Estimating the Economic Value of Adaptation to Climate Change with Choice Experiments: An application to the Aoos River basin in Greece

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**Abstract**

Climate projection models as applied by IPCC for the Southern Mediterranean basin indicate a strong drought trend. This pattern is anticipated to affect a range of services derived from river ecosystems. This paper aims to examine local residents’ preferences for adapting to climate change for a specific Aoos river basin in Epirus, Greece. The preferences are approached by a Choice Experiment in order to extrapolate econometric simulation of the choices towards adaptation of four prominent services of the Aoos system namely: irrigation, rafting period, hydropower production and ecological state. The econometric analysis is conducted by means of Conditional Logit and Nested Logit calibration models. Both models produce positive and significant estimates for all river-specific attributes. Nevertheless, the Nested Logit performs considerably better describing robustly that people are willing to move away from the ‘do nothing situation’ attaching significant economic values on adaptation strategies. This may also have implications about the use of Nested Logit model in unlabelled Choice Experiments, in cases that the IIA hypothesis is not satisfied by the choice empirical data.

**Keywords:** climate change, river uses, choice experiment, Conditional logit, Nested logit

**JEL code:** Q54 - Agricultural and Natural Resource Economics; Environmental and Ecological Economics; Environmental Economics; Climate; Natural Disasters

1. Introduction

Water resources are finite worldwide and their allocation varies spatially and temporally. The spot availability of water resources depends on the hydrological cycle and especially on the variation of precipitation, runoff (surface and underground) and the level of evapotranspiration. Climate comprises the basic component of ecosystems’ functions and thus climate change, through alterations in the hydrological cycle, perturbs their balance and imposes negative impacts in the water resources provision (Skourtos et al., 2011).
In Southern Europe and especially in the Mediterranean region, the impacts of climate change on water reserves are anticipated to accrue from the decrease of annual precipitation (Bates et al., 2008; Philandras et al., 2011). These impacts are largely linked to a decrease in the water use potential, which has already emerged due to the present high demand for water resources. In Greece, over the last five decades the precipitation patterns have been altered indicating a decrease of 30mm to 150mm per decade. Respectively, the rivers’ runoff has dropped between 5% and 10% during the last century in the Greek territory (Milly et al., 2005). Additionally, the application of different scenarios (e.g. A1B, A2, B2) recommended by the IPCC for the future climate trends, implies that the precipitation will drop further by another 3-7% and 14%-22% for the periods 2021-2050 and 2071-2100, respectively. Consequently, a decline is predicted for the total water potential from 7-20% to 30-50% for the respective time periods, for the entire country (CCISC, 2011).

The natural impacts of climate change affect the water supplies, the water quality, as well as the water ecosystems per se. The impacts on water potential will accrue due to the expected alterations in the volume of surface runoff and groundwater. The water deterioration conditions are anticipated to increase the pollutants in the water bodies, whereas the biology and hydromorphology of water ecosystems will be negatively affected (Feenstra et al., 1998). On the other hand, water resources provide goods and services and their management incorporates the socioeconomic dimension. For this reason the economic impacts of climate change on water provision of the Aoos River may affect a wide spectrum of activities, being expanded in many sectors of economy, with high importance for the society (Metroeconomica, 2004).

Bearing in mind the above remarks, the present study aims at investigating the economic impacts of climate change the forthcoming decades on different uses of the Aoos River in Epirus, Greece. The climate scenarios for the broader area indicate 10-15% precipitation reduction and 15-20% loss of the total water potential by 2100 (Giannakopoulos, 2011). The potential impacts of climate change on water provision of the Aoos River could significantly affect a wide range of economic sectors in the neighbouring mountainous town of Konitsa. Thus, the main focus of the study relies on Konitsa residents’ willingness to pay for adaptation interventions to climate change impacts on the local water resources to avoid welfare losses due to possible complications on river water uses, undertaking a Choice Experiment (CE) application.
2. Study area and methodology

