Valuing Climate Change Mitigation:

A Choice Experiment on Coastal and Marine Ecosystem

Kyriaki Remoundou[1], Pedro Diaz-Simal[2], Phoebe Koundouri [3]and Benedicte Rulleau[4]

[1] **School of Management and Business, Aberystwyth University, Wales.**

[2] **Instituto de Hidraulica Ambiental Universidad de Cantabria. Santander, España**

[3] **Athens University of Economics and Business and Grantham Research Institute on Climate Change and the Environment, London School of Economics and Political Science**

[4]

Abstract

This paper adds to the limited literature on eliciting willingness to pay (WTP) for mitigation measures against natural hazards caused by climate change, on coastal and marine environments. Our case study is Santander, a coastal region in Northern Spain. The case-study specific natural hazards concern (a) sea-level rise, high tides and extreme wave events that lead to floods and beach erosion, (b) rise in sea temperature that leads to invasive jellyfish outbreaks and changes in native biodiversity. In particular, we employ a Choice Experiment (CE) to elicit the value locals place on improvements, through the implementation of appropriate mitigation measures, in biodiversity, recreational opportunities and on decreases in health risks associated with the above-mentioned natural hazards. Results suggest that people value positively benefits in terms of increased biodiversity and recreation opportunities, as well as health risk reductions, and point to interesting policy implications.

Keywords: coastal areas, marine environment, climate change, natural hazards, choice experiment, biodiversity, recreation, health risks, jellyfish outbreaks.

1. Introduction.

Global climate change (CC) affects the physical, biological and biogeochemical characteristics of the oceans and coasts, modifying their ecological structure and functions, and consequently the amount of goods and services they provide (IPCC, 2001). Specifically, CC influences the marine and coastal ecosystems through changes in temperatures and sea level, ocean circulation, storminess and wave regimes. Changes occur on the level of nutrient availability, biological productivity, the timing of biological events and predator-prey relationships across the food web. In addition, global change-induced effects such as ocean acidification and introduction of non-indigenous species result in more fragile marine ecosystems. The increasing frequency of extreme weather events and sea level rise can also affect coastal ecosystems and result in significant erosion of beaches which in turn impacts on recreational values and tourism.

In this paper we focus on the economic valuation of the climate change induced effects, which negatively affect biodiversity and the size of local beaches, as well as invasive jellyfish outbreaks, which in turn affect recreational benefits and public health. Although there is some economic literature on the valuation of CC consequences, like sea-level rise and flooding (e.g. Dawson et al. (2011), Nicholls et al. (2008), Ng and Mendelsohn (2006), Brouwer and van Ek (2004), Wardekker et al. (2010)) there are only few studies assessing the willingness-to-pay (WTP) for CC mitigation options in coastal areas (e.g. Berk and Fovell (1999), Longo et al. (2012), Polomé et al. (2005), Rulleau and Rey-Valette (2013)). This paper aims to contribute to this limited literature by eliciting WTP to avoid CC related environmental and health risks in Santander, Northern Spain, using a choice experiment. Santander is a coastal region that faces a number of significant challenges due to CC (Losada et al., 2012). In particular, the vulnerability of marine dynamics to CC consequences affects the size of the beaches (Izaguirre et al., 2010) which are focal locations for social and touristic activities, as well as businesses and the building environment (Filatova et al., 2011). Moreover, CC significantly threatens native biodiversity. The bay and its intertidal area play an important role for migrating birds and invertebrates and include a Natura 2000 area, where the shell fish is being caught. CC is altering the morphology of the bay impacting on its ability to sustain biodiversity.

