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# Choice experiments to elicit the users' preferences for coastal erosion management: the case of *Praia da Amorosa*

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**Abstract**
Coastal erosion is a complex and increasingly important problem, largely due to its effects and management strategies. The current context of climate change, together with centuries of human occupation of shorelines, adds pressure for the development of sustainable coastal management policies, the success of which crucially depends on the consideration of all stakeholders' perspectives. This research investigates users' preferences over alternative options of coastal erosion management. Through the implementation of a discrete choice experiment, respondents' preferences regarding management alternatives are elicited, and their willingness to pay for alternatives' attributes is estimated. The results show that respondents prefer some interventions to mitigate the problem rather than no action, and prefer lighter intervention (palisades, gangways) to heavy infrastructures (rockfills, seawalls, groynes). Moreover, the results show the presence of preference heterogeneity and thus the need to use more flexible and complex models. Based on the results obtained, it is possible to drive some policy implications. First, the do-nothing option is not viable from the population's standpoint; second, although some type of coastal erosion protection is demanded by the general population, the preferred approach is for light forms, contrary to the policy adopted in the last century, and still overwhelmingly present in the territory. Lastly, given the considerable heterogeneity in respondents' preferences, careful consideration of the welfare impact of coastal interventions by population segments is required.

**Keywords** Environmental valuation · Choice experiments · GMNL · Preference heterogeneity · Coastal erosion management

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## 1 Introduction

Erosion is one of the most pressing problems of coastal zones as it affects the area's attractiveness with respect to recreational and economic activities (such as sun and beach recreation, water sports, fisheries, tourism, etc.), as well as its resilience to climate change and associated climatic events. The increasing vulnerability of coastal areas is evident in public policy plans and strategies. The most recent report by the Intergovernmental Panel on Climate change (IPCC) made the matter even more salient. Coastal areas have essential and appreciated resources, but they are subject to various natural and anthropogenic factors that threaten the natural and human coastal resources and might affect the population's well-being. Interactions of natural and anthropogenic factors could contribute to coastal erosion. Although the cause is not always evident, natural dynamics of coastal areas, climate change, use and occupation of the coast, and several coastal interventions are identified as causes of erosive processes (Coelho et al. 2009; Phillips and Jones 2006; Williams et al. 2018).

The accelerated coastal erosion makes it essential to protect the coast in order to guarantee the use of coastal resources and to preserve the natural and cultural heritage at risk. Although there is some consensus on the causes and consequences of erosion, coastal erosion management strategies involve several contradictory points of view in technical and scientific fields and also within the population. These contradictory points of view make the problem and possible coping strategies more complex. Despite the prevailing non-consensual nature of the debate, any effective management of coastal areas requires the identification and integration of all stakeholders' perspectives.

Academics and experts have a fundamental role in coastal zone management, in terms of recognizing the value of coastal attributes, understanding the technical alternatives to control coastal erosion, and the social acceptability associated with each alternative. Moreover, in the case of coastal zones with significant public heritage, the impact of alternatives on the well-being of the population affected by the effects of coastal erosion, and the public preferences for each alternative should be considered in public decision-making. Understanding individual welfare changes implies the elicitation of consumer preferences. The importance given by the population to different environmental coastal resources may prove to be fundamental to the sustainable management of coastal areas. Given the diversity of measures and their consequences, determining the value of environmental resources that are intended to be protected is crucial for identifying and justifying the most appropriate intervention to manage the problem of coastal erosion. Some coastal erosion management strategies range from hard (also described as heavy) engineering structures, such as seawalls and groynes, soft (also known as light) techniques that promote sediment deposition, managed retreat, to "no intervention" (Phillips and Jones 2006; Roca et al. 2008; Williams et al. 2018). Regardless of the type of intervention, approach, or technique used, the action should undergo an evaluation that considers social, economic, and environmental issues.

This paper investigates the users' preferences for coastal erosion management programmes and their determinants, using a choice experiment. A generalized multinomial logit (GMNL) model is selected to estimate preferences. Also, this study contributes to the scarce literature pertaining to eliciting individuals' preferences in this context, and supports the public process of coastal erosion management.

Our research focuses on key questions including whether coastal users prefer heavy engineering structures or the light interventions that tend to be performed according to natural coastal processes, or the "do-nothing" policy for coastal erosion management. We also

wish to identify determinants (sociodemographic and context variables) that affect users' preferences and whether preferences are heterogeneous. In addition, we investigate whether individuals are willing to pay to control erosion and for which attributes in the event that they do not favour the "do nothing" option. Understanding how people value coastal zones attributes can support the decision over coastal zone management priorities. We hope to achieve results that are useful for decision-makers in planning coastal management strategies for sustainable development of coastal areas.

The article is structured in four sections in addition to the introduction. Section 2 reviews the literature on non-market valuation methodologies and how it has been applied to issues related to coastal management; Sect. 3 describes the methodology and data collection; the results of data analysis are presented in Sect. 4; Sect. 5 concludes.

