Using the Choice Experiment Method to Inform River Management in Poland: Flood Risk Reduction vs. Habitat Conservation in the Upper Silesia Region

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Introduction

The Upper Silesia Region of Poland is susceptible to flooding as a result of centuries long mining activities in this area, which have significantly changed its landscape. The social, economic and environmental costs of imminent flooding in this Region are expected to be very high. The economic costs of the floods of 1997 and 2001, for example, are estimated to be in the region of one billion USD (Brakenridge et al., 1997; 2001). As a result of global climate change, the frequency and extent of floods and their corresponding economics costs are expected to increase in the near future, and not just in Poland but also in the other EU countries (Nichols et al., 1999). Consequently, the EU has taken a more involved approach in flood risk reduction, aiming to direct funds to projects and policies that aim to alleviate flooding risk in several flood prone areas of member countries, in addition to the Upper Silesia Region of Poland, the case study in this chapter.

Land deformation caused by the mining industry and the subsequent floods had another consequence. Unique ecological habitats have been formed in the flooded areas, harbouring important biodiversity riches, which according to the ecologists, should be conserved. In addition to the various economic values that these biodiversity rich areas generate (see e.g., Pearce and Moran, 1994; Bennett, 2003), they are also of high

recreational value to the locals, and they have the potential to become an attractive tourism location in Poland.   These habitats are, however, threatened by the current policies, which do not prohibit the mining industry from discharging their debris in the rivers, creating spoil heaps.   According to the ecologists, if the current situation prevails, levels of biodiversity in this region, including the number of different species of plants and animals, their population levels as well as the number of different habitats and their sizes will reach a minimum level. As explained in the previous chapter, the EU is committed to conserving the ecological status and especially biodiversity riches, in the wetlands and catchments, as stated in various EU regulations and Directives, including the Water Framework Directive (WFD, 2000/60/EC), Article 1(a) of which in particular calls for the prevention of further deterioration of European wetlands, their protection and the enhancement of their status; the EU Birds Directive (1979/409/EC) and the EU Habitats Directive (1992/43/EC).

A number of non-market valuation techniques have been employed to estimate the value of flood risk reduction in Europe. Brouwer and van Ek (2004) employed the integrated impact assessment method to estimate the benefits of flood risk reduction in the Netherlands. Ragkos et al. (2006) carried out a contingent valuation study to estimate the value of flood control in the Zazari-Cheimaditida Wetland in Greece. To our knowledge no study have so far employed the choice experiment method to estimate the benefits of flood risk reduction. Various choice experiment studies implemented in Europe, however, have investigated the value of conserving biodiversity, one of its components (e.g., a certain species) or conserving biodiversity as a part of a wider ecosystem (e.g., wetland or forests) (see, Carlsson et al., 2003; Horne et al. 2003; Birol et al., 2006a; 2006b; Christie et al., 2006; Birol and Cox, 2007). These studies are discussed in further detail in chapter 2 of this

volume. In addition, choice experiment method has also been applied to estimate recreational demand in Europe. Hanley et al. (2002), employ a choice experiment to model the demand for a recreational activity, rock-climbing, in Scotland, and Adamowicz et al. (2005) employ this method to inform forest management at recreational sites in Finland.

The study presented in this chapter, not only presents one of the first applications of the choice experiment method to value benefits from reduction in flood risk in Europe, but also aims to estimate the value of biodiversity, in addition to the local household's demand for recreational activities in this area. To this end, choice experiment and socio-economic data, as well as data on households' past recreational activities in the area and flood damages suffered in the past ten years, are collected from 192 households in the region. The results reveal that all households derive the highest benefits from reduction of flood risk to a low level, followed by recreational activities and biodiversity conservation in the area respectively. These results have important repercussions for the design of efficient and effective river management projects and policies in the area.

The rest of the chapter unfolds as follows: In the next section the case study area is described. Next section briefly presents the theoretical underpinnings of the choice experiment method and the econometric models employed in this chapter. The following sections describe the survey instrument, followed by the results of the choice experiment study and the value estimates derived. The final section concludes the chapter with policy implications for flood risk reduction, biodiversity conservation and recreation in the Upper Silesia Region of Poland, with implications for other EU countries.

The case study area

The choice experiment study reported in this chapter is implemented in the city of Sosnowiec, located in the Bobrek catchment, in the Upper Silesia Region of Poland. The region is an important industrial center located within the Upper Silesian Coal Basin. Five rivers run through the wider area, including Biala, Brynica, Jaworznik, Wielonka and Rawa, making the region susceptible to flooding episodes (Figures 1 and 2).