Furthermore, the rise in sea temperature and the modification in ocean productivity due to CC have led to jellyfish proliferation (Purcell, 2005). As a result beach users are increasingly exposed to jellyfish and other dangerous species present on the beaches which restricts their bathing activities due to increased health risks. According to the "Campaña medusas" study conducted by the Spanish Ministry of the Environment, 150 jellyfish outbreaks were reported together in Cantabria and in the Basque Country for the period 2007-2010 (26% of notifications for total Spain) (Ministerio de Medio Ambiente y Medio Rural y Marino, 2011). Jellyfish arrivals have been spotted on more than 60% of the 140 beaches of these two regions during the summer of 2010. While jellyfish outbreaks in Spain mainly concern indigenous species (*Cotylorhiza tuberculata*, *Pelagia noctiluca* and *Rhizostoma pulmo*) more than 98% of jellyfish washed up on Santander beaches are alien *Physalia physalis*. These alien species have stings that usually cause severe pain to humans, leaving whip-like, red welts on the skin that normally last two or three days after the initial sting, though the pain subsides after about an hour. However, the venom can travel to the lymph nodes and may cause, depending on the amount of venom, a more intense pain. A sting may lead to an allergic reaction. There can also be serious effects, including fever, shock, and interference with heart and lung function. Stings may also cause death, although this is extremely rare. Medical attention may be necessary, especially if pain persists or is intense, there is an extreme reaction, the rash worsens, a feeling of overall illness develops, a red streak develops between swollen lymph nodes and the sting, or either area becomes red, warm and tender. (Stein et al. 1989).

The remainder of this paper is structured as follows. In section two, we provide information on our case study, the Santander Bay in Spain. In section three we present our Choice Experiment study and data collection method. Section four reports the descriptive statistics and the estimation results. In the last section, we conclude by discussing the policy implications of our findings.

2. The Case Study: Santander, Spain

Santander is the capital city of the Region of Cantabria, Northern Spain. Its Bay is the largest estuary on the North coast of Spain with an extension of 22.42 km^2, 9 kilometres long and 5 kilometres wide. It is characterized by pocket beaches and small inlets isolated between rocky headlands. These beaches have an important role as focal locations for social and touristic activities. On average, Cantabria receives above 1.5 million tourists per year (50% in summer) and 4.25 million overnights (56% in summer). Commercial and hospitality services contribute to about 20% of GDP and of wages in the region. The Santander Bay is a member of "The Most Beautiful Bays in the World" Club and the city attracts 45% of the Cantabrian visitors. Summer activities are closely tied to the availability of beaches. Hence, Santander beaches are one of the most valuable natural assets in Cantabria.

Santander city itself has a population of around 190,000 people while more than 260,000 are living in the Bay. Due to this anthropic pressure, the morphology of the Bay has suffered important changes in the last centuries. It is estimated that more than 50% of its original extension has been filled up, drying up a large amount of marsh area, to be used as grasslands, to expand the Port of Santander, and to create new industrial and residential areas together with the local airport, located in the South of the Bay (Estudio para el Análisis Hidrodinámico de la Bahía de Santander y Diseño del Canal de Navegación, Junta del Puerto de Santander, 1988). As a consequence, works are underway aiming to recover the seaside ecosystem in some areas of high ecological value. Furthermore, most urban areas around the Bay include important industrial assets together with transportation and life-support systems that are endangered due to sea level rise and increasing storminess including higher waves and high winds.

Issues such as high tides and extreme wave events have traditionally attracted stakeholders' attention in the area (stakeholder's focus groups, THESUS FP7 project). Long-term erosion and winds are expected to give way to flooding. The middle and eastern parts of the Somo spit for instance are fully exposed to the North-Western Cantabrian swell waves. The spit is severely affected by periodic flooding events resulting in important erosion processes (Losada et al., 1991). Furthermore, it is highly vulnerable to CC induced sea level rise and wave modification. The Santander Bay already suffered damage caused by severe weather conditions such as Storm Becky in November 2011 that came with wave heights observed near-shore of about 8 metres and with a storm surge of 0.6 metres. The municipality estimated costs of material damage and the subsequent clean-up to exceed €400,000 in Santander alone for this sole event. Across Galicia, the adjacent region, costs are likely to have exceeded €4 million. Fortunately, human casualties were limited.