The town of Konitsa (40°2′44″N 20°44′56″E) is situated in the Northern Pindos mountain range and lies at an altitude of 700 m. The location of the town is at the southern exit of Vikos-Aoos canyon, which has been designated as a national park. The Aoos River flows through the homonymous canyon and crosses the town at its south-western part. The river is 260km long, 70km of which are found in the Greek territory. The average flow of the river is 52m$^3$s$^{-1}$ and is not characterized by major modifications. In its spring, there is a hydroelectric plant that produces an average of 10$^3$ MWh electricity per year. The town has about 3000 inhabitants, living in 750 households (Papageorgiou et al., 2005). Over the years, the local economy was based on the primary sector inasmuch the southern part of the town is an irrigated plain area. Currently, the interest has also turned to the tourism industry due to the national park, in which there are many hiking and rafting possibilities supported by the services of the Aoos River. In particular, the most characteristic direct and indirect river uses in Konitsa are: (a) irrigation of 1,000 hectares of the plain area; (b) rafting in efficient flow conditions for 7 months per year; (c) electricity production upstream of the town of 10$^3$ MWh/year. Additionally, the present situation of the Aoos River ecology is ‘good’ and thus meets the requirements of the EU Water Framework Directive 2000/60. Under climate change pressures (expecting a 20% decrease in river runoff) and no adaptation measures, the Aoos River services will significantly decline. More explicitly, the expected changes are, as follows: (a) irrigated land will be reduced to 700 hectares; (b) rafting period will decrease to 4 months per year; (c) electricity production will decrease by 25%; and (d) ecological state will be worsen to ‘poor’. However, moderate adaptation could alleviate the climate change impacts on the Aoos River, while more intense adaptation could maintain the present river status in the future.

Since market or actual data cannot reveal the public willingness to participate in adapting climate change impacts that may appear in a time horizon of 20-30 years, a stated preference technique is needed to simulate distant markets (Layton and Brown, 2000). Therefore, understanding the structure of the public’s preference over future horizons is crucial to formulate welfare improving public policy (Akter et al., 2012). Moreover, CEs as a representative stated preference approach, has considerable merit in measuring use and non-use values because they provide a richer description of the attribute trade-offs that individuals are willing to make (Adamowicz et al., 1998). As a result, many recent studies consider CEs as the most suitable technique for environmental valuation (Adamowicz et al., 1998; Alriksson and Oberg, 2008; Hoyos et al., 2010). The underlying basis of a CE is the idea
that “any good can be described in terms of its attributes, or characteristics, and the levels that these take” (Bateman et al., 2002). In the present study, the Aoos river uses are assigned as the attributes of the CE, while the levels are defined by the “amount” of services provided prior and posterior the consideration of climate change effects.

3. Experimental design and data collection

The survey design phase is the most important part of the design process, provided that it contains assumptions and decisions that affect and constrain the survey development. Applications of CEs to environmental goods or services mostly encompass three different alternatives (Birol et al., 2006; Mitani et al., 2008). Each of the two first alternatives consists of different attribute levels combinations, while the third is defined standardly as the situation that induces no action, change or improvement of one environmental good or service in return of zero cost. Based on the particular characteristics of the study area, the attributes involved in CEs referred to the most important direct and indirect river uses, namely: irrigation, rafting, hydroelectricity production and ecological state. In addition, a basic constituent of each design was the hypothetical cost that respondents should be voluntarily willing to pay per month, when selecting the preferred alternative. The attributes and the respective levels are presented in Table 1.

![Table 1: Attributes and levels for various scenarios included into the CE survey](image)

The design that permits different combinations to be generated by the product of the attribute levels number is referred as full factorial and in this study could give rise to 405 possible sets (3⁴*5¹). This number is far from respondents’ evaluation abilities and requires large cognitive and time sources. To delineate the number of different combinations a fraction factorial design is used, which statistically is a representative subsample of the total combinations. The latter is created using the principles of orthogonality (the levels of the attributes are altered independently from the other attributes level), balance (minimize the probability of one level repetition within the same choice card) and D-efficiency (ordinary least squares efficiency) (Nordh et al., 2011; Olschewski et al., 2012).
The previous conditions for the experimental design were specified into the Sawtooth software CBC version. Focusing only on main effects of the attributes, the routine ‘Complete Enumeration’ was employed. This routine considers all possible tasks and chooses the ones that lead to nearly orthogonal design, in terms of main effects. Minimal overlap is taken also into account and alternatives are kept as different as possible. Furthermore, given the small sample size ‘complete enumeration’ deemed to be appropriate to provide more information by combining utmost different options in every choice situation.