## 2 Literature review

Environmental resources, as public or quasi-public goods, tend to be used more intensively than would be socially appropriate. The inability of the market system to charge a price for the services provided by these resources calls for alternative strategies, which, in turn, raises the need to elicit the preferences of individuals with the goal of informing and supporting public decision-making processes, making it possible to establish priorities in the objectives and strategies in which monetary resources are limited. The process of valuing environmental goods and services seeks to contribute to a more efficient and equitable management of environmental resources.

In order to place an economic value on non-market goods and services by eliciting individuals' preferences, two main approaches have been developed: revealed preference and stated preference (Pearce et al. 2006). Contingent valuation and choice experiments are stated preference methods that use survey-based techniques in constructed or hypothetical markets to elicit individuals' preferences (Atkinson and Mourato 2008). The ability to deal with situations in which changes are multidimensional and trade-offs between dimensions become relevant is one of the main characteristics that makes choice experiments frequently used in environmental valuation (Atkinson and Mourato 2008; Hanley et al. 2001).

Choice experiments have repeatedly been employed to analyse several impacts in coastal areas. According to Liu and Wirtz (2010), discrete choice experiments (DCE) are widely applied in the integrated coastal zone management context, as DCE provides a way to include the relative importance of environmental impacts into the decision-making process. Hoyos (2010) emphasizes the significant and increasing role that DCE is playing in environmental decision-making. Several authors have used DCE to elicit individuals' preferences regarding coastal erosion management options (Ardeshiri et al. 2019; De salvo et al. 2018; Matthews et al. 2017; Phillips 2011), providing useful findings for policy and decision-makers. Ardeshiri et al. (2019) analysed Australians' preferences with respect to two alternative management options for the New South Wales coastline: either construct/maintain protective structures or allow the natural retreat of the coastline. A referendum choice experiment was employed with six attributes: (1) width of the beach, (2) length of the beach, (3) beach type, (4) beach distance from residences, (5) time horizon, and (6) cost. Using a latent class binary logit model, the results point towards significant preference for the second management option (allow the natural retreat), although the amounts were not sensitive to width and length.

De Salvo et al. (2018) found stronger preferences for lighter interventions for a beach resort in Sicily. The study considered three attributes in the erosion control options: (1) construction of sea barriers, (2) beach nourishment, and (3) expense. The authors used a multinomial logit model and to model heterogeneity they used a latent class model and a mixed logit model. The results show that users appreciate current sea advancement, are against construction of sea barriers, but in favour of beach nourishment, and reveal preferences heterogeneity.

The preferences for coastal erosion management options amongst visitors and residents of Buffalo Beach, Whitianga, New Zealand were studied by Phillips (2011). The choice experiment design comprised six non-monetary attributes: (1) hard protection structures, (2) width of the beach, (3) width of reserve/picnic area, (4) beach access, (5) properties removed, (6) flood risk, and a cost attribute. Through a mixed logit model and a latent class model, the author concluded that visitors were willing to pay considerable costs to remove rock walls at each end of the beach area. In addition, there was a clear preference for useable beaches and reserve areas behind the beach. In the same line, using virtual reality, Matthews et al. (2017) estimated preferences in DCE for alternative coastal area management options in Coromandel Peninsula, New Zealand, considering attributes with (1) erosion protection, (2) headland development, and (3) expense. Two conflicting views were reported: that of property owners, who argued for hard coastal defence structures, and the position of the council, who argued for the protection of natural landscape and recreation activities. The results show significant willingness to pay (WTP) values, although the results were insensitive to the scale of beach attributes and the random parameter logit models suggest significant preference heterogeneity in the sample. Bateman et al. (2009) also used virtual reality to test the robustness of DCE information presentation devices and concluded that virtual reality performs better than traditional tables of information. The context used is management of coastal areas subject to erosion and floods, in which man-made coastal defence infrastructures are discussed.

Blakemore et al. (2008) analysed the effect of a hard engineering protection structure in Pembrokeshire, Wales, by contingent valuation. The findings suggest that participants were willing to pay high costs to fund alternative (lighter) forms of coastal protection, in addition, many were willing to pay even higher amounts to have existing structures removed and replaced by natural solutions. Using the same approach, Marzetti et al. (2016) used a multi-country contingent valuation method eliciting private stakeholders' willingness to pay for coastal preservation (intended as defence from erosion). The authors compared willingness to pay between participants aware of the existence of integrated coastal zone management (ICZM) with those not aware, finding that individuals aware of ICZM were willing to pay substantially more. In addition, they found some effect of sociodemographic variables. However, this approach does not account for preference heterogeneity nor does it provide the value of the individual characteristics of the coastal zone.

In the context of climate change, Remoundou et al. (2015) used a DCE to identify residents' preferences for coastal risk management caused by climate change in Santander, Spain. The authors consider two types of effects of climate change: sea level rise, high tides, and extreme wave events (causing floods and coastal erosion) and rising sea temperatures, increasing the likelihood of jellyfish booms and changing local biodiversity. The attributes are based on the climate change effects on marine biodiversity, effects on health due to exposure to jellyfish, and effects on beaches' size due to sea level rise and erosion. Following a random parameter logit model, the results show clear significance of willingness to pay values to adopt mitigation measures that reduce the

harmful effects on health and nature. Mitigation measures comprised beach nourishment and improvement in the existing structures to protect the beach.