3. Methodology.

3.1. The Choice Experiment Design

A CE exercise is implemented in this study to elicit respondents' preferences for different CC mitigation strategies. Grounded on Lancaster's theory of value (1966), CE describe the good under valuation in terms of its characteristics, called “attributes”, and the levels these attributes take (Bennett and Blamey, 2001). One of the attributes is price, so that the marginal value of the other attributes can be evaluated in monetary terms. Accordingly, each valuation question, called a “choice set”, correspond to a set of alternatives constructed from different combinations of the levels of attributes, and respondents are asked to choose their most preferred.

In this work, we focussed specifically on the following CC challenges: (i) CC effects on marine biodiversity, which relate to loss of biomass with respect to shellfish, changes in big fishing banks location and the possibility that the Santander Bay may no longer provide habitat for migrating birds and invertebrates; (ii) CC effects on increased exposure to jellyfish *Physalia physalis*, which result to significant health risks; and (iii) impacts of sea level rise and erosion on Santander’s beaches size which impacts on recreational activities. These three challenges constitute the three attributes of our CE. They were chosen based on interviews conducted within THESUS FP7 project, with researchers, coastal managers, the Port Authority, Chamber of Commerce experts and general firms using coastal areas, as well as a review of the relevant literature.

The fourth attribute, the payment, was expressed as a new municipal tax on drinking water and waste water for the next five years. It was supposed that the additional funds collected would be managed by the municipality and be exclusively used for implementing the risk mitigation project. The choice of the payment vehicle and the management of collected funds, were again based on the analysis of the above-mentioned interviews, which indicate that earmarked municipal taxes are perceived as fair and easy to understand economic instruments for financing CC mitigation measures. Table 1 presents the attributes and their levels used in the analysis. Choice sets were generated using NGENE.

[Table 1 around here]

The valuation scenario first presented the current situation in Santander in terms of biodiversity, jelly fish presence and size of beaches. The vulnerability of Santander to CC was then explained along with the effects of CC on the different attributes under no mitigation measures. Potential policy responses were then described and respondents were explained how these may result in significant improvements in the level of the different attributes. Under the five year scenario, that is the focus of this paper, respondents were explained that the status quo option refers to the situation in Santander in five years' time if no mitigation measures are taken. They were also explained that for the mitigation measures to be applied they would have to accept a higher municipal tax on drinking water and waste water for the next five years. The levels for the attributes under the different scenarios were informed by the risk modelling work undertaken by scientists working in the THESUS project. Potential mitigations measures were presented to respondents. These included seasonal beach nourishment and upgrading of the existing coastal structures to protect the beaches from coastal erosion and the creation of marine protected areas to protect biodiversity. A number of measures aiming to prevent beach closures due to jellyfishes have been also introduced by the Spanish Ministry of the Environment as part of the national 'jellyfish plan' (Gallil 2013). These include increases in the number of lifeguards and first aid staff in the beaches but also the set-up of a network of fishermen charged to spot jellyfishes. Finally, boats previously used for rubbish collection have been turned to jellyfish hunting boats.

Table 2 presents an example of a choice card

[Table 2 around here]

The structure of the CE questionnaire was as follows. First the respondent was asked to unveil her perceptions regarding CC and the importance and significance of its effects for the world as a whole and Santander in particular. The respondent was also asked about her perceived impacts of CC on marine and coastal ecosystems in Santander. In the second section of the questionnaire, the choice cards were presented and the respondent was asked to state her preferred option from three management options (a status quo and two alternative scenarios). The individuals who showed reluctance to support any protection policy were asked a debriefing question aiming to clarify whether they were protesting against the valuation scenario (Bennett and Blamey, 2001). The realism of the status quo and the stated efficiency of the proposed scenarios in order to tackle the effects of CC in the Santander Bay were also assessed. Finally, the third section focused on respondents' socioeconomic condition.

3.2. Data collection

The target population consisted of all the individuals over 18 years of age who live in one of the cities of the Santander Bay area. We used quota sampling based on gender and age distribution in the population, as well as the population distribution within the different municipalities. This procedure aimed to reflect site specificities: retired people and those who work in the service sector tend to locate in the urban city of Santander, while Camargo, Astillero and Medio Cudeyo are characterized by the presence of industrial activity, while the remaining areas of the Bay are focused in agricultural and cropping activities. Tourist activities are widespread through-out the territory of the Bay.