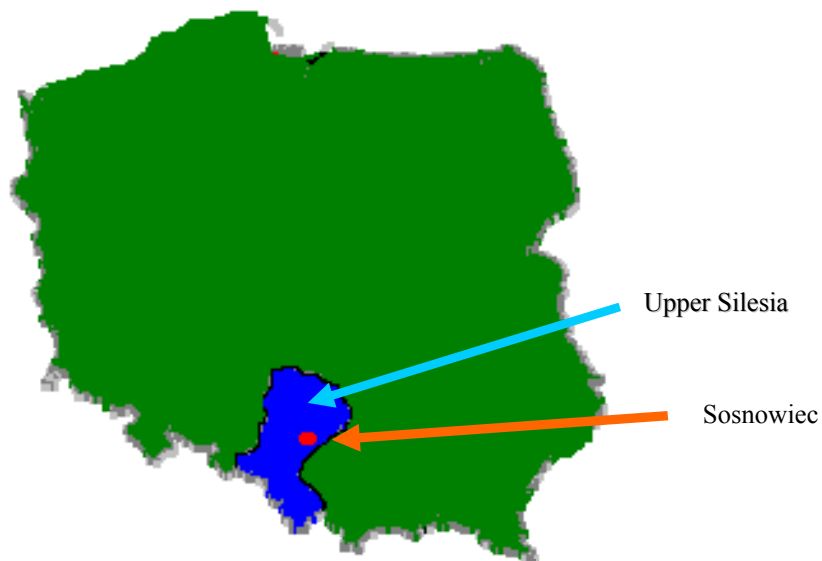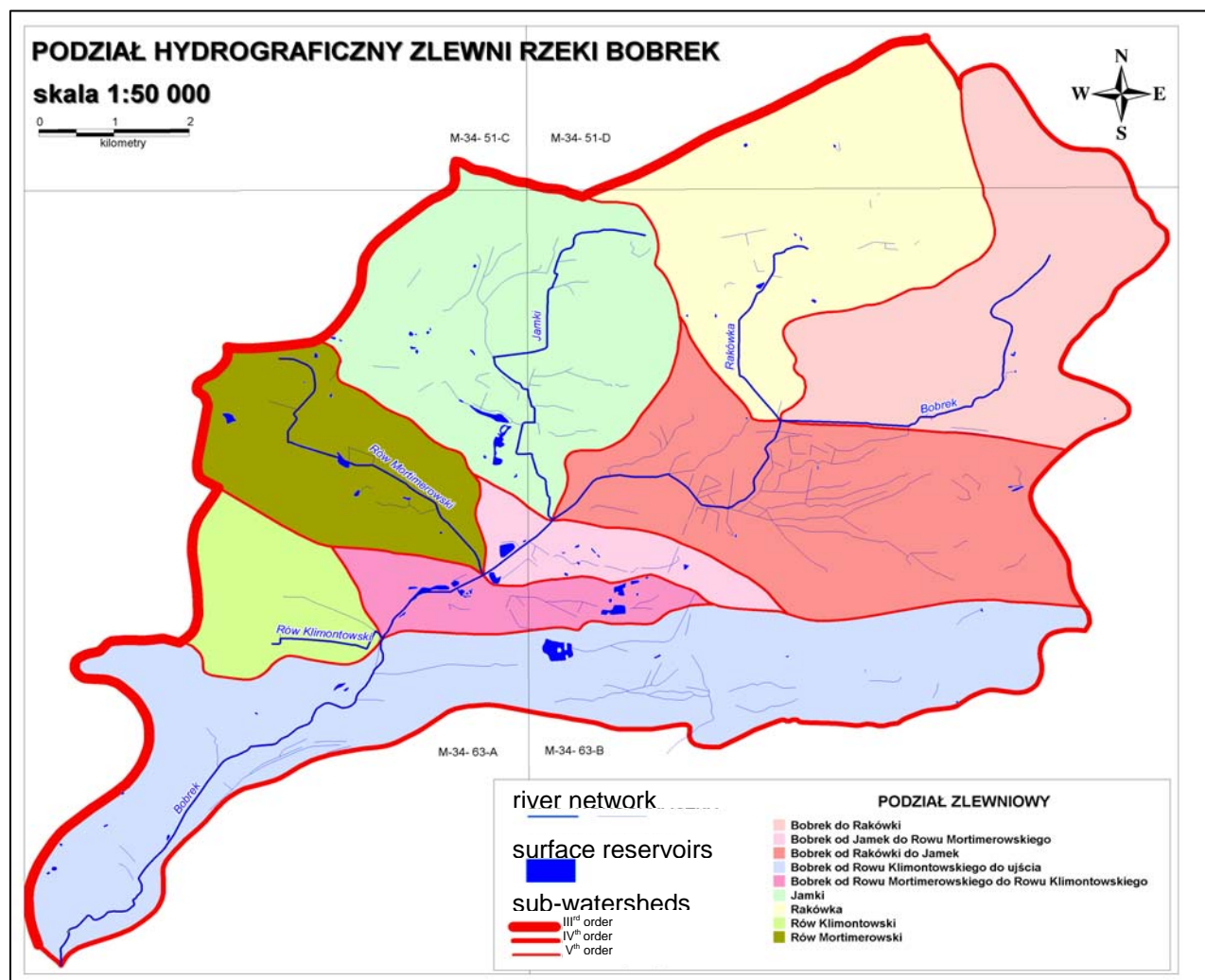Figure 1. Location of the study site in Poland