Ladenburg and Dubgaard (2009) analysed individuals' preferences about visual impacts from offshore wind farms on the marine and coastal seascape, employing a DCE in Denmark. They compared the willingness to pay between different types of coastal area users, such as fishermen, very frequent visitors, and less frequent visitors. The authors concluded that specific users of the coastal area and more frequent visitors were willing to pay approximately twice the amount that less frequent users were willing to pay. The policy inference drawn is that when positioning offshore windfarms, decision-makers should consider the detrimental effects on coastal users.

About coastal water quality, Hynes et al. (2013) investigated recreationists' willingness to pay for improvements mimicking the policy orientations of EU bathing water directive implementing DCE. The authors compared three empirical models (multinomial logit model, random parameters logit model, and latent class model), and found significant WTP associated with all attributes considered. Moreover, from random parameter logit and latent class models, they found some preference heterogeneity related to individual exposure to water health risks.

Coastal ecosystem services valuation was addressed by Halkos and Galani (2016) and Marre et al. (2015) using DCE for Greece and New Caledonia, respectively. Based on multinomial logit models, mixed logit models, and latent class models the studies estimated willingness to pay for coastal and marine ecosystem protection and revealed considerable preference heterogeneity. In the same line of concern for coastal natural resources, Hoyos et al. (2012) estimated the economic value of environmental impacts from the construction of a seaport. In DCE, they estimated the preference for environmental attributes (landscape, flora, fauna, and seabed) and concluded that conservation is more valued than loss.

From DCE information, several studies report significant differences between groups of respondents, supporting the need to consider preference heterogeneity in the specification and estimation of econometric models. The works of Liu and Wirtz (2010), which evaluated coastal resources in an oil spill management context, and Dachary-Bernard and Rivaud (2013), which elicited individuals' preferences for coastal land use changes, emphasize the importance and the need to take into account preference heterogeneity in decision-making.

Regarding determinants of individual choices, Phillips (2011) argues that the differences between residents' and visitors' preferences are a relevant factor in the coastal erosion management context. In addition, sociodemographic variables and location can influence the individual choice for coastal management strategies (Remoundou et al. 2015). Individuals with higher income are more likely to choose alternatives with intervention and/or preservation programmes (with associated costs) (Hynes et al. 2013; Marre et al. 2015). Younger individuals tend to choose alternatives with active management measures (Halkos and Galani 2016).

In Portugal, investigations addressing individuals' preferences for coastal erosion management in order to support decision-makers are scarce to our knowledge, none implementing a DCE. Our research provides information on users' preferences for coastal erosion management and willingness to pay to support coastal protection in the Northern Portuguese Coastal Zone. By employing a DCE in order to estimate the value of the individual attributes of the coastal zone, and using a GMNL model to allow for preferences heterogeneity among individuals, we analyse the influence of sociodemographic and context variables.

## 3 Methodology and data collection

To elicit the value of alternative coastal erosion management strategies controlling for area characteristics, we use the case of *Praia da Amorosa*, in the North of Portugal. In the municipality of Viana do Castelo, it is a coastal area just south of the Lima River and adjacent to the Viana do Castelo Sea Port. This area was chosen because it has a number of attractive characteristics for the analysis of users' preferences for coastal erosion management strategies. *Praia da Amorosa* has, over time, been subject to coastal erosion, affecting the coastal resources and recreational activities. The area is characterized by a diversity of natural resources (dunes, vegetation) that tend to complement the attractiveness of the beach recreation. *Praia da Amorosa* has significant urban infrastructures built relatively close to the sea. These characteristics are common to many coastal areas around the world.

In order to obtain the most information from participants in the study and to cross-validate the data collected, we used a mixed method approach, combining qualitative methods (expert interviews and focus groups), to develop the choice experiment questionnaire, and quantitative methods (discrete choice model) to analyse the data.

### 3.1 Discrete choice experiments: theoretical framework

Given that coastal erosion has a variety of impacts and considering the complexity and diversity of coastal zone attributes, a discrete choice experiment was selected. Discrete choice experiments construct hypothetical market situations by presenting a sequence of choice sets comprising alternatives. Alternatives vary in the level of the attributes included. In most applications, subjects are also presented with a "not buying" or "choose the current situation" (status quo) alternative. The discrete choice experiments have theoretical roots in theory of characteristics Lancaster (1966). Lancaster's characteristics-demand theory (Lancaster 1966) relies essentially on the assumption that goods have characteristics (in general, more than one) and consumers derive utility from these characteristics. Thus, goods can be defined and valued in terms of their characteristics (attributes). The theory of random utility (Hanley et al. 2001) is used to analyse individuals' choices in discrete choice experiments. This theory postulates that consumers choose the combination of attributes/levels that provides the highest utility level. It is further assumed that individual utility from alternative i ($U_{i,n}$) can be divided into a systematic component, $V\left(X_{i,n};\beta\right)$, and a random component, $\epsilon_{i,n}$

$$U_{i,n} = V\left(X_{i,n};\beta\right) + \epsilon_{i,n} \tag{1}$$

$U_{i,n}$ is the utility that alternative $i$ $[i=1,\ldots J_n]$ gives to decision-maker n $[n=1,\ldots,N]$. $X_{i,n}$ is a vector of explanatory variables describing i and n. $\beta$ is a vector of unknown parameters. V is systematic Utility. $\epsilon_{i,n}$ is a vector of random disturbances.