The survey was pretested in December 2010 on a sample of 80 residents. The final survey was administered from April to July 2011 in strategically chosen locations, such as commercial centres, industries and schools. Each respondent was presented with a paper questionnaire and was asked to fill it with help from the interviewer. The administration of the survey lasted about fifteen minutes. A total of 300 people were interviewed and 266 questionnaires were usable for the econometric analysis. We designed three different versions of the questionnaire each referring to a different time frame for the benefits under the valuation scenario. This paper reports the results from the 83 individuals who completed the 5 years version

4. Results

4.1 Descriptive Statistics.

Table 3 presents the main characteristics of the study sample. Mean respondent in our sample is 43 years old. 60% of sample is women while 70% are in full-employment. Mean distance of respondent's household from the seafront is 2.9 km which highlights that for the majority a climate change mitigation strategy is particularly relevant.

[Table 3 around here]

Different questions were used in order to assess residents' perception of risks. Respondents were first asked how severely they think a number of goods and services are threatened because of climate change and sea level rise. Replies were on a scale from 1 to 5 with 1 corresponding to least threatened and 5 to significantly threatened. The highest score was given for biodiversity (3.5) followed by tourism and local infrastructure (3.4). Respondents also perceived significant health risks from jelly fish outbreaks (mean score 3.3)

We also asked residents to state their agreement with statements referring to an increase in the frequency and extent of flooding, storms and beach erosion in Santander in different time frames. We discriminated among the short run (5 years), the medium run (30 years) and the long run (60 years). Answers were again coded on a five-point Likert scale with 1 corresponding to strongly disagree and 5 to strongly agree. Results suggest that respondents agree more with increases in the severity of storms, floods and beach erosion in the long run. For all threats mean values are higher for the 60 years version. Storms are residents' main concern in the short run, shortly followed by a reduction of the size of the beach. In the medium and the long run respondents are more concerned about increases in the frequency and extent of beach erosion. Finally, on the same Likert scale, the majority of the respondents agreed that current generations should protect the environment to ensure that future generations can continue to enjoy benefits from the goods it provides (mean score equals 4.5). Similarly, the majority of respondents agreed that intergenerational equity should be an important consideration for policy-making (mean score equals 4.3). The majority further declared willing to financially contribute to actions aiming to mitigate CC even if benefits were to be received by future generations (mean score equals 3.7). Our results thus point to significant bequest values associated with climate change mitigation measures. This is further reinforced by the fact that most respondents disagree that they don't spend much of their time worrying about the future (mean score equals 2.2).

4.2 Estimation Results

4.2.1 Model Specification

To analyse our choice data, we follow a random parameters logit model to allow for heterogeneity in preferences between respondents in the sample. In this class of models the coefficient vector for each individual is the sum of population mean and an individual variation.

Where X is the vector of the attributes and β_i the vector of the associated coefficients.

A constraint triangular distribution, imposing the equality of the location parameter to the scale, is assigned as the mixing distribution to ensure behaviourally consistent parameter signs and WTP estimates for the entire range of the parameters distribution (Hensher and Greene 2003; Hensher et al. 2005; Campbell et al. 2008). In our study all attributes are defined as improvements over the status quo and thus we have strong priors that all attributes positively contribute to respondents' utility. To allow for heterogeneity in preferences for cost, we specify the cost coefficient to also follow a constraint triangular distribution.

4.2.2 Utility Coefficients

Table 4 summarizes the results of the Random Parameters Logit estimation. The coefficients for biodiversity and recreation are positive and statistically significant. Results therefore suggest that people are holding positive values for improvements in biodiversity and recreational opportunities. Furthermore, the coefficient for health risks is negative implying that there is utility loss associated with an extra day of beaches being closed because of Medusa Portugessa outbreaks. Conforming to expectations, the coefficient for price is negative suggesting that respondents ceteris paribus prefer alternatives with a lower payment. The ASC is also negative implying that respondent do value a climate mitigation project and want to move away from the status quo of low recreational opportunities, low biodiversity and frequent beach closures due to health risks.

