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The Contribution of Non-Use Values to Inform the Management of Groundwater Systems: The Rokua Esker, Northern Finland

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Abstract

Rokua in Northern Finland is a groundwater dependent ecosystem very sensitive to climate change and natural variability. As such, the water level of most of the lakes is a function of the level of the groundwater table of the esker which is naturally recharged. The management of an ecosystem like this is very challenging and complex because of the many associated use and non-use values. The scope of this study is to expose, apart from the use values, the non-market values attached to the ecosystems services of groundwater systems and reveal their importance. In particular, this chapter illustrates the contribution of stated preference methods to orient policy making and presents results from an application of a choice experiment and contingent valuation method regarding ground water quantity. General public's elicited values highlight the importance of water management policy which contributes to the sustainability of groundwater dependent ecosystems. Importantly results highlight the need to broaden the policy options beyond the consideration of market and use values of groundwater systems. Instead these systems should be considered as part of the broader ecosystems and broader services considered in decision making.

Keywords: Choice experiment, Contingent valuation, Climate change, Water quantity, Groundwater dependent ecosystems.

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1. Introduction

This chapter focuses on the estimation of use but importantly non-use values to inform the management of groundwater dependent ecosystems (GDEs) using as a case study the Rokua Esker in Northern Finland. GDEs are ecosystems of great importance because of the conservation, biodiversity, ecological, social and economic values they provide. Their basic characteristic is that they require access to groundwater to maintain their healthy condition. Following Evans and Clifton (2001) GDEs include: (i) terrestrial ecosystems that rely seasonally or episodically on groundwater; (ii) river base-flow systems, including aquatic, hyporheic, and riparian ecosystems that depend on groundwater input, especially during dry periods; (iii) aquifer and cave ecosystems, often containing diverse and unique fauna; (iv) wetlands dependent on groundwater influx for all or part of the time; and, (v) estuarine and near shore marine ecosystems that rely on groundwater discharge.

As a result, a loss of groundwater resources is a major threat as ecosystems' functions and composition are reliant on the appropriate supply of groundwater. Consequently these ecosystems are very sensitive to climate change and natural variability. Across Europe, aquifers resources are dramatically changing with groundwater resources to face increasing quantitative pressure mainly from land use issues and consumption pressures (Klove et al., 2011). Also, all regions of the world show an overall net negative impact of climate change, freshwater resources and ecosystems and it is expected that many areas are likely to face a reduction in the value of the services provided by water resources (IPCC, 2007). Adaptation of measures and application of appropriate management practices have an important role in determining the impact of these pressures on water resources and on ecosystems.

As a response policy makers in Europe have developed the Water Framework Directive (Directive 2000/60/EC - WFD) which is probably the most ambitious piece of environmental legislation in the EU. While imposing environmental objectives to be achieved, the WFD also calls for the use of a set of instruments and procedures for analyzing the socio-economic and environmental impacts of water uses and at the same time provides guidance for the selection of measures for achieving these objectives. The WFD requires that Member States take the necessary measures for the protection of water bodies, promoting a sustainable water use based on a long-term protection of available water resources. The most cost-effective programme of measures should be selected in order to meet the WFD environmental objectives in all water bodies.

For groundwater bodies, along with WFD, GWD requires the achievement of a ‘good groundwater status’ which is achieved when both its quantitative and chemical status are good. As emphasised in the new Groundwater Directive (GWD) (2006/118/EC), groundwater is characterised as particularly important for dependent ecosystems and for its use in water supply for human consumption. The value of GDEs such as wetlands or terrestrial ecosystems has been long recognized (Hynes, 1983). Therefore, according to the GWD when establishing threshold values for groundwater pollutants, Member States need to consider the extent of interactions between groundwater and associated aquatic and dependent terrestrial ecosystems. However, although, the WFD includes provisions to protect groundwater from pollution, and to ensure that groundwater abstraction does not threaten dependent terrestrial or wetland ecosystems, it is important that more emphasis is put on the fact that an aquifer has to be viewed as an ecosystem related to the surrounding environment (Danielopol et al., 2004). This is required in order to achieve an integrated and sustainable groundwater management that addresses the protection of ecologically valuable areas.

Economic valuation contributes to improved water management decisions by informing decisions makers about the full social cost of water use and full benefits of the goods and services that water provides. Many of the ecosystems functions that water resources sustain, among others recreation and aesthetic benefits, biodiversity benefits, research benefits, existence benefits, do not have a market price and as such are not recognized as having an economic value by the decision makers (Bateman et al., 2003; Perman et al., 2003). Achieving a good water status requires necessarily the application of non-market economic valuation techniques, such as stated preference methods.