RUM assumes that decision-makers are utility maximizers, and therefore prefer the alternative that provides them with the highest utility. Alternative $i$ is chosen over alternative $j$ if and only if,

$$U_{in} \geq U_{jn} \quad \forall j \in C_n \tag{2}$$

where $C_n$ is a set of $J_n$ alternatives faced by n.

As utility includes a random part, a given choice of alternative is observed with some probability:

$$P\left(i|X_n;\beta,\theta_\varepsilon\right) = \text{prob}\left(U_{in} \geq U_{jn} \forall j \in C_n\right) \tag{3}$$

Data collected with DCE are modelled following the theory of random utility developed by McFadden (1974). Having three or more alternatives to choose from (three being the most common), we are in the presence of a multinomial model. We assume that the disturbances $\epsilon_{i,n}$ are independently and identically distributed (IID) extreme value type-I (Gumbel) with zero mean and variance $\mu^2\pi^2/6$, where $\mu$ is a positive-scale parameter. The individual choice probability is (Ben-Akiva and Lerman 1985):

$$P_{in} = \frac{\exp\left(\mu V_{in}\right)}{\sum_{j\in C_n} \exp\left(\mu V_{in}\right)} \tag{4}$$

The log-likelihood function is given by:

$$\text{Ln}L = \sum_{i=1}^{N} \sum_{i\in C_n} y_{in}\left(\ln\left(P_{in}\right)\right) = \sum_{i=1}^{N} \sum_{i\in C_n} y_{in}\left(\beta' X_{in} - \ln \sum_{j\in C_n} \exp\left(\beta' X_{jn}\right)\right) \tag{5}$$

A troublesome assumption of the models is the IID, which translates into preferences that are independent of irrelevant hypothesis (IIA). Among the alternatives available for relaxing the IIA (Ryan et al., 2008), we opt for the random parameters or mixed logit model. The most significant characteristic of this model is that parameter estimates are random, and we thus have individual-specific $\beta$'s.

The estimation of the previous log-likelihood function is done using the generalized multinomial logit routine developed by Gu et al. (2013) for STATA. The GMNL assumes that consumer choice behaviour exhibits heterogeneity, and thus the modelling must account for variations in the consumers' behaviours. Fiebig et al. (2010) propose the use of the GMNL as a very flexible model accommodating both preference and scale heterogeneity.

The GMNL allows the inclusion of independent alternative-specific variables (attributes of the alternatives) and individual-specific variables. In addition, it is possible to estimate random or fixed coefficients. It is possible to analyse the effect of the characteristics of both individuals and alternatives on the choice probability. The inclusion of individual-specific variables in the model allows us to capture differences in the individual preferences (to detect heterogeneity of systematic preferences).

### 3.2 Attributes and levels of the coastal erosion management programmes

To develop discrete choice experiments, it is necessary to perform several tasks, such as: identify attributes and levels; choose experimental design; construct the choice sets; design the questionnaire; and finally, analyse the data (Hanley et al. 2001; Hoyos 2010; Lancsar and Louviere 2008).

Identifying the attributes and levels is crucial in the development of choice experiments. Attributes and levels are usually identified from literature and from qualitative methods, such as interviews and focus groups (Dachary-Bernard and Rivaud 2013; Lancsar and Louviere 2008; Marre et al. 2015). Hoyos (2010) argues that advice of experts and focus groups may facilitate the definition of appropriate attributes and levels.

Previous studies on coastal erosion management options have identified beach width and length as relevant, together with location and ecosystem/biodiversity effects. In addition, other variables appear to be important in explaining respondents' valuation of attributes. These variables include sociodemographic characteristics such as age and gender, distance to coast, and type of use of coastal area.

In order to design an appropriate questionnaire, we conducted seven interviews with academics and experts and three focus groups with users of the zone under study. The academics and experts interviewed undertake activities that directly or indirectly involve the complex problem of coastal erosion management, and it was possible to obtain technical and scientific information, experiences, and opinions related to coastal erosion. In particular, the effects of the interventions in the closest Seaport north of Amorosa (Viana do Castelo) and of the dams in rivers flowing into Amorosa were considered highly significant.

Given that the interests and perceptions of individuals differ depending on the type of coastal user (see for example, Phillips (2011)), one focus group was held with permanent users (users that frequent the area throughout the year) and two focus groups with occasional users. The interaction and discussion amongst the participants allowed us to gather perceptions and opinions about the erosion problem in *Praia da Amorosa*, addressing causes, consequences, and ways of acting. The information collected by qualitative methods informed and validated the questionnaire design, mainly the specification of attributes and their respective levels.