Eventually, the afore-described strategy in our study yielded 96 different alternatives, which were merged into pairs plus the status quo scenario. The generated 48 choice sets were blocked into 8 versions of 6 choice sets and each respondent was allocated one of each version randomly. A hold-out choice set was also included to introduce the respondents to all of the different attribute levels (the fixed set was drawn up by all the attribute levels) and make clear to them what the choice exercise pertained to. Dominant choice tasks were reconsidered or slightly altered in order to be consistent and utility balanced.

The design report indicates that this strategy is nearly optimally balanced, since the entire attribute levels are presented equal number of times. In terms of orthogonality the design procedure of Sawtooth uses the ordinary least squares efficiency to impute relative standard errors of main effects in each level. The efficiency derives from the comparison of the present standard errors with those if the design was optimally orthogonal. An empirical rule demonstrates the closest the OLS efficiency is to 1.0 the better design it is. In the present study, orthogonality was slightly disregarded being around 0.95 for most of the attribute levels. The latter occurred due to the low number of questionnaire versions (only 8) and the minimum number of choice sets (only 2) that held low to reduce fatigue effects and the number of inconsistent choice sets. The logit report of simulated data for a specified number of respondents produced the standard errors in utility estimation for each attribute level. In the context of the present design standard errors around 0.05 were achieved for all attribute levels that is acceptable and quite efficient (Orme, 2010). An example of a choice set is presented in Table 2.

<table>
<thead>
<tr>
<th></th>
<th>Status quo</th>
<th>Alternative 1</th>
<th>Alternative 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Irrigated Area</td>
<td>700 ha</td>
<td>900 ha</td>
<td>1000 ha</td>
</tr>
<tr>
<td>Rafting period</td>
<td>4 months</td>
<td>6 months</td>
<td>7 months</td>
</tr>
<tr>
<td>Electricity production</td>
<td>Decrease by 25%</td>
<td>Decrease by 10%</td>
<td>No decrease</td>
</tr>
<tr>
<td>Ecological state</td>
<td>poor</td>
<td>fair</td>
<td>good</td>
</tr>
<tr>
<td>Cost per month</td>
<td>0€</td>
<td>10€</td>
<td>20€</td>
</tr>
</tbody>
</table>
The CE technique is part of a broader questionnaire, which attempts to reveal various aspects of the examined issue. Preferences elicitation is doable by asking different question types prior the choice exercises, whilst the choice tasks enables the procedure of trading off on attributes. The attributes that the environmental good is composed of, are selected to better represent the total utility of the environmental good. Respondents’ socioeconomic profile is also of interest in order to acquire data on the individual-level basis. Perceptions about the examined issue and socioeconomic characteristics of the participants except for initial principles may constitute significant components of extended or interacted forms of utility models examined by using variables that stem from perceptions or/and respondent’s socioeconomic profile.

The questionnaire deployed for this study was structured into five parts. First, respondents confronted with broad questions about the local environmental status with special regard to the river ecosystem of Aoos. Second, respondents faced general questions in order to know how and how much people use the Aoos River. Third, participants were asked to provide their opinions about climate change issues in the global perspective and how this may affect water provision in the local watershed. Fourth, people encountered the choice tasks and were allowed to trade off on the main Aoos river uses. Fifth, survey questions were included concerning socio-demographic characteristics and follow-up control questions.

The survey was carried out during the period of January and February 2013 to the residents of the Konitsa town. Candidates were selected randomly and were personally interviewed. In total 303 questionnaires were completed. Approximately 15% of the respondents (i.e. 45) opted standardly the status quo scenario mainly for protest reasons.

4. Descriptive statistics

Respondents were 41 years old on average. The average family size was about 3.5 persons. Up to 67% of the respondents stated that their permanent residence was at the Konitsa town, while a 21% were at the town for working purposes. Regarding education, two large groups emerged one of high-school graduates (25.1%) and one of university degrees holders (27.7%). The majority was employed (84.2%) and declared a total annual household income that did not exceed €14,500 on average.

Looking at people’s perception of their living environment, it appeared that for 75% the local environmental conditions had been good or very good. The Aoos River was indicated by the respondents as an important ecosystem for most of them (86.8%), while the opinions about
the Aoos River status were divided, since half of the respondents described it as “fair” or “low” and half as “good” or “very good”. In the same framework, 59.1% of the participants noted that the Aoos River has changed for the worse in the last 10-15 years. Questions regarding use or non-use values provided by the river found the majority of people in agreement with the notion that the river does provide all these services. Most of the people who manifested that they do use the Aoos River mentioned recreational purposes. A small group (11.9%) that uses the river water for economic purposes does so mainly due to irrigation needs.