Stated preference methods, based on social survey techniques to elicit public preferences, have been used since the 1970s by environmental economists to value the non-market benefits of environmental changes. Of these, Choice experiments (CE) are becoming a popular means of environmental valuation; where respondents are required to trade-off changes in the levels of different attributes that describe the good against the cost of these changes. Contingent Valuation (CV) method is another stated preference technique in which a hypothetical market is being created and respondents are asked directly to express their willingness to pay (WTP) for existing or potential environmental conditions not registered on any market (Mitchell & Carson, 1989).

In this study both techniques are employed to explore how people value groundwater quantity in an environment very sensitive to climate change and natural variability. The purpose of the CE is to investigate the local public’s preferences for alternative management scenarios, defined by their impacts on water quantity on the environment, recreation and total land income and by improved scientific information on climate change. Complementary a CV method was employed to investigate individuals' behavior in a setting of uncertainty with respect to the damage level in the absence of a revised water management.

The rest of the paper unfolds as follows. Section 2 offers on overview of the case study area, while Section 3 presents the survey design. Section 4 describes the models that were employed for the estimation, while Section 5 in its first subsection presents the results from the CE application and then results from the CV. Finally, Section 6 discusses and concludes the role of valuation results in policy design.

2. The Case Study Area

The case study is Rokua esker located in Northern Finland. It is a part of a chain of esker ridges with small "kettle" lakes situated within the esker area. Rokua is a dependent groundwater ecosystem. As such, the water level of most of the lakes' in Rokua is a function of the level of the groundwater table of the esker, the latter is naturally recharged. However, during the last few decades, it has been observed a significant reduction in the water level of many small lakes. Scientists monitored groundwater quantity and observed that groundwater level tended to decline even in a period where precipitation-evaporation ratio was increasing. For this decline in water quantity in groundwater and lakes many reasons have been discussed such as climate change or the land use and drainage. Forest drainage of the surrounding peat lands appears to disturb groundwater dynamics and thereby water level of lakes. However there is yet a degree of uncertainty as scientific knowledge is lacking on this complex ecosystem. The impacts of drainage and also the natural variability or impact of climate change on groundwater dynamics are not very clear yet. Even though more research is needed in order to better understand the extent and the nature of the problem, scientific observations give sufficient evidence that a policy to mitigate a possible future environmental deterioration is needed. Water resources in Rokua provide a diverse array of goods and services which can be translated to direct or indirect values, as presented in Table 1, for local society and visitors.

Table 1. *Total Economic Value Components of Water Resources in Rokua*[a]

Direct Use Values	Forestry Energy resources (peatland) Recreation Forestry

	Irrigation for agriculture / Domestic water supply (to a lesser extent)
Indirect Use Values	Nutrient retention Pollution abatement External eco-system support Micro-climatic stabilisation Reduced global warming Soil erosion control
Option Values	Potential future uses of direct and indirect uses Future value of information on climate change
Non-use Values (bequest, existence and altruistic values)	Biodiversity Cultural heritage

[a]Adopted and modified from Barbier et al. (1997)

3. Survey Design

The main goal of the questionnaire, as in stated preferences techniques, is to try to elicit information about environmental preferences from individuals through the construction of hypothetical but realistic scenarios of water management practices that involve an improvement in environmental aspects of water quantity. The complete questionnaire covered a number of topics and was divided into 5 sections, see Table 2 below. An accurate and clear description of attributes and their associate levels with the policy under consideration as well as an introduction to the study area were provided in the beginning of the questionnaire. To obtain more information on individuals' attributes, the questionnaire contained debriefing questions, questions that revealed environmental consciousness of the respondents and socio-economics questions (age, gender, income categories, occupation and educational attainment).

Table 2. *Questionnaire structure*

Section A	Presenting the problem	Site description Scientific facts Good to be valued Attributes to be valued Scenarios
Section B	Choice experiment questions	8 sets of choice cards
Section C	Debriefing Questions	Questions to explain why respondents were or were not WTP
Section D	Environmental Behaviour Questions	Questions that reveal environmental consciousness
Section E	Contingent Valuation Question	Question to examine risk behaviour
Section F	Socio-economics questions	Among others age, education, job and income

The development of the survey instrument took place over a period of a year and involved initially focus groups discussions, face to face interviews with local stakeholders and extensive discussions with experts. Discussions with local stakeholders revealed people's understanding of the issues related to the management of water resources and services in Rokua. Stakeholders (forestry, peat land industry, 2nd house owners, local residents and service providers) were asked general questions, whether they are familiar with environmental conditions of water resources in Rokua and the issues related to it, i.e. land use issues and climate change and finally whether and how they value environmental goods or services that Rokua esker provides. After discussions with experts the valuation problem was refined. In particular the exact attributes to be valued as well as the increase in their levels after the implementation of a policy option as well as the corresponding levels in case of deterioration were defined. The survey was administered with face-to-face interviews from April to August 2011. A random sample of 170 respondents was collected from Oulu and around the municipalities of Utajärvi and Vaala where Rokua area is situated. The sample consisted from either local inhabitants of the area or recreational users of Rokua.