In interviews and focus groups, beach recreation and the dune ecosystem were highlighted as the main characteristics of the area under study. The most prominent concerns and effects of coastal erosion were related to changes in beach width and dune system, leading to discussion of the ways in which erosion management can take place in the study area. Thus, the chosen attributes describe three aspects of coastal erosion: (1) the type of intervention with respect to hard or soft visible structures, (2) the beach width, and (3) the dunes' vegetation. Additionally, a monetary attribute was included, the value of which would be collected annually through a national individual income tax, if interventions were implemented. When a monetary attribute is included, marginal utility estimates can be converted into willingness to pay for changes in the level of each attribute (Hanley et al. 2006; Hoyos 2010). The inclusion of a cost attribute provides an estimate of the monetary contribution that users are willing to pay for a given coastal intervention. Table 1 presents the attributes and their levels. The three non-monetary attributes related to aspects of coastal erosion have two levels and the cost attribute is set to levels of 20€, 40€, and 80€. The type

**Table 1** Attributes and levels

| Attributes | Levels |
|---|---|
| Type of intervention | Type I (palisades, gangways)<br>Type II (rockfills, seawalls, groynes) |
| Beach width | Maintenance of the beach width (relative to the current width)<br>Increased beach width (relative to the current width) |
| Dunes' vegetation | Maintenance the dune vegetation (relative to the current)<br>Increased dune vegetation (relative to the current) |
| Cost | 20€; 40€; 80€ |

of intervention attribute is assumed to have a level related to soft interventions, soft visible structures, such as palisades and gangways, which promote sediment deposition and restore natural defences of the coastal zone; and another level associated with hard engineering structures, such as rockfill, seawalls, and groynes. Also investigated were beach width and dunes' vegetation attributes, comprising one level for interventions to maintain the current situation (width of beach or the dune vegetation); and a level for interventions to increase the width of the beach or the dune vegetation.

In order to construct the alternatives included in the choice sets presented to respondents, we used the experimental design of Lourenço-Gomes et al. (2013), which tests different methods of constructing choice sets, concluding for a specific design maximizing D-efficiency. The use of Lourenço-Gomes et al.'s (2013) experimental design is possible as the number of attributes and levels is the same. Combining attributes and their levels, six choice sets were constructed with three alternatives: two alternatives composed of interventions to control coastal erosion and one option proposing "no intervention" (at zero cost). A baseline alternative (status quo or do-nothing option) must be included in order to interpret the results according to the economic welfare standard and thus obtain adequate welfare measures (Hoyos 2010). If this alternative is not considered, respondents may be forced to choose an alternative they do not want, and if so, welfare measures will therefore be inaccurate (Hanley et al. 2001). Respondents expressed their preferences over 12 different combinations of attribute's levels at non-zero cost. Respondents expressed their preferences over 6 choice sets, making their choice from 2 alternatives at non-zero cost, and 1 alternative at zero cost. Table 2 depicts an example of a choice set.

### 3.3 Questionnaire design

The questionnaire was designed and organized in four sections. In addition to valuation questions, the questionnaire addresses familiarity and perception of coastal erosion, sociodemographic questions, and questions regarding the risk attitudes of the respondents.

The first part contextualizes the problem and investigates the familiarity of respondents with the theme of coastal erosion. This section is composed of questions regarding respondents' perceptions of most significant environmental problems in Portugal, their opinion on aspects related to coastal erosion (seriousness, causes, possible coping

**Table 2** Example of a choice set

| Choose your preferred intervention form | | | |
|---|---|---|---|
| | Intervention | | |
| | A | B | No intervention |
| | Type I Intervention<br>+<br>Increased beach width<br>(relative to the current)<br>+<br>Increased dune vegetation<br>(relative to the current) | Type II intervention<br>+<br>Maintenance of the beach width<br>(relative to the current)<br>+<br>Maintenance of the dune vegetation<br>(relative to the current) | |
| | 20€ | 80€ | 0€ |
| Choice | A ☐ | B ☐ | No intervention ☐ |

strategies, responsibility towards coastal erosion). Respondents were also asked about the causes and the effects of coastal erosion in Portugal, possible causes and effects of coastal erosion, and statements that reveal some attitudes, perceptions, and knowledge inherent to the coastal erosion process. In the second section, respondents were asked about their preferences regarding alternatives for managing coastal erosion in the area where the study was implemented. An informative text on the main detectable effects of coastal erosion on the study area, alternative intervention programmes, and the payment vehicle were presented to respondents. The description of the type of intervention attribute was supplemented with pictures to further clarify the issues to the respondents. It was explained to respondents that the alternative of no intervention may result in decreased beach width and less dune vegetation in the future. The second part also includes follow-up questions about difficulty of choice tasks and whether individuals considered all the attributes in selecting an option. The third section deals with the respondents' opinion, knowledge, and perception of coastal erosion in the *Praia da Amorosa* area and the respondents' relationship to the site. The fourth part ends the survey with sociodemographic questions, and questions regarding the risk attitudes of the respondents with respect to financial, labour, health, and general decisions.

A pre-test was conducted to check for respondents' understanding of the questions as well as length and timing of the questionnaire.