Figure 2. Map of the Bobrek catchment

The main economic activities in the area include heavy industry and mining with some of the world's largest butaminous coalmines located in the region. The mines are concentrated close to the rivers, constantly changing and eroding riverbanks and their morphology. Mining activities have been taking place in this area for over two centuries. Scientific evidence from Central Mining Institute, Silesian University, AGH University of Science and Technology, and Krakow University of Technology claim that mining industry has

significantly deformed the local landscape and the riverbed, thereby rendering the region extremely vulnerable to floods even after light rainfalls. Given the size of the local communities, it is estimated that approximately 50000 individuals may suffer the effects of an imminent flooding episode.

In 1992 the Polish government facilitated the construction of concrete barriers on the rivers' banks in order to minimize the risk of flooding in the region. Mining industries were deemed responsible for protecting their mines by constructing spoil heaps on the rivers' banks. This strategy, however, was not successful since it increased the speed of flowing water, thereby generating negative externalities for downstream communities. Moreover, recreational activities in the catchment became limited as a result of the blocking of the river access by the concrete barriers. Furthermore this policy was not successful in providing flood control as the extensive floods of 1997 and 2001 can attest.

The high economic and social costs of flooding episodes are borne mainly by the local residents, but also by the overall national economy, as well as by the nearby countries. Despite these costs, floods have also brought about some benefits: Unique ecological wetland habitats have been formed on those lands that have been flooded by the rivers. New species of both animals and plants live in these habitats. Ecologists from Silesian University recognise these biodiversity riches and assert that they should be conserved. In addition, these habitats created by the over flown rivers are now of high recreational value, with the potential to serve as attractive tourism location. The continued existence of these habitats, are currently under threat from the pollution caused by the spoil heaps created by the mining industry.

The Choice Experiment Method

As explained in the other chapters of this book, the choice experiment method has its theoretical grounding in Lancaster's model of consumer choice (Lancaster, 1966), and its econometric basis in random utility theory (Luce, 1959; McFadden, 1974). To illustrate the basic model behind the choice experiment presented here, consider a household's choice for a river management strategy and assume that utility depends on choices made from a set C, i.e., a choice set, which includes all the possible river management strategy alternatives. The household is assumed to have a utility function of the form:

$$U_{ij} = V(Z_{ij}) + e(Z_{ij}) \tag{1}$$

where for any household i, a given level of utility will be associated with any river management strategy alternative j. Utility derived from any of these alternatives depends on the attributes of the river management strategy (Z_j), such as the flood risk level, biodiversity level in the habitats and the level of difficulty of access to the river for recreational purposes.

The random utility theory is the theoretical basis for integrating behaviour with economic valuation in the choice experiment method. According to random utility theory, the utility of a choice is comprised of a deterministic component (V) and an error component (e), which is independent of the deterministic part and follows a predetermined distribution. This error component implies that the household's utility cannot be observed with certainty. Choices made between alternatives will be a function of the probability that the utility associated with a particular river management strategy j is higher than those for other strategies. Assuming that the relationship between utility and attributes is linear in the

parameters and variables function, and that the error terms are identically and independently distributed with a Weibull distribution, the probability of any particular river management strategy j being chosen can be expressed in terms of a logistic distribution. Equation (1) can be estimated with a conditional logit model (CLM) (McFadden, 1974; Greene, 1997 pp. 913-914; Maddala, 1999, pp. 42), which takes the general form:

$$P_{ij} = \frac{\exp(V(Z_{ij}))}{\sum_{h=1}^{C} \exp(V(Z_{ih}))} \qquad (2)$$

where the conditional indirect utility function generally estimated is:

$$V_{ij} = \alpha + \beta_1 Z_1 + \beta_2 Z_2 + \ldots\ldots + \beta_n Z_n \qquad (3)$$

Where α is the alternative specific constant (ASC), which captures the systematic but unobserved information about households' choices, n is the number of river management strategy attributes considered, and the vectors of coefficients β_1 to β_n are attached to the vector of attributes (Z).

The assumptions about the distribution of error terms implicit in the use of the CLM impose a particular condition known as the independence of irrelevant alternatives (IIA) property, which states that the relative probabilities of two options being chosen are unaffected by introduction or removal of other alternatives. If the IIA property is violated then CLM results will be biased and hence a discrete choice model that does not require the IIA property, such as random parameter logit model (RPLM), should be used. Another limitation of the CLM is that it assumes homogeneous preferences across households. Preferences, however, are in fact heterogeneous, as explained in other chapters of this book. Accounting for heterogeneity enables estimation of unbiased estimates of preferences, enhancing accuracy and reliability of welfare estimates and enabling prescription of

policies that take equity concerns into account (Greene, 199). As also discussed in other chapters, information on who will be affected by a policy change and the aggregate economic value associated with such changes is necessary for making efficient and equitable policies (Boxall and Adamowicz, 2002).