3.1 Choice Experiment Design

The good to be valued in Rokua choice experiment is the revision of the water management in a way to meet the objectives of water framework and groundwater directives which is the main European legislation in place to protect groundwater. A detailed description of choice experiment design can be found in Koundouri et al. (2012). Policy under consideration includes restriction of peat land drainage in the groundwater area, expansion of the conservation area and compensation when legally required. Implementation of the above would enable management of Rokua to comply with environmental, water and biodiversity legislation. The key requirements of the WFD in relation to groundwater dependent ecosystems are to achieve and maintain "*good status*" of these water bodies by 2015 and meet the overall environmental objectives for groundwater according to Article 4 (b). Designations and actions ought to be implemented in order to maintain good water quantity in lakes, spring and aquifer and to sustain as many ecological and landscape functions as possible.

In this direction, proposed policy options will contribute to restore lakes' water level and to avoid future possible deterioration. At the same time environmental improvements would also lead to an increase in recreational values. Income opportunities of local people could also get affected. For example, environmental degradation that could occur in the absence of a holistic management could result to a decline in the popularity and the number of visitors to Rokua area and as a result income from such activities would decline.

Policy under consideration is characterized by 5 different management attributes which are presented in Table 3. At this point it should be also noted that during testing the questionnaire as well as during the face-to-face interviews no indication that respondents experienced interrelationships between the attributes was revealed.

Table 3. *Water management attributes and levels used in the CE*

Attribute	Definition	Management Level
Water Quantity	This attribute refers to the total quantity of water available in groundwater aquifer, lakes and spring.	**Increased**: most of the lakes have restored their water level **Same as now**: some lakes have water quantity problems. Current state of water is sustained. **Limited**: water quantity has been considerably declined. The last alternative reflects what is expected to happen in the absence of revised management in the future *(Status quo level).*
Recreation	This attribute refers to the sum of all values (direct and indirect) derived from recreational activities.	**Increased:** environmental improvements result in an increase in recreational values. **Same as now:** current levels of recreational values are sustained. **Low**: This is the case where no measures are taken. As a result of environmental degradation in the absence of the revised management, recreational values are going to decline *(Status quo level).*
Total Land Income	This attribute refers to the **total** income opportunities for the local people emerging from economic activities of **logging, peat harvesting** and **tourism** industry based in Rokua area.	**Same as now:** Total income will remain unchanged. **Restricted**: Total income opportunities will get restricted *(Status quo level).*
Investment on Research	This attribute refers to the scientific research to better understand long-term environmental changes in Rokua.	**High**: More Resources **Medium**: Current Resources *(Status quo level).* **Low**: Stop current research
Price	One-off payment	0€,10€, 20€, 50€, 100€

Source: Koundouri et al. (2012)

Experimental design techniques were employed in SPSS to obtain an orthogonal design (Louviere et al., 2000; Hensher et al., 2005) consisted of main effects in 32 pair-wise comparisons of alternative wetland management scenarios randomly blocked to 4 different versions, each with 8 choice sets. Each set contained two different wetland management scenarios and an option to select neither scenario considered as the *status quo* baseline alternative. The two wetland management scenarios are characterized by a change in attributes with respect to the *status quo* alternative.

3.2 Contingent Valuation

Complementary to the choice experiment a CV question following a split-sample approach was employed to investigate individuals' behavior in a setting of uncertainty with respect to the damage level in the absence of the revised water management. Most of the studies in the water resources valuation literature employing a CV method aim to determine the WTP for water services considering single changes i.e., from a lower to a medium or higher level water quality. Thus there is a fundamental assumption behind the survey design that all different scenarios presented can be achieved with certainty so respondents can reveal their underlying preferences upon certain outcomes (Roberts et al., 2008). Yet there are only few studies that have incorporated issues of uncertainty regarding the exact nature of damage under the *status quo* as well as the timing and the extent outcomes of the proposed environmental policies.