The questionnaire was administered through personal interviews between August and September 2016, to users of the *Praia da Amorosa*, where the study was implemented. In total, 184 questionnaires were completed (3312 choice responses, corresponding to 184 respondents).

## 4 Results

### 4.1 Descriptive statistics

Table 3 depicts the distribution by type of respondent according to the subject relationship to the site: Most of the sample, 67%, are occasional visitors, 19% are residents, and 14% are frequent visitors of the area throughout the year.

Regarding the frequency of visits, 33% of respondents frequent the area throughout the entire year, and approximately 35% of occasional users frequent the area in summer and winter.

Concerning the sample, Table 4 presents summary statistics on individual characteristics. Roughly 55% of respondents are women and the average age is 43 years. The sample composition regarding age and sex is comparable to residents in the area.

**Table 3** Distribution by type of user

| | *N* | Relative frequency (%) |
|---|---|---|
| Residents | 35 | 19 |
| Permanent visitors (all year) | 25 | 14 |
| Occasional visitors | 124 | 67 |
| Total | 184 | 100 |

**Table 4** Risk and sociodemographic variables

| | Mean (median)/ frequency | SD | Min | Max |
|---|---|---|---|---|
| Financial risk attitude (0 risk averse–100 risk taking) | 25 | | 0 | 100 |
| Monthly income (€) | 1684 | 1218 | 250 | 5000 |
| Age | 43 | 16 | 18 | 83 |
| Sex: woman | 55% | | | |

To explain individuals' options, we also asked respondents to state on a scale from 0 to 100 (whereby 0 means risk averse and 100 risk taking) how risky they judge their decisions to be regarding financial matters. The median level is 25, corresponding to more than half of the respondents being extremely risk averse.

The distance of users' location from the coast is also considered as a possible determinant of individuals' options. To analyse these effects, respondents were asked to indicate on a map where they lived, or usually stayed when visiting. One-third of respondents are located 300 metres or less from the coastline, and two-thirds are located less than 450 metres, as reported in Table 5.

Overall, 61% of the respondents considered coastal erosion as one of the most significant environmental problems that affects Portugal and when focusing on coastal erosion in the area of *Praia Amorosa*, 46% considered it serious and 38% very serious.

On the causes of coastal erosion at *Praia da Amorosa*, the most frequently indicated cause was sea level rise, which is eminently related to climate change.

Regarding the choices of respondents for coastal erosion management programmes, roughly 87% of the choices correspond to intervention programmes and 13% of the choices reveal a preference for no interventions. Table 6 presents the choices by type of user. In all groups of users, intervention programme options represent the largest proportion of choice.

**Table 5** Distance to the coast

| Distance to coast | Absolute frequency | Relative frequency | Cumulative frequency |
|---|---|---|---|
| Less than 150 m | 15 | 12 | 12 |
| 150–300 m | 27 | 21 | 33 |
| 300–450 m | 38 | 30 | 63 |
| 450–600 m | 28 | 22 | 85 |
| More than 600 m | 19 | 15 | 100 |

**Table 6** Choices by type of user

| | Intervention programmes option Relative frequency (%) | No intervention options Relative frequency (%) |
|---|---|---|
| Residents | 92 | 8 |
| Non-residents | 86 | 14 |
| Permanent visitors (all year) | 81 | 19 |
| Occasional visitors | 87 | 13 |
| Total | 87 | 13 |

About the difficulty of choice tasks, roughly 34% of respondents answered neither easy nor difficult, 29% answered easy, 26% said difficult, and only 3% stated that the choice tasks were very difficult. Furthermore, when asked whether all attributes were taken into consideration in the choice task, 83% of respondents selected all attributes alternative. In addition, the respondents that did not consider all attributes gave more importance to the type of intervention and the cost attributes.

### 4.2 Estimation results

Table 7 presents the results of the estimation of GMNL models testing alternative specifications, ultimately aiming to determine the order of preference regarding coastal management options attributes, while controlling for heterogeneity of preferences. Model 1 does not control for sociodemographic variables, while models 2–5 include sociodemographic variables. Model 6 includes two variables interacting the variables for being a resident of Amorosa and the type of intervention. In addition to the DCE attributes, sociodemographic variables such as sex, age, income, average risk aversion, residency in Amorosa, distance to coast from place of stay when in Amorosa, and climate change being the most important cause of coastal erosion. Estimation was performed with Stata software developed by Gu et al. (2013), and Hole (2007).

The results are robust as the key lessons do not change across specifications. The attributes considered in the DCE are consistently statistically significant. Considering the effect of sociodemographic variables in explaining the heterogeneity of preferences, models 2–5 show no statistically significant effect. However, the model fit significantly increases when the variable distance to coast is included (model 3), as evident in the decrease in the AIC and BIC indicators. Model 6 includes the variable resident interacted with the type of infrastructure.