[Table 4 around here]

4.2.3 Willingness to Pay estimates

Based on the utility coefficient estimations the marginal WTP for each attribute in each version is calculated as:

$$WTP = \frac{\beta_{attribute}}{\beta_{price}}$$

Table 5 displays the results of the WTP estimation for the two versions of our study. The 95% confidence intervals are reported in the parentheses. They are calculated using the Krinsky-Robb method.

[Table 5 around here]

Estimated WTP for all attributes are statistically significant. It should be noted that the above values correspond to annual WTP estimates for 5 years. To allow for comparisons the present value of the amounts is calculated assuming a 3% discount rate (table 6).

Our estimates therefore suggest that people hold significant values and are willing to pay to support a mitigation strategy that would improve biodiversity and recreational opportunities and eliminate health risks from jelly fish outbreaks.

5. Policy Implications

In this paper we employ a nonmarket valuation study to elicit Santander Bay residents' valuation for improvements in biodiversity and recreational opportunities and decreases in health risks associated with the presence of jellyfish. Santander Bay is extremely vulnerable to climate change impacting its marine ecosystem's ability to provide goods and services. In particular, sea-level rise, high tides and extreme wave events have resulted in significant erosion in the main beaches whereas the rise of the sea temperature has caused an increase in the frequency of beach closing due to jellyfish outbreaks. Results suggest that people value positively benefits in terms of increased biodiversity and recreation opportunities. They are also willing to pay to hedge against health risks relating to the presence of jellyfish.

Our results provide useful insights for the design of optimal (economically efficient, socially acceptable and environmentally sound) mitigation measures to hedge against extreme natural hazards in the Bay of Santander. They suggest that people hold significant values for goods and services provided by marine and coastal ecosystems and are aware of the risks to these ecosystems and their capacity to sustain these goods and services due to CC. Furthermore, the monetary estimates under this study could inform the appraisal of a CBA to investigate whether different planned mitigation measures are economically efficient. The Spanish Ministry of the Environment is already implementing a series of mitigation measures aiming to eliminate CC related effects and is planning additional future measures. Existing measures include systematic seasonal beach nourishments and construction of coastal structures (seawalls, groins, riprap dikes) aiming at physical protection. The ministry is planning to extend those measures in the future. Furthermore, the proliferation of alien jelly fishes is a matter of on-going concern. Jelly fishes can result in significant health effects and beach closures which in turn restrict recreational opportunities and impact on the number of tourists. As part of the national 'jellyfish plan', a set of protocols has been developed for observing and monitoring jellyfish populations and for dissemination. Furthermore, the government is planning to increase the number of lifeguards and first aid staff present in the beaches and also deploy fishermen and boats previously used for rubbish collection to collect jellyfishes. These measures entail significant costs. Knowledge of the value people are placing in the goods and services marine ecosystems sustain is important in assessing the cost-effectiveness of the proposed measures. However, evidence from valuation studies directly eliciting welfare gains from climate change effects elimination is scarce. In a similar study, Galil, Gowdy and Nunes (2013) find significant welfare losses associated with the alien jellyfish outbreaks in a study among coastal recreationists in Israel. The authors further find that a quarter of the respondents would resume seaside visits once the swarm disappears. They therefore advocate in favor of the introduction of daily information updates regarding jellyfish presence. Kontogianni and Emmanouilides (2013) also report significant benefits from reducing the frequency of jellyfish outbreaks in the Golf of Lion, South France. Our study contemplates existing evidence and adds to this limited literature by finding significant values associated with reduction of the frequency of outbreaks,

We further find that people are willing to pay to hedge against CC related risks for the benefit of the future generations. Based on replies to attitudinal questions regarding intergenerational equity we expect a significant bequest component in the values we elicit. Bequest values are commonly reported in non-market valuation studies eliciting values for environmental goods and services (Carson et al 1992, Cummings and Harrison 1995, Walsh et al 1984). Bequest values are extremely relevant in the case of CC given the long run nature of CC related impacts.