Johansson (1988) in a CV study in Sweden presented some preliminary results on the consistency of WTP measure for public goods in an uncertain world. Respondents were asked about their willingness to pay for four different programs that each would save all or some of the species. The result of one of the program was uncertain, i.e. respondents were informed that there was a 50% chance for the program to save all species and 50% to save every second species. The remaining programs would save 50%, 75% and 100% of the species respectively. Macmillan et al. (1996) employed a CV method to estimate WTP of the Scottish population for uncertain recovery and damage scenarios from reduced acid rain deposition in the semi-natural uplands of Scotland. In order to incorporate uncertainty with respect to the damage level in the absence of further reductions in emissions recovery, a split-sample survey format has been used that presented six alternative ecosystem recovery levels and damage levels scenarios.

Similarly in Rokua case study, uncertainty was introduced through the use of subjective probabilities. That is in the absence of any better information equal probabilities to the mutually exclusive outcomes of water states1 (State A: High, State B: Good, State C:

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[1] For the presentation of water states the visual presentation of water provided by WFD has been used:

Moderate, State D: Poor, State E: Bad) have been assigned. Following work of Macmillan et al. (1996), in the first sub-sample respondents were informed that in the absence of a revision of water management there is 50% chance that water quantity will remain at current levels, that is State (C), and 50% chance for level to go to State (E), implying an expected future damage State (D). In the other sub-sample respondents were informed that water quantity will be with certainty at State (D). In both cases the revision of water management would result in a certain level of improvement. WTP bids (as a one-off payment) were elicited through a Payment Card Contingent Valuation (PCCV) mechanism. This method was first developed by Mitchell and Carson (1981 and 1984) as an alternative to the bidding game. As the authors (Mitchell and Carson, 1989) noted, this approach does not require large samples compared to referendum approach. However, although this method avoids the anchoring effects of dichotomous choice since respondents select their own WTP amount (Ariely et al., 2003) it is regarded that the chosen range of amounts can influence respondent's answers[2]. Respondents were asked to state the amount that best described their maximum WTP in 6 points range of offered bids from 0 to > €100[3]. The maximum amount of €100 was derived from focus group interviews. An opportunity was also provided to state a higher WTP.

The aim of this set up is to test whether or not utility will differ between a management option according to which the expected future damage under *status quo* will be moderate but uncertain and a programme where future damage under *status quo* will be moderate but certain. Macmillan et al. (1996) has concluded that when individuals are faced with future environmental damage they appear to be risk-averse. As a result, the CV question is employed in order to investigate respondents' risk behaviour and hence to observe how and if the valuation result changes when respondents are aware of the uncertainty regarding environmental losses with respect to the *status quo* level.

4. <u>Model Specifications</u>

The models for both CE and CV we present in this study are the final equations selected following a specification search that tested all relevant explanatory variables in the data, and their natural logarithms, for significance, and kept only those that were found to be statistically significant at the 10% level.

HIGH	GOOD	MODERATE	POOR	BAD

[2] Carson and Groves (2007) offers a discussion on these issues.

[3] Offered bids were: €0, €2, €5, €10, €20, €50, €100, >€100

To contribute to an assessment of the validity of PCCV responses, we first examined descriptive cross-tabulations of sample WTP against variables in the dataset. We then conducted our econometric analysis beginning with a combination of explanatory variables, by picking the seemingly most important variables, and estimated two models using Ordinary Least Squares (OLS) regressions. The first regression was run with WTP as the dependent variable; the second with *ln_ WTP* as the dependent variable, where *ln_ WTP* is the natural *log* of (*1+ WTP*). Findings from this analysis showed that the model with the 'log-linear' specification (*ln_ WTP*) as the dependent variable fit the data substantially better than the model with WTP as the dependent variable. Subsequent analysis therefore focussed on models with *ln_ WTP* as the dependent variable. Furthermore, models were corrected for heteroskedasticity using the robust covariance estimator.

Based on the OLS regression, the WTP function for groundwater quantity is:

$$Ln\,(1+WTP) = \beta_0 + \beta_1{*}Gender + \beta_2{*}Income + \beta_3{*}Degree + \beta_4{*}Group + \beta_5{*}Visit \qquad (1)$$

Then, according to the average selected sample and using *Equation 1* the WTP is calculated.

Regarding the model specification for the analysis of CE data, Hausman and McFadden (1984) test led to the rejection of the IIA property, and therefore to the use of another model which relaxes the IIA assumption. As reported in Koundouri et al. (2012), where an overview of CE methodology can be found, the error components logit model (ECM) provided a better insight on preference heterogeneity and therefore was preferred. According to this model's specification the random part of utility[4] is decomposed to an individual unobserved effect and other variables that influence choice ($\varepsilon_{ij} = \alpha_i + k_{ij}$) and the possibility for error components in the combined Change nest and the No Change nest is examined. Because the probability function does not have a closed form solution, the model is estimated using simulated maximum likelihood methods (Train 2003).