Both random and fixed components are statistically significant, except for the width attribute, which is significant only as a random component. As expected, the cost coefficient is negative, implying that an increase in cost will decrease the utility of the coastal erosion management alternatives. This result is consistent with similar studies (De Salvo et al. 2018; Matthews et al. 2017; Phillips 2011; Remoundou et al. 2015) that found respondents' preferences for lower cost coastal risk mitigation strategies. The statistical significance of Dune_veg implies that respondents are sensitive to the dune vegetation. This finding is consistent with the dune destruction concern reported in interviews and focus groups. One of the more salient environmental characteristics of the area under study is the dune ecosystem, and individuals reveal some notion of its importance as a natural defence barrier. Respondents reveal perception of vegetation function to promote sediment deposition. A restored and vegetated dune was also found significant by Matthews et al. (2017) when eliciting preferences for coastal erosion management alternatives. Type_light and Type_heavy parameters denote that coastal users prefer some type of intervention to control coastal erosion rather than no action. De Salvo et al. (2018) found a similar result that coastal users prefer actions to protect the beach from erosion rather than accepting the status quo.

Regarding sociodemographics, some variables are statistically significant, but the results are not uniform across specifications. Accounting for variations in the individual behaviour deserves special attention in the choice analysis of coastal interventions strategies. Significant random component, sex, and income coefficient suggest preference heterogeneity, that is, the coastal attributes of alternatives do not influence the

**Table 7** GMNL estimation results

| | Model 1 | Model 2 | Model 3 | Model 4 | Model 5 | Model 6 |
|---|---|---|---|---|---|---|
| *Mean* | | | | | | |
| Cost | −0.0160*** (0.0023) | −0.0142*** (0.0022) | −0.0116*** (0.0033) | −0.0180*** (0.0034) | −0.0219*** (0.0070) | −0.0246*** (0.0068) |
| Type_light | 3.4898*** (0.4101) | 3.0223*** (0.4322) | 2.7520*** (0.7530) | 3.6932*** (0.6473) | 4.5551*** (1.4150) | 4.7995 (1.3192) |
| Type_heavy | 3.1421*** (0.3575) | 2.7407*** (0.3760) | 2.3076*** (0.6248) | 3.3777*** (0.5836) | 4.1578*** (1.2695) | 4.4685* (1.2083) |
| Tlight*resid | | | | | | 1.5746*** (0.9542) |
| Theavy*resid | | | | | | 0.8499*** (0.8540) |
| Width | −0.1823 (0.1393) | −0.1714 (0.1236) | −0.0548 (0.1487) | −0.1929 (0.1501) | −0.2647 (0.1963) | −0.2718 (0.2123) |
| Dune_veget | 0.1904* (0.1124) | 0.1770* (0.0953) | 0.2023* (0.1179) | 0.2140* (0.1187) | 0.2452* (0.1996) | 0.2717* (0.1669) |
| Heterog | | | | | | |
| Sex | | 0.0133 (0.2142) | | 0.2559* (0.1388) | 0.2470* (0.1409) | 0.1241 (0.1470) |
| Age | | | | | −0.0062 (0.0044) | −0.0057 (0.0044) |
| Income | | | | −0.0001* (0.0001) | −0.0001* (0.0001) | −0.0001* (0.0001) |
| Avg_risk | | | | | 0.0025 (0.0029) | |
| Cause_CC | | | | | 0.0015 (0.1440) | |
| Resident | | | | −0.0759 (0.1679) | −0.0971 (0.1698) | |
| Distance_coast | | | 0.0484 (0.0694) | | | |
| *SD* | | | | | | |
| Width | 1.2900*** (0.1650) | 1.1653*** (0.1598) | −1.1393*** (0.2990) | 1.4037*** (0.2390) | 1.7337*** (0.5196) | 1.8696*** (0.5031) |
| Dune_veget | −0.7123*** (0.1386) | −0.5674*** (0.1484) | 0.5127*** (0.1885) | −0.7224*** (0.1992) | −0.8379*** (0.3224) | −0.9873*** (0.3140) |
| AIC | 1789.426 | 1788.048 | 1242.694 | 1788.397 | 1791.905 | 1783.021 |
| BIC | 1838.268 | 1842.996 | 1294.305 | 1855.555 | 1877.379 | 1862.39 |
| TAU | 0.0229 (0.1904) | 0.0133 (0.2142) | −0.0473 (0.2187) | 0.0172 (0.2082) | 0.027 (0.8930) | 0.0455 (0.2658) |
| LL | −886.713*** | −885.024*** | −612.3469*** | −883.198*** | −881.952** | −878.510** |

Significance level ***$p<0.01$; **$p<0.05$; *$p<0.10$

preferences of coastal users in the same way amongst respondents in the sample. Preference heterogeneity for coastal erosion strategies was also identified by De Salvo et al. (2018) and Matthews et al. (2017). Hynes et al. (2013) found considerable heterogeneity in preferences over water and beach quality attributes to revisions of the EU bathing water directive. Coastal user heterogeneity preference for reducing the visual dis-amenities of offshore wind farms was detected by Ladenburg and Dubgaard (2009).

Interestingly, when interacted with the type of infrastructure, the variable resident is statistically significant.

Using the software developed by Gu et al. (2013), estimates of respondents WTP are reported in Table 8 for models 2, 3, and 6.

