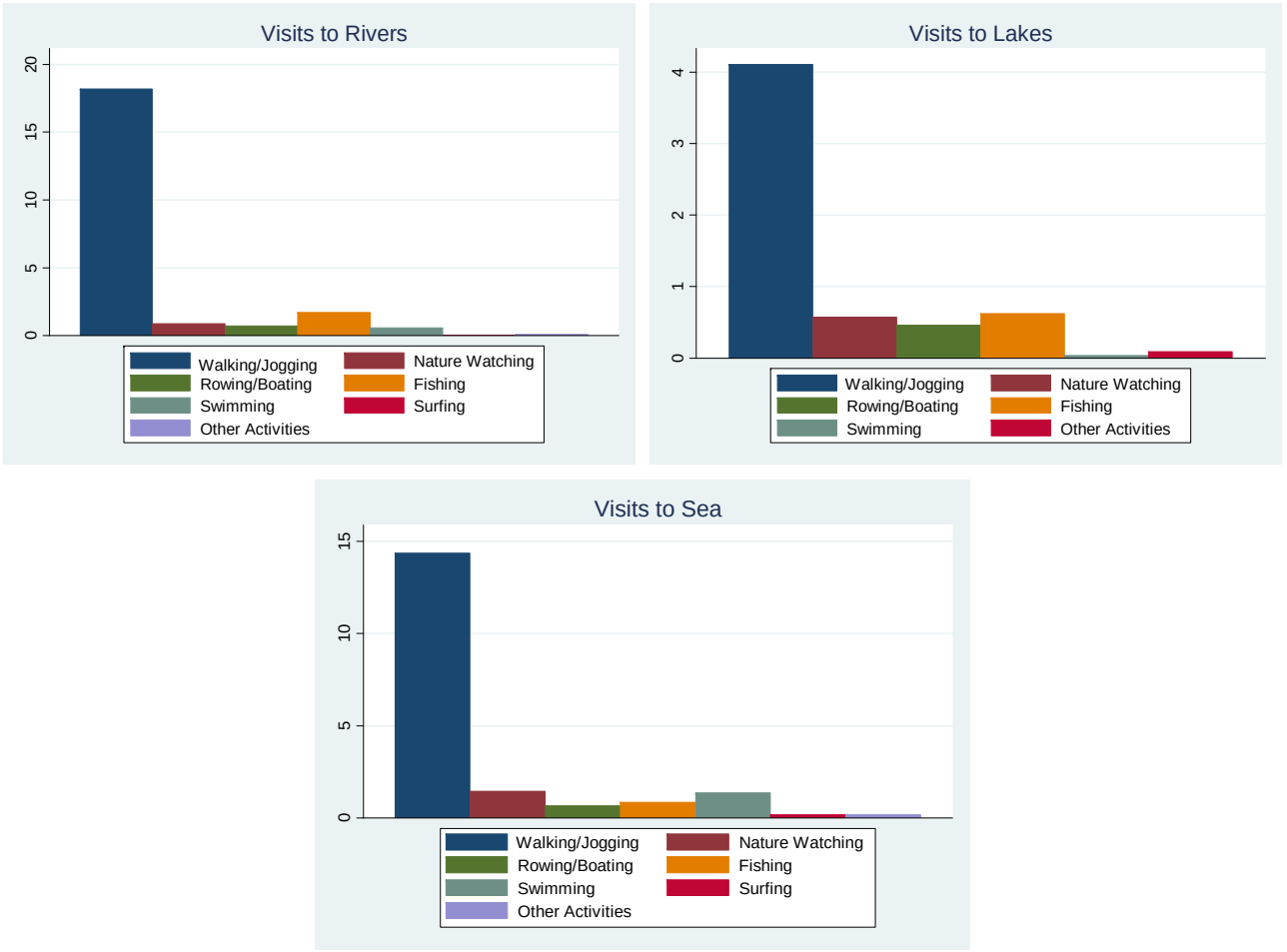
A key objective of this paper was to assess if and how preferences for the environmental improvements differed by type of water body. This is a useful question for policy-makers as it established whether priority should be given for improvements of certain types of water bodies over other types. Furthermore, 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 type of water body was particularly warranted to establish a ranking of benefits arising from ecosystem services from the publics' viewpoint. In this

[4] Although we acknowledge that the ecological quality of rivers and lakes will also feed into the quality of estuaries and seas.

paper, we found that welfare was most improved by improvements at river bodies followed by improvements at lakes and finally improvements at sea, however, these estimates were not statistically different from each other.

As a final note on the actual water attributes assessed, this study found that residents had the highest WTP for a good level of water quality and smell and the second highest WTP was associated with the moderate level of this attribute. The results suggested that the visual aspect of ecosystems was very important to Irish residents. The next most valued attribute was associated with the health of the ecosystem and only slightly lower welfare estimates were retrieved for the conditions of banks and shoreline attributes. The lowest valued attribute was associated with recreational access. As a result we can say that respondents showed a higher preference for actual quality improvements of the water bodies compared to improvements in their recreational potential. This finding likely reflects the fact that residents were most engaged with walking/jogging activities at water bodies rather than recreational activities that led to direct contact with the water. Furthermore, the results show that non-use values associated with environmental improvements retrieved higher welfare estimates than associated use values. This finding is consistent with studies conducted previously in Ireland and internationally (Stithou et al., 2012, Kataria et al., 2012). The results also provide insight to policy-makers that facilitate the targeting of resources towards improvements in the environmental quality of water bodies compared to their recreational potential. However, this needs to be balanced against the potential economic value that on-water recreationalists, across all water body types, have been shown to generate for local economies (Inland Fisheries Ireland, 2013). This study highlights that while access for primary and secondary recreation are valued by respondents, having access for visual recreation only such as walking or jogging, does provide substantial economic benefit to residents.

Figure 1. Average number of Visits for Recreational Activities to Water Bodies in Last 12 months



Acknowledgements
This study has been funded as part of the Science, Technology, Research and Innovation for the Environment (STRIVE) Programme 2007–2013. The programme is financed by the Irish Government under the National Development Plan 2007–2013. It 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 environmental research.

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