Almost 90% of the respondents were concerned about the future condition of the river Aoos, while 21.8% identified the reduction in water flow as the most possible threat. About 77% of the respondents were aware about climate change issues. Furthermore, around 70% were convinced that climate change will affect the river, and about half of them said that they were concerned about the impacts on water flow (48%). About one-third of the respondents foresee that the impacts of climate change on the river Aoos will arise in about 20-30 years. Almost all respondents recognized the need of adaptation measures against climate change at a local level. Regarding river water uses priorities, respondents opted for the good ecological status of the river (48.8%), the irrigation water (42.6%), the hydroelectricity production (5%) and the rafting activities (3.4%).

5. Theoretical background of estimation models

5.1. Conditional Logit model

In CEs the utility of a good or service derives from its attributes and levels, a theory that first launched by Lancaster (1966). Furthermore CEs comply with the random utility theory, which is the basis for the econometric simulation of any choice (Luce, 1959; McFadden, 1974). The respondent is assumed to have a utility function of the form

\[ U_{ij} = V_{ij} + \varepsilon_{ij} \]  \hspace{1cm} (1)

where \( U \) is the indirect utility function, \( V \) the deterministic component and \( \varepsilon \) is the non-observable component of individual choice, which is independent of the deterministic part and follows a predetermined distribution. This error term implies that predictions cannot be made with certainty.

Consumers attempt to maximize their utility \( ceteris paribus \) from a good or service under a price constrain. Therefore, choices made between alternatives are based on the probability that the utility stem from a particular option \( j \) is higher than any other option \( n \).
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 above model can be estimated with a CL model (McFadden, 1974), as in Equation 3.

\[
P_{ij} = \frac{e^{\mu z_i}}{\sum_{j=1}^{J} e^{\mu z_i}}
\]  

(3)

where \(j = 1, 2, \ldots, J\) indicates the alternative, \(\theta\) a vector of parameters, \(z\) the characteristics (levels) of the attributes and \(\mu\) is the scale parameter, which is typically assumed to equal one in any single sample, implying constant error variance (Ben-Akiva and Lerman, 1985). The log-likelihood function for the maximum likelihood estimates is as follows:

\[
\ln L = \sum_{i=1}^{N} \sum_{j \in C} d_{ij} \ln P_{ij}
\]  

(4)

where \(N\) is the number of respondents, and \(d_{ij}\) is a dummy variable that equals one when respondent \(i\) chooses alternative \(j\), and zero otherwise.

A basic assumption of CL model is that the choice sets must comply with the ‘Independence from Irrelevant Alternatives’ (IIA) property. The IIA property implies that the relative probabilities of two alternatives being chosen from a choice set are unaffected by the introduction, or removal, of other alternatives in that choice set (Bliem et al., 2012). This property derives from the random components of utility, which are supposed to be independently and identically distributed. The latter implies that the error terms are independent of the different alternatives included in the choice sets. If the IIA property is not satisfied from the dataset the CL is not the appropriate model to estimate unbiased coefficients.

5.2. Nested Logit Model

The Nested Logit (NL) model allows partial relaxation of the IIA property, and is useful when some alternatives are similar to other alternatives in unobserved factors (Train, 1986). Figure 1 illustrates the structure of NL adopted for the Aoos River CE application. The first
level in Fig. 1 is: ‘Adaptation Scenarios’ or ‘Status Quo (No Adaptation)’. Conditional on the choice of Adaptation Scenarios, there are two further alternatives in the second level: ‘Scenario 1’ or ‘Scenario 2’. With this structure, there are only two alternatives at each level and the notion of an irrelevant alternative is no longer pertinent. In other words, the NL assumes homoskedasticity only within the nests but not across the nests.

![Figure 1: Choice Tree]

The NL model is specified as follows. Let choice set \( C \) be partitioned into \( K \) subsets, which are denoted \( C_1, \ldots, C_K \). In our application, \( K=2 \) and \( C=\{C_{\text{scenarios}}, C_{\text{status quo}}\} = \{(1,2), (0)\} \) (See Fig. 1).