It is interesting to note that WTP estimates do not vary significantly amongst models. Importantly, the effect of being a resident in Amorosa increases estimated WTP for both types of infrastructures, although the increase is significantly greater for light infrastructure. The width of the beach and dune vegetation are less valued. This effect can be explained by the fact that respondents might assume that these attributes will be guaranteed if the infrastructure is ensured. The most valued attribute is light infrastructure, followed by heavy infrastructure.

However, it is important to stress that both interventions are preferred to the do-nothing approach. In the literature (Blakemore et al. 2008; Phillips and Jones 2006; Roca et al. 2008) and in interviews with academics and experts, it is recognized that light interventions can act as effective short-term measures, in the area of influence of the intervention, but in the long term are characterized by vulnerabilities that affect the direct and adjacent areas of influence. Moreover, generally, heavy engineering is more expensive than alternative light intervention techniques, which are a more natural method. Blakemore et al.'s (2008) findings suggest that individuals did not appreciate the visual intrusion of the new hard engineering coastal defence, and were willing to pay to have it removed and replaced with a more natural option. In addition, De Salvo et al. (2018) concluded that soft interventions, like beach nourishment, were positively valued, and hard interventions, like emerged barriers, were negatively valued. Matthews et al. (2017) also concluded that some individuals have negative attitudes toward preferences for seawalls to protect properties. The willingness to pay for coastal zone interventions evidenced in our study is consistent with empirical studies over coastal zone preservation. Concerned WTP for sandy beach preservation in the face of future coastal erosion was evidenced by Ardeshiri et al. (2019). Using another stated preference approach, the contingent valuation method, Marzetti et al. (2016) reveals some evidence for WTP for beach preservation due to coastal erosion in four Mediterranean regions in Italy, Greece, and France. Nevertheless, a willingness to pay approach for coastal zone interventions may not fully address the positive effects that a strategy of preservation of natural resources may have on productivity and the economic system in the medium term (Aldieri et al. 2019).

**Table 8** Willingness to pay estimates

| | Model 2 | | | Model 3 | | | Model 6 | | |
|---|---|---|---|---|---|---|---|---|---|
| | WTP | LL | UL | WTP | LL | UL | WTP | LL | UL |
| Type_light | 213 | 168 | 257 | 237 | 165 | 309 | 195 | 153 | 237 |
| Type_heavy | 193 | 149 | 236 | 199 | 133 | 265 | 181 | 141 | 223 |
| T.light*resid | | | | | | | 64 | −8 | 136 |
| T.heavy*resid | | | | | | | 35 | 33 | 102 |
| Width | −12 | −28 | 5 | −5 | −29 | 20 | −11 | −27 | 5 |
| Dune_veg | 12 | −2 | 27 | 17 | 20 | 40 | 11 | -3 | 25 |

## 5 Conclusions

This paper provides useful insights for the design of efficient and equitable public policies in the domain of sustainable coastal erosion management, protecting the interests of the population. The preferences of the users of *Praia da Amorosa* can support the process of coastal erosion management, given the need to define priorities in protecting and preserving coastal resources. The respondents reveal a preference for soft interventions, without hard fixed engineering materials, which according to the Portuguese Coastal Working Group, have been the interventions favoured under the coastal protection policy in recent years. Regardless of the type of intervention, coastal protection policies should be informed by social, economic, and environmental concerns. Our findings reveal an environmental concern with coastal resources and a preference for light interventions such as palisades and gangways, as well as dune vegetation preferences for coastal erosion mitigation.

The paper raises important questions for the design of sustainable coastal policies that are increasingly important in the context of climate change. Uncertainty and complexity are important traits of coastal erosion processes, as different actions may reinforce themselves, implying an acceleration of these processes. The several dams on the Douro River and its tributaries, for instance, modify the flow pattern and may, as a consequence, contribute to a lower capacity of the coastal sediment transport system, thus accelerating coastal erosion. In the face of this, academics and experts should manage to be humble regarding coastal policies implications. The consequence is that even if discrete choice experiments as a mechanism for eliciting individuals' preferences may not operate as a final and determinate criterion for public decision-making, it may play the role of a heuristic offering to support decision-making in many situations, because in coastal erosion management, cost, time, and uncertainty are critical factors.

Regarding the significance of the variable distance to coast from place of stay when in Amorosa in explaining the perception of seriousness of coastal erosion amongst the users of *Praia da Amorosa*, the policy implications to be drawn rely on the involvement of local communities and communication actions.

However, the fact that the perception of the users of *Praia da Amorosa* about the causes of coastal erosion does not always correspond to the academics' and experts' opinions (see, for instance, what is said above about the impact of dams on the acceleration of coastal erosion) raises important questions. In particular, what is intended to be the scope and relevance of the involvement of local communities in allowing the different and possible conflictive perspectives of coastal erosion management techniques to surface and be open to scrutiny? What role can academics, experts, and public decision-makers play in empowering communities?

Additionally, the preference for light interventions opens space for envisaging other more natural courses of action, such as planned retreat of coastal populations and the use of nature-based solutions to manage coastal erosion.

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