[4] The utility of a choice is comprised of a deterministic component (V) and an error component (ε) which is independent of the deterministic part and follows a predetermined distribution: $U_{ij} = V(z_{ij}, s_i) + \varepsilon(z_{ij}, s_i)$, where, for any individual *i*, a given level of utility will be associated with any alternative *j*. The researcher observes some attributes of the alternatives as faced by the individual, labelled $z_{ij}\ \forall j$, and some attributes of the individual, labelled s_i, and can then specify a function that relates these observed factors to the individual's utility.

As the CE method is consistent with utility maximization and demand theory (Hanemann, 1984) the marginal value of change in water management program attribute can be calculated as:

$$MWTP = -\frac{\beta_{attribute}}{\beta_{cost}}$$

(2)

This part-worth (or implicit price) formula represents the marginal rate of substitution between one-off payment and the water management program attribute in question.

Before presenting model results, Table 4 describes the socio-economic and attitudinal characteristics of the final usable sample for each method.

Table 4. *Profile of respondents*

Variable	Definition	CE Sample	CV Group 1	CV Group 2
Age	Average age of a person (in years)	41.58[a]	41.36	41.46
Gender	Dummy variable equals 1 if female, 0 if male	40	48	34
Children	Dummy variable equals 1 if respondent has children, 0 otherwise (%)	43 [a]	42	44
Degree	Dummy variable equals 1 if respondent has education with university degree and above, 0 otherwise (%)	35	38	30
Visited Rokua	Dummy variable equals 1 if individual has visited Rokua in the past, 0 otherwise (%)	78[b]	80	76
Income	Average annual gross household income (seven income bands from less than €10.000 to above €70.000)	3.74[c]	3.76	3.61
Group	Dummy variable equals 1 if respondent belongs to Group 1 , 0 otherwise	54 [a]	-	-
	Sample size, N	166	91	79

[a] N=165, [b] N=164, [c]N=153

5. Model Results

5.1 Error component model- CE results

The error component models were estimated by simulated maximum likelihood using Halton draws with 500 replications (Train 2003). All the choice attributes were statistically significant. The models were estimated with NLOGIT 4.0 (Greene 2002) and the full data set of 1328 observations from 166 respondents. Initially, a full set of socio-economic variables was entering the utility function either through interactions with the ASC or as interaction terms with the choice attributes. Variables such as respondents' household size, gender or association with the farming or forestry community were not significant and are not included in the final model specifications. The first model reported in Table 5 includes only the choice attributes as explanatory variables in the utility function. All the estimated coefficients have the expected signs. Cost of new management is negative and significant, whereas an increase in seagrass area, riverside vegetation and rare species are positive and significant at the five per cent level. The ASC parameter is negative and significant, indicating that respondents generally prefer the 'new-management' options over the no-management scenario, *ceteris paribus*. The latent error term captures unobserved error correlations between the two new alternatives that deviate from the *status quo* option. The error component is significantly different from 0, indicating heterogeneity across the utilities that respondents derive from the new alternatives. It should be noted that results of this model are also reported in Koundouri et al., (2012).

Table 5. *ECM results*

	Attribute-only model[a]		**Model 1 with interactions**[a]		**Model 2 with interactions**	
	est.	*t*-ratio	est.	*t*-ratio	est.	*t*-ratio
Water Quantity	0.435***	4.699	0.400***	4.052	0.236**	2.017
Recreation	0.209 ***	2.761	0.171**	2.110	0.091	0.867
Research	0.551***	7.096	0.583***	7.182	0.383***	3.391
Total Land Income	0.158**	2.072	0.174**	2.183	0.236**	2.521
Cost	-0.016***	-9.846	-0.017***	-9.939	-	-9.991
SQ	-5.899***	-3.979	-8.778**	-2.385	-5.126**	-2.068
Age*SQ			0.070	1.205		
Gender*SQ			-4.437**	-2.517	-	-3.010
Children*SQ			-4.359**	-2.084		
Visit*SQ			4.958**	2.158		
Income*SQ			0.342	0.655	0.410	0.780
Degree*SQ			-3.835**	-2.083		
Degree*Water Quantity					0.465***	2.897

Degree*Recreation					0.278*	1.729
Degree*Research					0.504***	3.160
Degree*Total Land Income					-0.174	-1.150
St. Dev. of latent random effects						
No Change	3.388	0.994	0.877	0.234	0.753	0.220
Change	7.802***	3.275	7.214***	5.031	7.552***	5.234
LL	-964.8493		-865.2540		-874.6694	
χ^2	988.2157		923.7392		940.0641	
Pseudo-R^2	0.34		0.35		0.35	
BIC	1.49641		1.51479		1.51052	
Observations	1328		1208		1224	
# of respondents	166		151		153	