The utility that respondent \( i \) obtains from alternative \( j \) in subset \( C_k \) is defined as follows:

\[
U_{ij} = W_{ik} + Y_{ij} + \varepsilon_{ij} \text{ for } j \in C_k
\]  

(5)

The observed component of utility is thus decomposed into two parts, namely: \( W_{ik} \) that varies between subsets, but not over alternatives within a subset, and \( Y_{ij} \) that varies over alternatives within subset \( k \). The probability of choosing alternative \( n \) in subset \( C_k \) can be expressed as the product of the marginal probability that respondent \( i \) chooses any alternative within subset \( C_k \) and the conditional probability that he/she chooses alternative \( j \) given that an alternative in \( C_k \) is chosen \( (P_{ij|Ck})\):

\[
P_{ij} = P_{ij|Ck} \cdot P_{iCk}
\]  

(6)

These two probabilities can be expressed as follows.

\[
P_{ij|Ck} = \frac{e(Y_{ij} / \mu_k)}{\sum_{i} e(Y_{il} / \mu_k)}
\]  

(7)

\[
P_{iCk} = \frac{e(W_{ik} / \mu_k V_{ik})}{\sum_{m=1}^{K} e(W_{im} / \mu_k V_{im})}
\]  

(8)
Where

\[ IV_{ik} = \ln \sum_{i \in C_k} e^{(Y_{il} / \mu_k)} \]  

\( IV_{ik} \) is called the ‘inclusive value’ of subset \( k \) because the term, \( \mu_i IV_{ik} \), means the expected utility that respondent \( i \) can expect from the alternatives in subset \( C_k \). In our application, \( \mu IV_i \) represents the utility that respondent can expect from the choice of adaptation projects. The parameter \( \mu \), which takes the value between 0 and 1, is a measure of the correlation of unobserved utility in the nest: a higher value of \( \mu \) means greater independence and less correlation. Full independence among all the alternatives in all nests (\( \mu_k = 1 \)) reduces the NL model to a multinomial logit model.

6. Results

The parameter estimates for the CL and NL models are reported in Table 3. Both models perform quite similar results in terms of river-specific attributes ranking. All the parameters have the theoretically expected signs of coefficients with statistical significance at the 1% level for most of the coefficients. To measure goodness of fit, we report Pseudo-\( R^2 \) as well as the Akaike information criterion (AIC) and Bayesian information criterion (BIC). Our results for both models show that the fit indices for the NL clearly outperforms the CL model, implying that the IIA condition is not applied in the present choice data set.

<table>
<thead>
<tr>
<th>Variable</th>
<th>CL Model</th>
<th>NL model</th>
</tr>
</thead>
<tbody>
<tr>
<td>Irrigation area</td>
<td>0.09*** (0.025)</td>
<td>0.0613*** (0.021)</td>
</tr>
<tr>
<td>Rafting period</td>
<td>0.048* (0.026)</td>
<td>0.036** (0.017)</td>
</tr>
<tr>
<td>Electricity production</td>
<td>0.016*** (0.003)</td>
<td>0.010*** (0.003)</td>
</tr>
<tr>
<td>Ecological state</td>
<td>0.55*** (0.04)</td>
<td>0.346*** (0.086)</td>
</tr>
<tr>
<td>Price</td>
<td>-0.046*** (0.006)</td>
<td>-0.029*** (0.007)</td>
</tr>
<tr>
<td>ASC</td>
<td>0.164 (0.114)</td>
<td>0.622*** (0.215)</td>
</tr>
<tr>
<td>( \mu )</td>
<td></td>
<td>0.595*** (0.149)</td>
</tr>
</tbody>
</table>

**Summary statistics**

<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Log-Likelihood</td>
<td>-1771.902</td>
<td>-1769.210</td>
</tr>
<tr>
<td>Pseudo ( R^2 )</td>
<td>0.1128</td>
<td>0.2223</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>-----</td>
<td>------</td>
<td>------</td>
</tr>
<tr>
<td>AIC</td>
<td>3555.804</td>
<td>3552.42</td>
</tr>
<tr>
<td>BIC</td>
<td>1797.714</td>
<td>1799.324</td>
</tr>
<tr>
<td>Observations</td>
<td>5454</td>
<td>5454</td>
</tr>
<tr>
<td>Sample Size</td>
<td>303</td>
<td>303</td>
</tr>
</tbody>
</table>