The RPLM can account for unobserved, unconditional heterogeneity in preferences across households. Formally:

$$U_{ij} = V(Z_j(\beta + \eta_i)) + e(Z_j) \tag{4}$$

Similarly to the CLM, utility is decomposed into a deterministic component (*V*) and an error component stochastic term (*e*). Indirect utility is assumed to be a function of the choice attributes (Z_j), with parameters β, which due to preference heterogeneity may vary across households by a random component η_i. By specifying the distribution of the error terms e and η, the probability of choosing *j* in each of the choice sets can be derived (Train, 1998). By accounting for unobserved heterogeneity, equation (2) now becomes:

$$P_{ij} = \frac{\exp(V(Z_j(\beta + \eta_i)))}{\sum_{h=1}^{c} \exp(V(Z_h(\beta + \eta_i)))} \tag{5}$$

Since this model is not restricted by the IIA assumption, the stochastic part of utility may be correlated among alternatives and across the sequence of choices via the common influence of η_i. Treating preference parameters as random variables requires estimation by simulated maximum likelihood. Procedurally, the maximum likelihood algorithm searches for a solution by simulating *k* draws from distributions with given means and standard deviations. Probabilities are calculated by integrating the joint simulated distribution.

Even if unobserved heterogeneity can be accounted for in the RPLM, however, this model fails to explain the sources of heterogeneity (Boxall and Adamowicz, 2002). One solution to detecting the sources heterogeneity while accounting for unobserved heterogeneity is by including interactions of individual characteristics with choice specific attributes in the utility function. The RPLM with interactions can pick up preference variation in terms of both unconditional taste heterogeneity (random heterogeneity) and individual characteristics (conditional heterogeneity), and hence improve model fit. When the interaction terms with household characteristics are included, the indirect utility function estimated becomes:

$$V_{ij} = \alpha + \beta_1 Z_1 + \beta_2 Z_2 + ... + \beta_n Z_n + \delta_1 S_1 + \delta_2 S_2 + ... + \delta_l S_m \tag{6}$$

where, as before α is the ASC, n is the number of river management strategy attributes considered and the vector of coefficients β_1 to β_n are attached to the vector of attributes (Z). In this specification, m is the number of household specific characteristics employed to explain the choice of the river management strategy, and the vector of coefficients δ_1 to δ_l are attached to the vector of interaction terms (S) that influence utility. Since household characteristics are constant across choice occasions for any given household, these only enter as interaction terms with the river management strategy attributes.

Survey Design and Administration

The first step in choice experiment design is to define the environmental good to be valued in terms of its attributes and their levels. It is essential to identify those attributes that the public considers important regarding the proposed policy change, as well as those levels

that are achievable with and without the proposed policy change (Bateman et al., 2003). The good to be valued in this choice experiment study is the river management strategy. Following discussions with scientists from the Central Mining Institute, the Silesian University, the AGH University of Science and Technology and the Krakow University of Technology, and drawing on the results of focus group discussions with the local population, three river management strategy attributes were chosen: surface and underground flooding risk, biodiversity found in the habitats and access to the river for recreational purposes. All three of these attributes were specified to have two levels.

The flood risk attribute refers to the risk of flooding in the area in the next 10 years. At the moment, measures such as the building of barriers are not undertaken, and hence the risk of flooding is high. If, however, both underground and surface barriers are built, risk of flooding can be minimised to a low level. It is proposed that to avoid past mistakes, surface barriers should be built in wood and the underground ones should be built in concrete. The river access attribute refers to the public's access to the riverbank for recreational purposes (e.g., walking, cycling, fishing). At the moment access to the river is difficult, following the building of concrete vertical walls a few years earlier. If however, concrete walls are demolished and the river is re-canalised similarly to its natural state, it could easily be accessed for recreational purposes. Finally, biodiversity attribute refers to the number of different species of plants and animals, their population levels, number of different habitats and their size in the river ecosystem in the next ten years. Even though as a result of flooding, biodiversity levels have increased to higher levels, in the area, present regulations do not prohibit the mining companies from creating spoil heaps by discharging the remnants of their mining activities in the river. This malpractice poses a threat to the newly

formed habitats, and it is expected to decrease the biodiversity levels to a low level within the next ten years. If, however, mining companies are prohibited from creating spoil heaps and if reclamation activities, such as afforestation, take place, biodiversity levels can reach a higher level in ten years.

The payment vehicle was a percentage change in the local taxes paid by the households in the next ten years. Percentage change on the household's present level of tax level was preferred over fixed changes in the tax levels, since the former allows for a continuous monetary variable. Furthermore, allowing for higher and lower tax levels compared to the status quo level enables understanding of whether the households are willing to pay to have higher/lower levels of these attributes or willing to accept compensation to let go higher/lower levels of these. Finally, taxation was preferred as a payment vehicle over voluntary donations since households may have the incentive to free-ride with the latter (Whitehead, 2006). Table 1 summarises the definition of the attributes and their levels.

