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Assessing the heterogeneity of public acceptability for mangrove restoration through a choice experiment

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ABSTRACT

Mangroves are one of the most biodiverse but degraded type of ecosystems globally. There has been a strong impetus for mangrove restoration globally to compensate for mangrove loss. Understanding the public acceptability and preference heterogeneity for mangrove restoration could help practitioners tailor restoration programs, improve stakeholder engagement, and ultimately improve the chances of restoration success. Here we conduct a choice experiment to understand the heterogeneity of public acceptability for mangrove restoration in the Large Xiamen Bay (LXB), China. We estimate the total economic value of mangrove restoration and compare the marginal willingness to pay (MWTP) for each attribute (including an ecosystem disservice) between participants with different socio-demographic characteristics and living locations. Using both the random parameter logit model and latent class model, our results reveal that the respondents' location, socio-demographic characteristics, interaction with the coastal environment, and knowledge about mangroves have significant effects on their acceptability and preference for mangrove restoration. Such findings can provide guidance to practitioners when planning and implementing mangrove restoration projects, to improve the effectiveness and equity of restoration actions in LXB and beyond. By including an ecosystem disservice our study arguably elicits more comprehensively preference tradeoffs, which should be considered in future applications of choice experiments for ecosystem restoration.

1. Introduction

Mangroves are one of the most biodiverse ecosystems on the planet (Lee et al., 2014), and provide many different ecosystem services to local and global communities. These include, among others, food, raw materials, climate regulation, coastal protection and recreational opportunities (Friess et al., 2020). However, mangrove ecosystems and their services are threatened by human activity and natural processes, including deforestation, overexploitation and sea-level rise (Goldberg et al., 2020). Despite the large-scale loss of mangroves in the past decades, widespread conservation and restoration actions have reduced the rate of mangrove deforestation from 1 to 2% to roughly 0.13% per year over the last three decades (Bryan-Brown et al., 2020).

Large-scale mangrove restoration has received substantial policy traction in the past decade. Some international examples include the strong restoration goals articulated in the United Nations Decades on Ecosystem Restoration and the post-2020 Global Biodiversity Framework. The former seeks to spur restoration actions globally for very diverse types of ecosystems with many of the current flagship initiatives involving large-scale mangrove restoration (UNEP, 2023). The latter came into effect following the 15th Conference of the Parties of the United Nations Convention on Biological Diversity (CBD-COP15) to guide actions worldwide to preserve and protect nature and its essential services to people en-route to living in harmony with nature by 2050. One of its main aims is for at least 30% of degraded ecosystems to be under effective restoration by 2030 (Target 2) and restoration featuring in other targets (e.g. Target 10–11) (CBD, 2022). Mangrove-related guidance and indicators have already been developed to achieve the 2050 vision for biodiversity (Wetlands International, 2021). Similarly, at the national level many countries with large mangrove cover such as

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Indonesia and China have set up goals for restoring mangroves: 600,000 ha by 2024 for Indonesia (Mursyid et al., 2021) and 18,800 ha by 2025 for China (Wang et al., 2021a).

However, despite the strong international and national policy interest and impetus for ecosystem restoration (including for mangroves), several challenges remain. For example, ecosystem restoration interventions can have significant costs, both related to the technical and management costs of the restoration interventions (De Groot et al., 2013), as well as the opportunity costs associated with other land uses (Morán-Ordóñez et al., 2022). At the same time, the shifting environmental and social baselines "require" the articulation of restoration goals that not only reflect ecological criteria when assessing restoration success and effectiveness, but also consider the effects of restoration on human wellbeing, equity, landscape multifunctionality, and resilience (Fischer et al., 2021). As a result it has been argued that restoration initiatives should be context-specific and consider broader social and economic benefits in order to encourage greater stakeholder involvement (Aronson and Alexander, 2013). With the increasing interest in identifying the intricate linkages between restoring ecosystem health and improving social wellbeing, there have been many studies unraveling social preferences in the context of ecosystem restoration (Alba-Patiño et al., 2021; Aronson et al., 2016).