[a] Reported also in Koundouri et al. (2012)
(*) indicates significant at 10%; (**) indicates significant at 5%; (***) indicates significant at 1%

The attribute-only model does not provide information about the sources of individual heterogeneity. In the second error component model reported in Table 5, socioeconomic variables were interacted with the ASC and the choice attributes. In addition, attributes were interacted with respondents' characteristics and out of a range of model specifications tested, the model that provided the best fit to our data set included gender, income, and interaction effects between education of respondents and the choice attributes in the utility function. Comparing the log-likelihoods and the pseudo- R^2 goodness-of-fit measures between models, the models with interactions that account for sources of preference heterogeneity provide a much better model fit than the attribute-only model.

Overall the models are statistically significant and all attributes are significant determinants of choice, apart from recreation in Model 2 with interactions. The cost price is negative, indicating that an alternative is less likely to be chosen if the cost is higher, while other attributes' coefficients conform to theoretical expectation of increasing marginal utility. For both types of models attribute-only and with interactions, respondents prefer water management practices which ensure higher water quantity, recreation, research potential and positive effect on total land income. The models also demonstrate a negative and significant coefficient for the *status quo* indicating that *ceteris paribus*, the *status quo* alternative is less desirable than the other options maintained also in both types of specifications.

Regarding models with interactions capturing individual observed heterogeneity, it is observed that in Model 1 respondents who are older and have visited Rokua in the past are more likely to choose the *status quo* than Option A or B, showing that familiarity with the site does not necessarily encourage Change. An opposite effect is observed for female respondents, with children and a higher than secondary education. It is also noted that income has no effect on choice which could be explained by the reluctance of participants to reveal their real income. Model 2 captures conditional heterogeneity by including in the utility function interactions of respondent's educational level with choice specific attributes and interactions of income and gender with ASC. Results show that respondents with higher levels of education are likely to prefer management scenarios that assure and improve water quantity, research and recreation attributes. Furthermore, similarly to Model 1 with interactions female respondents are less likely to opt for the *status quo* scenario. Finally, the error component for the combined alternatives A and B is statistically significant, for all models, revealing alternative specific variance heterogeneity (heteroscedasticity) in the unobserved effects of these alternatives.

Using the Krinsky and Robb (1986) procedure with 1000 draws in LIMDEP 9.0 NLOGIT 4.0., respondents' valuation of water management program attributes (following *Equation 2*) and 95% confidence intervals were calculated for the attribute-only and with interactions ECM models and are reported in Table 6.

Table 6. *Implicit prices (per household, one-off payment) for water management attributes from NMNL and ECM and 95% confidence intervals*

Attributes	**Attribute-only model**	**Model 1 with interactions**	**Model 2 with interactions**
Water Quantity	25.75	22.54	13.02
	(15.93, 35.73)	(13.44, 32.18)	(0.83, 25.05)
Recreation	12.46	9.71	0.00[a]
	(3.63, 22.15)	(0.57, 18.88)	
Research	33.05	33.50	21.41
	(24.22, 43.02)	(24.12, 43.34)	(9.36, 34.89)
Total Land Income	9.33	9.76	12.82
	(0.67, 17.51)	(1.50, 17.78)	(3.46, 22.73)

[a] WTP estimate was not found to be significantly different to zero and is expressed as zero.

The estimated WTP values for all models indicate that overall an average household values positively the improvements. Specifically in terms of research it is willing to pay from €21 to €33 to ensure that the scientific research to better understand long-term environmental changes will not stop. Another important attribute for the households is improved water quantity that varies from €13 to €26, while increased potential for recreation and total land income range from €9 to €13. Therefore, implicit prices clearly demonstrate the importance of water quantity for the respondents by supporting water management that will not allow the decline of total quantity of water available in groundwater aquifer, lakes and spring.

5.2 Log-linear model- CV results

Table 7 presents our main model estimation results for PCCV elicitation method estimated by OLS with *ln (1+WTP)* as the dependent variable[5]. To ensure the variance of coefficient estimates are consistently estimated, we use for all models the White Standard Errors employed in the LIMDEP heteroscedasticity command[6].