Table 1: Attributes, their Definitions and Levels

Attribute	Definition	Levels
Flood Risk	Risk of flooding in the area in the next 10 years	Low, <u>High</u>*
River Access	Public's access to the river for recreational purposes in the next 10 years	Easy, <u>Difficult</u>
Biodiversity	Number of different species of plants and animals, their population levels, number of different habitats and their size in the river ecosystem in the next 10 years.	<u>Low</u>, High
Local Tax	Percentage change in the monthly municipal tax paid by every household in the area in the next 10 years	-10%, -5%, <u>0</u>, +5% +10%

*Status quo attribute levels are underlined

A large number of unique river management strategies can be constructed using these attributes and their levels. Using experimental design techniques (Louviere et al., 2000) an orthogonalization procedure was used that resulted in 32 pairwise comparisons of

river management strategies. These were randomly blocked into four versions, each containing eight choice sets consisting of two river management strategies and an opt-out alternative, which represented the status quo, in which case no management actions would be undertaken. Inclusion of the status quo or another baseline scenario is important for the welfare interpretation of the estimates and for their consistency with demand theory (Louviere *et al.*, 2000;Bennett and Blamey, 2001; Bateman *et al.*, 2003).

Figure 3. Example choice set

Assuming that the following three river management strategies were the only choices you had, which one would you prefer?			
Management strategy Characteristics	Management strategy A	Management strategy B	Neither Management strategy: Status Quo
Flood risk	Low	Low	High
Biodiversity	Low	High	Low
River access	Difficult	Easy	Difficult
Council tax	5% decrease	5% decrease	Same as now
I prefer (Please tick as appropriate)	Management strategy A	Management strategy B	Neither management strategy

The choice experiment survey was implemented in March and April 2007 in the city of Sosnowiec, located in the Bobrek catchment, with in house face-to-face interviews. Binding time and budget constraints allowed for a sample of 200 households from the local population. A quota sample was collected and the survey was administered to be representative of the local population in terms of income and geographical distribution (i.e., distance from the river). Those household members who took part in the survey were by and large those who were main household decision makers and/or heads of the households. In total 96 percent of those approached, i.e., 192 households were interviewed

The choice experiment survey started with the enumerators reading a statement identifying the current issues in the area regarding flood risk, biodiversity conservation and use of the river for recreational activities. Subsequently the households were presented with a description of the attributes used in the choice experiment and they were asked to state their preferred river management strategy among three such strategies in eight choice sets. Overall a total of 1536 choices were elicited from 192 households.

In addition to the choice experiment, the survey also collected social, demographic and economic data, including the respondents' age, gender, education, household income and local tax paid by the household, as well as information on whether the household uses the river for recreational activities and flooding episodes that have effected the household in the past decade. Descriptive statistics for the key variables are presented in Table 2.

Table 2. Descriptive Statistics of Respondents and their households, Sample Size=192

Socioeconomic Variables	Mean (std.dev.)
Age of the respondent (in years)	45.6 (16.2)
Household size	2.8 (1.1)
Monthly gross household income (in zloty)	2478.1 (1253)
Monthly household local tax (in zloty)	183.9 (11.8)
Household's distance from the river in meters	462 (249.8)
Number of flood episodes suffered in the last decade	2.52 (2.99)
Total damages to the household from floods in the last decade (in zloty)	7115.8 (6611)
	Percentage
Respondent with a University degree and above	26
Household with at least one child	70.8
Household visitor of the river for recreational purposes	54.6
Household flooded	13
Flooded household compensated	28

The sample households' average monthly income, average monthly local tax paid by the household and the demographic composition of the household, as well as the age and education levels of the respondents are representative of the population. Even though on

average households are located almost half a kilometre (462 meters) away from the river, almost 13% have been flooded an average of 2.5 times in the past decade. The total average damages suffered by flooded households in the past ten years is 7115.8 zloty (€1871), and for some as high as 25000 zloty (€6574). Less than a third of these flooded households have been compensated, most of whom (49%) by the mining industry, some (28%) by the government and a minority (13%) by an insurance company. Over a half of the sample are regular visitors of the rivers. They stated that they use the river for a wide array of recreational activities ranging from walking and sailing to appreciating its aesthetic beauty and bird watching, as well as for educational purposes.

Results

The data for econometric analysis were coded according to the levels of the attributes. Attributes with two levels (i.e., flood risk, biodiversity level, river access) entered the utility function as binary variables that were effects coded as 1 to indicate low level of flood risk, high level of biodiversity and easy river access, and -1 to indicate high level of flood risk, low level of biodiversity and difficult river access (Adamowicz *et al.*, 1994; Louviere *et al.*, 2000; Hensher *et al.* 2005). The attribute with five levels (i.e., percentage increase in local tax) was entered in cardinal-linear form, and then multiplied by the households' actual level of local tax, in order to calculate the level of this attribute for each household. Since this choice experiment involves generic instead of labelled options, the alternative specific constants (ASC) were set equal to 1 when either river management strategy A or B was chosen and to 0 when the households chose the status quo (Louviere *et al.*, 2000). A

relatively more positive and significant ASC indicates a higher propensity for households to take no action to manage the river.