Note: standard errors in parentheses *: p<0.1, **: p<0.05 and ***: p<0.01

The ASC (equals 1 if scenario other that status quo are chosen) is positive and significant in the NL specification indicating the tendency towards Adaptation Scenarios and thus a positive effect on the probability of choosing Adaptation Scenarios (i.e. Scenario 1 or Scenario 2), when compared with the probability of choosing Status Quo. The estimated parameter $\mu$ in the NL model is 0.595 and statistically significant at the 1% level. This indicates a relatively low correlation in unobserved factors within the Adaptation Scenarios nest in Fig. 1 and supports the Nested hierarchical approach of the choice sets (i.e. $\mu<1$). This result implies that the expected utility that the respondent can expect from the choice of Adaptation Scenarios (i.e., Scenario 1 or Scenario 2) positively affects the upper level of decision making (i.e., Adaptation Scenarios or Status Quo in Level 1 of Fig. 1). In the case where there is only a single alternative in a nest (e.g. Status Quo), that nest is considered degenerated and the scale parameter $\mu$ for this nest equals one (Koppleman and Wen, 1998; Lee and Wadel, 2010).

Except the fit statistics estimated for each model that provide useful indications about model performance on the current data-set together with the IIA assumption, a likelihood ratio test (LR) for nested-models was conducted in order to empirically approve the violation or not of the IIA assumption (Ben-Akiva and Swait, 1986). The LR test statistic is represented by:

$$LR = 2(\ln L(\beta_{unrestricted}) - \ln L(\beta_{restricted}))$$  \hspace{1cm} (10)

This formula requires that a restricted model (in our case, the restricted model is the CL estimates) can be transformed into an unrestricted model by imposing some constraints (the unrestricted model is the NL estimates). The ratio under the null hypothesis is distributed as Chi-square distribution with the degrees of freedom equalling the number of constraints. The null hypothesis in the present test is that $H_{0\text{IA}}$: $\beta_{\text{NL}} = \beta_{\text{CL}}$. The test statistic is 5.384 while the critical value of the $\chi^2$ distribution at the 5% level and for 1 degree of freedom is 3.84. Therefore, the $H_{0\text{IA}}$ is rejected since $LR > \chi^2_{0.05}^2$, resulting to the violation of the IIA assumption.
7. Welfare Analysis

The WTP values for the marginal change in an attribute (known as ‘implicit price’) are estimated (Table 4) by dividing the estimated coefficient on the attribute of interest by the negative coefficient on the monetary variable (Eq. 11).

\[
WTP = - \frac{\beta_j}{\beta_{PR}}
\]  

(11)

Table 4: Marginal WTP for the CE attributes

<table>
<thead>
<tr>
<th>Attribute</th>
<th>Implicit price (€)</th>
<th>Implicit price (€)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>CL model</td>
<td>NL model</td>
</tr>
<tr>
<td>Irrigation area</td>
<td>1.95</td>
<td>2.14</td>
</tr>
<tr>
<td>Rafting period</td>
<td>1.04</td>
<td>1.26</td>
</tr>
<tr>
<td>Electricity production</td>
<td>0.34</td>
<td>0.34</td>
</tr>
<tr>
<td>Ecological statement</td>
<td>11.92</td>
<td>12.07</td>
</tr>
</tbody>
</table>

The abovementioned implicit prices do not provide estimates of compensating surplus (CS) for alternative adaptation scenarios. Welfare measures derive from the marginal rate of substitution between residual of the initial utility state and alternative utility state divided by the marginal utility of income, which is represented by the coefficient of the payment attribute. Thus, in order to estimate WTP for adaptation to climate change, three distinct hypothetical scenarios were defined, as follows:

- Scenario 0 represents the ‘do-nothing’ case that is no adaptation actions are considered. As a result, river water uses deteriorate due to climate change with subsequent loss of utility. More explicitly, the irrigated land will be reduced from 1,000 hectares to 700 hectares, the rafting period will be confined to 4 months per year, the electricity production will decrease by 25%, and the ecological state will experience a decline from ‘good’ to ‘poor’.