Table 7. *Estimation Results for PCCV*

	Log-linear pooled		**Log-linear group 1**		**Log-linear group 2**	
	est.	*t*-ratio	est.	*t*-ratio	est.	*t*-ratio
Gender	0.966***	3.893	1.131***	2.927	0.824**	2.263
Income	0.001***	6.979	0.001***	6.867	0.002**	2.073
Degree	0.749***	3.099	0.578	1.615	0.875**	2.309
Group	-0.174	-0.675				
Visit	0.0001	0.379	0.0001	0.145	-0.071	-0.169
Constant	2.387***	10.475	2.185***	7.128	2.460***	5.235
F statistic	10.03		8.54		4.03	
R^2	23%		28%		18%	
Observations	170		91		79	

(*) indicates significant at 10%; (**) indicates significant at 5%; (***) indicates significant at 1%.

Although, the R^2 for the PCCV models are modest, significant relationships among variables such as gender, income and education have been revealed. The coefficients are almost uniformly in line with expectation, with WTP varying with income while use of the water environment was positive (log-linear Pooled and Group 1) but not significant. Turning to other effects for which we held no clear prior prediction, we find that well educated respondents and female respondents all gave higher values on average, and were more likely to accept the scenarios, than those with lower educational attainment and male respondents. However, the dummy variable for group although negative is not statistically significant and therefore doesn't pick up any differences between the groups. Based on the average sample and using *Equation 1*, the WTP from Pooled data, Group 1 and Group 2 are reported in the third column of the Table 8. Findings show that respondents who faced uncertainty (Group 1) stated a smaller WTP compared to respondents of the second group who were willing to pay marginally more. Therefore, results of Table 8 are not conclusive regarding the effect of uncertainty on stated values. In the literature risk behaviour has been observed in the context

[5]Some respondents chose the option >100 among the payment options. This involves 5 respondents from Group 1 and 5 respondents from Group 2. These are included using the maximum bid as upper bound bid.

[6]Although, the classic correction for heteroscedasticity is the HC0 estimator proposed by Huber (1967) and White (1980), MacKinnon and White (1985) discussed three improvements, HC1, HC2, and HC3 from which the latest is the best as suggested by Long and Ervin (2000), especially in small samples.

of uncertainty in financial losses. Kahneman and Tversky (1979) presented a body of empirical evidence that individuals are risk-seekers when financial losses are in prospect. Yet this result opposes Macmillan's et al. (1996) findings that individuals are risk-averse when faced with uncertain future environmental damage. It is regarded that further research could shed more light on this respect.

Table 8. *Mean WTP per household (one-off payment) for good status of water quantity and quality in 5 to 10 years from now*

	PCCV max WTP[a]	PCCV regression model
Pooled	41.55 (39.51)[b]	20.71
Group 1	40.42 (39.48)	15.20
Group 2	42.85 (39.76)	19.90

[a] All zero bidders are included [b]Std.Dev.in parentheses

Overall, Tables 6 and 8 demonstrate the importance of water quantity for the respondents which is a prerequisite condition for healthy GDEs.

6. Policy Implications and Conclusions

The notion of the total economic value of groundwater-related ecosystem is very important for a holistic economic assessment that considers also that the functions performed by GDEs are an important component of the overall environmental services provided by a groundwater system. Therefore, decision-making needs to be informed by economic analysis that entails a relative assessment of the: (i) cost of protection in terms of the loss of alternative uses of groundwater and land, and the administration of the land-use and groundwater control policy and (ii) benefits of protection in terms of *in-situ* value of groundwater and groundwater-related ecosystem services (Foster et al., 2006). In addition, findings of the current study confirm the significance of such benefits.

Overall, results show that respondents generally favour changes in water management and they prefer to deviate from the described *status quo* option by choosing a management scenario rather a no-management scenario. Both CE models, attribute-only and with interactions, revealed that individuals prefer water management practices which ensure not only higher water quantity but also recreation, research potential as well as positive effects on total land income. Scientific research that reduces environmental uncertainty should be encouraged and promoted, since results indicate that an average household is willing to pay from €21 to €33 in order to ensure that the scientific research to better understand long-term environmental changes in Rokua will not stop. Another important attribute for the households is improved water quantity that varies from €13 to €26 (average value of €20).

CV models revealed also the importance of water quantity and quality for the respondents revealing an average value of €19 per household (one-off payment). It is interesting that female respondents and those with higher education are most likely to accept changes on the management revealing the higher environmental consciousness of those groups. On the other hand, results indicated that familiarity with the case study has an opposite effect as elder people who have already visited Rokua are the most likely to choose the *status quo* option. In addition, when applied the CV method respondents were presented with uncertainty regarding the losses conditional on a certain level of improvement. In the first subgroup respondents made a decision in a context of uncertainty that damage will occur while in the second in a context of certain damage. So the CV question was employed in order to investigate respondents' risk behaviour and hence to observe if the valuation result changes when respondents are aware of the uncertainty regarding environmental losses. Both groups showed a moderate WTP for the services, with only a slightly lower WTP for the group confronted with only uncertain damage. However, interpretation of the above result does not provide a strong evidence of respondents' risk value under different degrees of uncertainty.