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8. Tables and figures

Figure 1: Bay of Santander in 1997 (source: NASA)

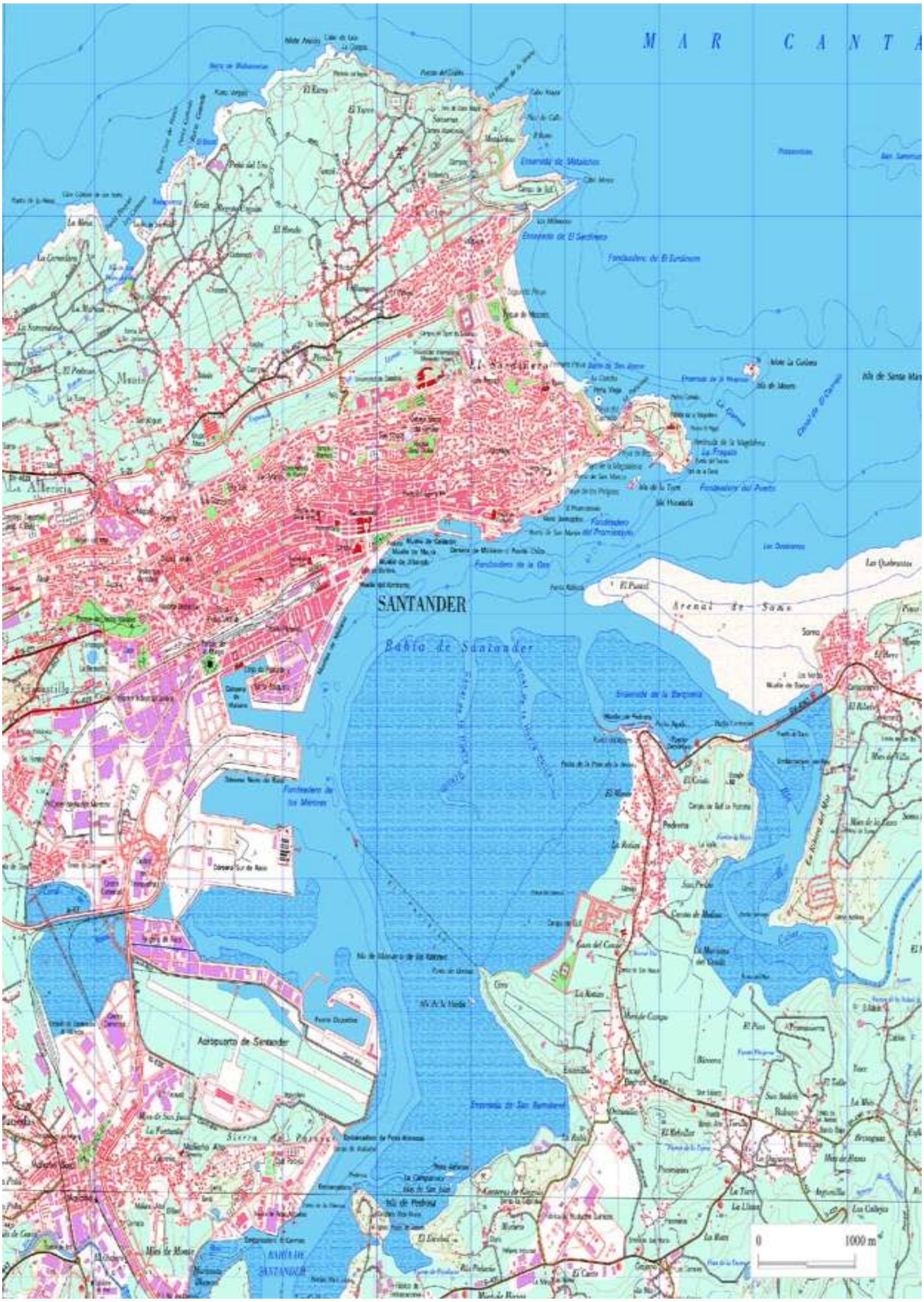

Table 1: Attributes and their levels.