Retaining the assumption that observable utility function follows a strictly additive form, a CLM for the choice of river management strategy was estimated using LIMDEP 8.0 NLOGIT 3.0. The model was specified so that household choice was only affected by the ASC and the four attributes of the choice experiment. The results of the CLM for the pool of 192 households are reported in first column of Table 3.

Table 3. CLM, RPLM and RPLM with Interactions

	CLM	RPLM		RPL with Interactions	
Variable	Coefficient (s.e.)	Coefficient (s.e.)	Coeff. Std. (s.e.)	Coefficient (s.e.)	Coeff. Std. (s.e.)
ASC	0.381*** (0.105)	0.023 (0.161)		0.079 (0.148)	
Flood Risk	0.343*** (0.043)	0.777*** (0.168)	0.661** (.367)	0.289** (0.138)	0.361 (0.359)
Biodiversity	0.076** (0.04)	0.183** (0.075)	0.69** (0.277)	-0.433*** (0.144)	0.456** (0.232)
River Access	0.137*** (0.042)	0.274*** (0.0748)	0.303 (0.444)	-0.112 (0.15)	0.292 (0.408)
Tax Rate	-0.029*** (0.003)	-0.101*** (0.018)		-0.176*** (0.029)	
Flooded • Flood Risk				0.849*** (0.212)	
Flooded • River Access				-0.346** (0.178)	
Flooded • Tax Rate				0.056** (0.026)	
Visited • Biodiversity				0.417*** (0.117)	
Visited • River Access				0.257** (0.121)	
Visited • Tax Rate				0.043*** (0.016)	
Income • Flood Risk				0.00012*** (0.529×10^{-4})	
Income • Biodiversity				0.00017*** (0.507×10^{-4})	
Income • River Access				0.00014*** (0.5549×10^{-4})	
Income • Tax Rate				0.19×10^{-4}*** (0.657×10^{-5})	
No of observations	1536	1536		1536	
Log Likelihood Function	-1498.707	-1435.446		-1351.822	
ρ^2	0.11	0.15		0.2	

***Indicates significance at 1%, ** Indicates significance at 5% and * Indicates significance at 10%

The results indicate that all attributes are highly significant determinants of management plan choice. Furthermore, the estimated coefficients have the expected signs. These indicate that individuals prefer low flood risk, high biodiversity and easy river

access. Consistently with demand theory, the coefficient of the monetary attribute has negative sign indicating that individuals prefer alternatives with lower tax rates to those with higher tax rates. The positive and significant ASC captures other factors affecting choice that are not included in the model and can also be interpreted as an indication that the households prefer to move from the status quo to either river management strategy A or B.

As explained above the CLM imposes the assumption of IIA that can be unrealistic in many settings. In case this assumption fails, the CLM is a misspecification. In order to test the assumption of IIA the Hausman and McFadden (1984) test for the IIA property is carried out. The IIA test involves constructing a likelihood ratio test around the different versions of the model where the choice alternatives are excluded. If IIA holds then the model estimated on all choices should be the same as that estimated for a sub-set of alternatives (Hensher *et al.* 2005, p. 519). The results of the test indicate that IIA property is rejected at the 5% level for two cases while it is inconclusive in the third case. Therefore the CLM is may not the appropriate specification for the estimation.

Consequently the data is estimated by using the RPLM, similarly to the case studies presented in chapters three and four of this volume. In addition to circumventing the IIA assumption, the RPLM can take into account the unconditional unobserved heterogeneity among the households. In order to investigate whether or not the data exhibit unobserved unconditional heterogeneity the RPL model is estimated using LIMDEP 8.0 NLOGIT 3.0. All choice attributes expect the monetary payment were specified to be normally distributed (Train, 1998; Revelt and Train, 1998). The results of the RPLM are reported in the second column of Table 3.

The Swait-Louviere log likelihood ratio test rejects the null hypothesis that the regression parameters of CLM and RPLM are equal at 0.5% significance level. The use of the RPLM model therefore results in an improved fit, also suggested by the increase in the ρ^2 from 0.11 in CLM to 0.15 in RPLM. This evidence supports that the RPL model is the correct specification for the data.

The estimated standard deviations of the RPL are significant for the flood risk and biodiversity. This implies that there is significant choice specific unobserved unconditional heterogeneity for these attributes. Even though the standard deviation for the flood risk attribute is significant, it is not large enough to affect the overall sign of the coefficient thus suggesting that the entire sample prefers lower flood risk of higher (Boxall and Adamowicz, 2002). Whereas the large and significant standard deviation for the biodiversity attribute implies that there may be households that prefer lower levels of this attribute. In this specification ASC becomes insignificant, implying that consideration of heterogeneity in this model eliminates the effect of households' unobserved information on their choice of a river management strategy.