- Scenario 1 stands for a moderate adaptation policy. In this case, all river water uses are preserved to some extent from climate change-induced impacts. More specifically, the irrigated land will decrease by 10% (i.e. from 1,000 to 900 hectares), the rafting period will be shorten from 7 months per year to 6 months per year, and the electricity production will decrease by 10%. Finally, the Aoos River ecology will be characterized as ‘moderate’.

- Scenario 2 foresees a strong adaptation policy that maintains the present river status in the future. To wit, irrigation land will remain the same as today (i.e. 1,000 hectares), river water level will support rafting activity for 7 months per year, electricity production will
not decrease, and the present situation of the Aoos River ecology will be characterized as ‘good’, meeting the requirements of the European Water Directive 2000/60. To find the CS associated with each of the above-described scenarios, the difference between the welfare measures under the status quo and the alternative scenarios are estimated. Welfare changes are then obtained by using the CS formula described by Hanemann (1989), as in Equation 12.

\[ CV = -\frac{1}{\beta_{pr}} (V^1 - V^0) \]  

(12)

where \( \beta_{pr} \) is the parameter estimate of cost, and \( V^0 \) and \( V^1 \) represent a representative respondent’s utility before and after the change under consideration. The estimates of WTP for the alternative scenarios are given in Table 5.

<table>
<thead>
<tr>
<th>Scenario</th>
<th>CL model</th>
<th>NL model</th>
</tr>
</thead>
<tbody>
<tr>
<td>Scenario 1</td>
<td>27</td>
<td>45</td>
</tr>
<tr>
<td>Scenario 2</td>
<td>45</td>
<td>65</td>
</tr>
</tbody>
</table>

As expected, the CS increases moving from the status quo situation to the adaptation scenarios considered. For the best-fit NL model, the results indicate that households are willing to pay almost 45 € per month (i.e. approximately 540 € per year) for moderate adaptation. The voluntary contribution increases to 65 € per month (i.e. about 780 € per year) for an all-inclusive solution for adaptation, which will preserve all human and ecosystem services of the Aoos River to current levels.

8. Policy Implications and Concluding Remarks

This study attempts to monetize the economic impacts of climate change on mountain rivers. Towards this direction, a CE was conducted using a face-to-face survey on a sample of Konitsa residents in order to analyze trade-offs of choices and to estimate the welfare effects of adaptation measures.

The results of the survey highlight that any river uses loss leads to utility losses, with greater river uses loss being more costly in utility terms. Therefore, all the estimated models indicate positive and significant economic benefits associated with different river ecosystem services (both use and non-use values). In particular, respondents were willing to pay to move away from the ‘do-nothing’ situation towards a new direction that could preserve the
current levels of Aoos River uses by means of appropriate climate change adaptation measures. The benefit estimates for these attributes indicate that Konitsa’s households are willing to contribute per month 2€/ for every 100 hectares preserved irrigation area, 1.20€ for having an extra month efficient flow to conduct rafting activities, 0.35€ for every 10% more hydropower production and 12€ for upgrading the ecological state to the next better provision level (‘poor’, ‘fair’, ‘good’). The CE as performed in this study seems to be useful in providing information about the benefits of adaptation measures to protect river services from climate change and, thus, it promotes the deliberation process among policy-makers and stakeholders.

The IIA property is violated across this dataset indicating that respondents may have different priorities and preferences in order to make their choices, since the inclusion of a new alternative can affect the relative probability of choosing among the alternatives. This evidence indicates the perceptions’ variability on climate change adaptation for river uses, underpinning the sector and the site-specific implications of climate change impacts on water resources. The empirical application of the NL model to the framework of river services’ adaptation is promising, relaxing the IIA property and accounting for the multi-dimensional nature of climate change impacts on water resources.

The NL models are usually used in the cases where particular alternatives describe specific choices (i.e. labelled alternatives), inasmuch unlabelled alternatives have limited possibilities to fall into meaningful nest categories. Nevertheless, from the econometric point of view the NL specification at the case of unlabelled experiment does not pose any constraints (Vojáček and Pecáková, 2010). The use of the NL simulation for unlabelled experiments is found also performing quite well in some other environmental studies (Mitani et al., 2008; Othman et al., 2004). Since there is no a priori optimal econometric approximation for any choice dataset, various tests and comparisons should be carried out among different simulation models in order to acquire robust welfare estimates. In this study, the NL model is superior to the widely used CL model in the context of climate change impacts on water resources, providing a spark for further application of this model approximation in environmental preference research.

References