Attribute	Levels
Biodiversity and Fishery	1. Low: The area for shell fishery is altered by CC and is not suitable for this type of fisheries anymore. The Bay of Santander no longer provides a habitat for migrating birds and invertebrates (Status Quo)* 2. Medium: The shell fishery area is preserved but reduced and the Bay no longer provides an habitat for migrating birds and invertebrates 3. High: Current level of biodiversity is preserved
Number of days beaches are closed due to jellyfish outbreaks	1. 5 days/year 2. 10 days/year 3. 15 days/year (Status Quo)
Beach Size (recreation)	1. Low: The 4 main beaches in Santander reduce from 3 km long and turn to pocket beaches. Pocket beaches and beaches located at the flood prone Somo spit disappear due to erosion (Status Quo) 2. High: Nourishment of the main beaches in Santander and of pocket beaches preserve their size throughout the year
Additional annual cost to your household	1. €0 (Status Quo) 2. €50 3. €75 4. €100 5. €125 6. €150

*Status Quo levels refer to the situation in Santander in 5 years' time under no mitigation measures

Table 2: Example of Choice Card.

	Alternative1	Alternative2	Alternative3 (no policy action)
Biodiversity	Medium	High	Low
Number of days beaches are closed due to jellyfish outbreaks	5	15	15
Beach Size	High	Low	Low
Additional annual cost to your household for the next 5 years	125	50	0
I prefer			

Table 3: Descriptive statistics of the sample

Number of respondents	83
Personal characteristics	
Age (mean)	43
Female (% of women)	59.0
Occupation (% full time)	69.9
Number of people per household (mean)*	3.2
Children (% of household with children)	55.4
Education (% with university degree)***	10.8
Household income (% inferior to €2,000)1	68.3
Distance of the house from the beach (mean, in km)	2.9
Goods and services threatened nowadays by CC	
Recreation from the beaches (mean score)	2.9
Biodiversity in the coastal and marine ecosystem (mean score)	3.5
Tourism and local infrastructure (mean score)	3.4
Human Health (mean score)	3.3
Consequences of CC	
Increase in frequency and extend of floods...	
... in the next 5 years	2.4
... in the next 30 years	3.4
... in the next 60 years	3.8
Increase in frequency and extend of storms...	
... in the next 5 years	2.9
... in the next 30 years	3.4
... in the next 60 years	3.8
Reduction of the size of the beach	
... in the next 5 years	2.6
... in the next 30 years	3.6
... in the next 60 years	4.2
Intergenerational or contribution questions	
Current generations should protect the environment to ensure that future generations can continue enjoying the benefits from the goods it provides.	4.5
Intergenerational equity should be an important consideration for policy making	4.3
I would financially contribute to actions aiming to mitigate CC even if benefits are to be received by future generations	3.7
I prefer enjoying the present and don't spend a big part of my time worrying about the future	2.2

[1] According to the Spanish National Statistics Institute, the average annual income of Spanish households reaches €25,732 in 2009 i.e. €2,144 per month

Table 4: RPL estimation results

Attribute	Coefficient (St error)
Biodiversity medium	1.26*** 0.22
Biodiversity high	1.04*** 0.21
Health risk (per additional day)	-0.11*** 0.03
High recreation	0.62*** 0.16
Price	-0.06*** 0.007
ASC	-4.66*** 0.57

Table 5: WTP Estimation

Attribute	WTP [95% Confidence Interval]
Biodiversity medium	20.52 [12.75 29.55]
Biodiversity high	16.93 [10.29 24.8]
Health risk reduction (per day)	1.86 [0.91 2.99]
Recreation high	10.09 [4.9 15.89]

Table 6: Present values of the WTP estimates (r = 3%)

Attribute	Present values (in Euros)
Biodiversity medium	94
Biodiversity high	77.5
Heath risk reduction (per day)	8.52
Recreation high	46.21