Unobserved heterogeneity is often the result of differences of the socioeconomic characteristics of the respondents (Boxall and Adamowicz, 2002). In order to gain insight in the sources of unobserved heterogeneity and identify the socioeconomic characteristics that may provide its foundations, a RPLM with interactions was estimated. The method of interacting social and economic variables with choice attributes is also employed in chapters four, five and thirteen of this volume. In this study, whether or not the households have been flooded in the last ten years, their income levels, as well as whether or not they visit the river for recreational purposes were considered to be important determinants of

choice. The results of the RPLM with interactions are reported in the third column of Table 3.

The Swait-Louviere log likelihood test suggests that the RPL model with interactions is an improvement over the RPLM. Furthermore, the explanatory power of the model increases relative to the RPL model without interactions as indicated by the increase in ρ^2 to 0.2, which is considered to be an extremely good fit Hensher *et al.* (2005, p. 338).

The RPLM with interactions results to insignificant derived standard deviations for the river Access and flood Risk attributes, whereas the standard deviation for the biodiversity attribute is significant and large, revealing that some households prefer higher levels of biodiversity. Further, the results reveal that households that were flooded at least once in the past ten years are willing to pay higher taxes for river management strategies A and B and they prefer those river management strategies which generate lower flood risk and difficult river access. Households that visit the river for recreational purposes are more likely to choose those river management strategy alternatives with high level of biodiversity and easy river access. They are also willing to pay higher taxes for river management. Finally, the higher the household income the more likely it is that the household chooses a river management strategy with low level flood risk, high level of biodiversity, easy river access and these households are also willing to pay higher taxes for river management.

Willingness to Pay Estimates

The choice experiment method is consistent with utility maximisation and demand theory (Bateman *et al.* 2003), therefore welfare measures can be calculated from the estimated parameters by using the following formula:

$$CS = \frac{\ln \sum_i \exp(V_{i1}) - \ln \sum_i \exp(V_{i0})}{\beta_{localtax}} \tag{7}$$

where CS is the compensating surplus welfare measure, $\beta_{payment}$ is the marginal utility of income (represented by the coefficient of the monetary attribute in the choice experiment, which in this case is the local tax) and V_{i0} and V_{i1} represent indirect utility functions before and after the change under consideration. For the linear utility index the marginal value of change in a single river management strategy attribute can be represented as a ratio of coefficients, reducing equation (7) to

$$WTP = -2 \left(\frac{\beta_{attribute}}{\beta_{localtax}} \right) \tag{8}$$

This part-worth (or implicit price) formula represents the marginal rate of substitution between payment and the river management strategy attribute in question, or the marginal welfare measure (i.e., willingness to pay, WTP) for a change in any of the attributes. Since all three of the river management strategy attributes, i.e, Flood Risk, River Access and Biodiversity, are binary, the WTP is multiplied by two (see, Hu *et al.*, 2004):

The best fitting model in this study is the RPLM with interactions reported in the last column of Tables 4. This function can be used to calculate the value assigned by the household to each river management strategy (Scarpa *et al.* 2003), by modifying Equation (8):

$$WTP = -2\left(\frac{\hat{\beta}_{attribute} + \delta_{attribute} \times S_1 + ... + \delta_{attribute} \times S_3}{\hat{\beta}_{localtax} + \delta_{localtax} \times S_1 + ... + \delta_{localtax} \times S_3}\right) \qquad (8')$$

Variables S_{1-3} are the three household specific characteristics under consideration. Using Wald Procedure (Delta method) in LIMDEP 8.0 NLOGIT 3.0., households' valuation of river management strategy attributes are calculated for the best fit RPLM with interactions and are reported in Table 4. The first column reports the WTP of the sample average, where as the succeeding columns report the valuation of flooded households, visitor households, as well as those that are wealthy (i.e., those whose average monthly gross income greater than or equal to the value corresponding to the 75th percentile of the income distribution of the sample) and poor (i.e., those whose average monthly gross income less than or equal to the value corresponding to the 25th percentile of the income distribution).

Table 4. Marginal WTP for river management strategy attributes for the RPLM with interactions for the average, flooded, visitor, wealthy and poor households (zloty[a]/household) and 95% C.I.

Attribute	Average Household	Flooded Household	Visitor Household	Wealthy Household	Poor Household
Flood Risk	14.5***	45.5**	21.5***	27.8***	11.2***
	(12.9-16.2)	(26-9-64.1)	(18.2-24.8)	(21.5-34)	(9.4-12.9)
Biodiversity	4.6***	4.6	12.5***	20.2***	-0.6
	(3.3-5.9)	(1.6-7.6)	(9.9-15.1)	(15.6-24.8)	(-2-0.9)
River Access	6.6***	-2.1	12.7***	21.7***	1.3
	(5.4-7.9)	(-3.6-7.7)	(10.4-15)	(17.1-26.3)	(-0.1-2.7)

[a] 1 zloty= €0.257 (1 March 2007), at the time this choice experiment was carried out. *** 1% significance level; **; 5% significance level, and * 10% significance level with two-tailed tests.