At this point it should be noted that while the economic benefits related for example to water supply may be easier to realize, non-use values of groundwater are often neglected. There are few studies that have estimated non-use values related to quality (Hasler et al., 2005; Press and Söderqvist, 1998; Rozan et al., 1997; Jensen et al., 1995) or quantity (Koundouri et al., 2012) of groundwater. Rozan et al., (1997) estimated a €52 per household/year in 1995 of non-user households to protect the Alsatian aquifer (France). This value was considered as a proxy of its existence value and was used to assess the economic non-use value of the aquifer. Similarly, Press and Söderqvist (1998) employed CV method to estimate the benefits of groundwater protection in the Milan area (Italy) in order to also consider non-use values directly. The authors elicited a value of ITL 640 000 per household/year. Jensen et al. (1995) by using CV method estimated the WTP for groundwater protection from pollution at DKK 1000 household/year elicited by an open-ended payment format, and at DKK 2100 using the close-ended format. Furthermore, Hasler et al. (2005) employed a national CE study in order to assess the non-marketed benefits associated with increased protection of the groundwater resource revealed an estimated WTP of DKK 1,899 household/year for protected and naturally clean groundwater, not in the need for purification, a WTP for good conditions for flora and fauna in waterways and lakes of DKK 1,204 household/year, and a WTP for purified water of DKK 912 household/year (all in 2005 prices). The authors also used a CV study to estimate the value of both naturally clean groundwater and very good conditions for plant and animal life (DKK 711 per household/year) and purified water (DKK 529 per household/year). It is noted that comparing values of the above studies with the current one, after accounting for differences across countries and years, show that the latter (CV and CE) has elicited values of lower magnitude with regard to water quantity.

Apart from stated preference methods *in situ* values have been assessed by using the distance function methodology. Koundouri and Xepapadeas (2004) estimated the individual farmer's valuation of the marginal unit of groundwater in Kiti aquifer in Cyprus at £0.009 m^3 (in 1999 Cyprus pounds). Furthermore, the socially optimal shadow price of *in situ* groundwater (in Cyprus pounds) for the Kiti aquifer in Cyprus in 1999 was determined to be £0.2017 per m^3 of water, using an optimization model simulated under conditions of optimal groundwater extraction (Koundouri and Christou, 2000).

Furthermore, Koundouri (2000) reports the established *in situ* per cubic meter groundwater's total economic value. This total economic value is equal to the relevant backstop technology for water, which is for example the per cubic cost of desalination (at €0.05). Divergence between this value and the estimated above shadow price of *in situ* groundwater points to the significant non-use values of groundwater, such as option value and ecosystem resilience value, as well as alternative use values of economic sectors other than agriculture.

From a policy perspective the findings of the current study provide an insight into the return value of the various services that groundwater dependent ecosystems can provide. This result aims to inform policy making of how individuals value non-use and existence values of these ecosystems. Hence, it is regarded that results emphasise the need to broaden the policy options (e.g., related to the WFD implementation or future land use and ecosystem protection policies) beyond the consideration of only market and use values of groundwater systems and they contribute to justify decisions (*ex-ante* and *ex-post*) taken by government agencies (Bonnieux & Rainelli, 1999; Pearce & Ozdemiroglu, 2002).

As Boulton (2005) observes, mismanagement of the resource takes place and that happens for different reasons such as the difficulties of assessing groundwater volumes, recharge rates and sources, and groundwater quality, the relatively slow recognition of the linkages between groundwater and many surface water ecosystems and the lack of public visibility of groundwater's lag-time between changes in groundwater regime or quality and the response by surface GDEs.

Therefore, acknowledging and establishing vertical linkages between water bodies and exploring the relation between groundwater recharge and discharge is one of the most important aspects of the protection of ecologically valuable areas, especially when facing climate's change uncertainty. Finally, given the likelihood of significant uncertainty over the impact on GDEs decision-making strategy will normally have to embrace one or other of the following (Foster et al., 2006): (i) the precautionary principle of not authorizing any development until ecosystem risks are established and managed (ii) pragmatic initial development of groundwater resources with careful monitoring, evaluation and adaptation of development plans in the event of significant impacts and (iii) reserving specific environmental flows within the overall groundwater resource management strategy and planning to sustain key wetlands.

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