The results indicate that the average household is WTP the highest level for low flood risk, followed by river access and biodiversity. This ranking of the attributes is the same for the four households types: flooded, visitor, wealthy and poor. When the four household types are compared, it can be seen that the flooded household is WTP the highest

for low flood risk, whereas the wealthy household is WTP the most for biodiversity and river access attributes. In order to assess whether there are significant differences in the WTP values of these four household types, following Rolfe & Windle (2005), a Poe et al. (1994) simple convolutions process was undertaken. After having calculated the WTP using the Wald Procedure (Delta method), differences between WTP values were calculated by taking one vector of WTP from another. The 95% confidence interval is approximated by identifying the proportion of differences that fall below zero. The results are reported in Table 5.

Table 5. Proportion of WTP differences for river management strategy attributes falling below zero

	Flood risk	Biodiversity	River access
Flooded vs. visitor	0.915	0.9993	0.9953
Flooded vs. wealthy	0.8201	0.9985	0.9995
Flooded vs. poor	0.97255	0.99035	0.74705
Visitor vs. wealthy	0.88765	0.9775	0.9907
Visitor vs. poor	0.99985	1	1
Wealthy vs. poor	0.99335	1	0.99995

The results of the Poe et al. test reported above reveal that flooded, visitor and wealthy households' WTP for low flood risk is not significantly different than zero at 5% significance level. Therefore, the poor households are WTP the least for reduction in flood risk, however this result might be due to these household's budgets (i.e., their ability to pay) constraining their WTP. What percentage of these households have been flooded, whether or not and how much compensation they have received and their distance to the river should be investigated in greater detail in order to be able to recommend equitable flood risk reduction policies and projects to be designed. WTP for biodiversity differs across all household types at less than 5% significance level. Wealthy households are WTP

the most for conservation of biodiversity, followed by visitor households. For river access, flooded and poor households exhibit similar WTP values, and wealthy households are WTP the most for river access, followed by visitor households. For both biodiversity and river access attribute, what fraction of wealthy households are visitors of the river for recreational purposes, as well as their answers to the follow up questions, which were aimed at differentiating between different sources of value, should be investigated further in order to differentiate between use and non-use values

Policy Implications

Capturing of the welfare effects of flood risk reduction projects and policies is crucial for carrying out the appropriate cost benefit analyses to inform those projects and policies that maximise economic efficiency while minimising flood risks. Even though costs of flood control initiatives are relatively easy to calculate, estimation of the economic benefits of flood risk reduction is a challenging task. Similarly, for biodiversity conservation and recreational activities, estimation of the costs of biodiversity conservation or provision of recreational sites is generally easier than estimation of the benefits generated by these environmental goods and services. This is due to the public good nature of these environmental goods and services, as well as use and non-use values attached to them, implying that there are no markets or market prices that could be used for the estimation of the economic benefits that would arise from projects or policy changes that effect these environmental goods and services. Non-market valuation techniques, therefore, could be applied in order to estimate the total economic benefits generated by flood risk reduction, biodiversity conservation and provision of recreational services.

The study presented in this chapter employs the choice experiment method to investigate the local households' valuation of, trade-offs between and ranking of the most important river management attributes in the Upper Silesia region of Poland. This method is considered to be the most suitable non-market valuation method to study this environmental problem, since river management projects and policies effect multiple environmental services and goods. The river management attributes considered included flood risk reduction, conservation of biodiversity and facilitation of recreational activities in the area. The results reported in this chapter reveal that the average household value positively and significantly improvements in all of the river management attributes. They derive the highest benefits from reduction of flood risk, whereas their valuation of improvements in recreational facilities is half, and their valuation of biodiversity conservation at a high level is a third of their valuation of flood risk reduction. This ranking is similar across household types.

These results indicate that even though the main concern of these households is minimisation of flood risks, they also derive substantial benefits from recreational activities and biodiversity, i.e., use and non-use values of the river. The river management strategies in this region should therefore be designed and implemented in such a way that the precautions taken to alleviate flooding (e.g., building of underground and surface barriers) also incorporate facilitation of recreational activities, for example by re-canalising the river similarly to its natural state, rather than building concrete surface barriers to minimise flooding risk. Further the significant valuation of biodiversity by the locals necessitate development and implementation of policies which prohibit the mining companies from creating spoil heaps by discharging the remnants of their mining activities in the river.

Moreover, reclamation activities, such as afforestation, should be undertaken in order to conserve biodiversity riches in the area. These findings have implications for policies and projects for flood risk reduction in other EU countries, as the results estimated in this recent EU member state reveal that conservation of the environment (e.g., biodiversity as per EU Directives and Regulations) and minimisation of flood risks need not be conflicting objectives.

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