For example, several studies have aimed to elicit social preferences in the context of ecosystem restoration, as a means of informing restoration actions (Alba-Patiño et al., 2021). Choice experiments have been one of the most promising methods to estimate the willingness to pay (WTP) for restoration action due to their ability to identify preferences for multiple ecosystem services and evaluate the total economic value of environmental change or ecosystem management (Khan and Zhao, 2019). There have been several choice experiment applications for ecosystem restoration (Hynes et al., 2021; Kunwar et al., 2020), including a few for mangrove restoration (de Rezende et al., 2015; Iqbal, 2020; Wang et al., 2021b). Mangrove-related choice experiments have mainly focused on valuing mangrove ecosystem services, including nursery and breeding ground for fish, biodiversity richness and abundance, shoreline erosion protection, education and research (Wang et al., 2021b), leaves, grasses and twigs collection, fruit and honey collection (Iqbal, 2020), and water quality (Wang et al., 2021b).

However, there are two major knowledge gaps when eliciting societal preferences for ecosystem restoration in general (and mangrove restoration in particular), as discussed below. First, few previous studies in the context of ecosystem restoration have investigated the heterogeneity of preferences and the underlying sources. Second, a large fraction of ecosystem restoration studies has failed to account for ecosystem disservices from restoration actions. These two gaps are particularly evident in the mangrove restoration literature.

In terms of preference heterogeneity, it has been argued that its robust assessment can be key to improving public involvement and ultimately, the success of ecosystem restoration (Cai et al., 2020). For example, the public (or different social segments) may have strong preferences for particular ecosystem services from restored landscapes, which could impact their participation and acceptance of restoration actions (Pueyo-Ros et al., 2019). Similar to designing, planning and implementing ecosystem restoration actions, it is also essential to understand the heterogeneity of public preferences and the relationship with particular socio-economic and individual characteristics. This information can help to both identify target households and regions for the successful implementation of restoration planning (Beharry-Borg et al., 2013), as well as to guide the design of effective restoration actions (Chen et al., 2018). Heterogeneity in choice experiments stems from the fact that choice behaviors are determined by individual preferences and differences in the characteristics of ecosystem management and restoration (Cai et al., 2020). In the specific context of mangrove restoration the heterogeneity of its benefits may arise from the socio-demographic characteristics of individuals (e.g. education or income) (Iqbal, 2020), interaction with the coastal environment (e.g. distance or frequency of visits to the seashore) (Danley et al., 2021), or knowledge about mangroves (Jin et al., 2018). However, comparatively few choice experiments in mangrove restoration applications have dealt adequately with heterogeneity as most studies tend to investigate the economic value and preferences (Wang et al., 2021b). As the delivery of the social benefits of ecosystem restoration are strongly linked to public acceptability it is necessary to develop a strong evidence base about the characteristics of (and factors behind) heterogeneity of preferences for ecosystem restoration (Fischer et al., 2021), including for mangrove restoration that is rather underexplored in the literature.

When it comes to ecosystem disservices, several studies have identified that restoration actions may generate different disservices such as bushfire risk (Wilson et al., 2019), an increase in ecological hazards or nuisances (Buckley and Crone, 2008), or negative feelings such as dislike, disgust or fear (Treves et al., 2013). Specifically for mangroves, both natural and restored mangroves can generate varied disservices such as odor (Friess et al., 2020) or sickness and bad air (Cummings and Shah, 2018). It has been argued that both ecosystem services and disservices should be taken into account when valuing ecosystem management through stakeholder assessment (Zabala et al., 2021). However, relatively few choice experiments on the field of ecosystem management have considered disservices, with some of the rare examples including pest abundance when developing sponge parks (Toledo-Gallegos et al., 2022) and irrigation water demand in agroecosystems (Zabala et al., 2021). In fact most studies employing choice experiments for ecosystem restoration have not considered possible disservices (Hynes et al., 2021; Kunwar et al., 2020), something that is also visible in the mangrove restoration literature (Iqbal, 2020; Wang et al., 2021b). However, as ecosystem disservices sometimes cause strong negative perceptions about mangroves and their restoration (Friess et al., 2020) it is important to not only present the benefits of mangrove restoration in choice experiments, but also their negative effects, in order to avoid deviating the scenario from real market evidence and causing hypothetical bias (Hensher, 2010). Arguably, understanding better the effects of such disservices for public preferences (and the underlying heterogeneity) is important for creating a comprehensive evidence base for the public acceptability of restoration actions, which is particularly important under such great ambitious goal of ecosystem restoration.

Considering the above, this study aims at assessing the heterogeneity of public acceptability and preferences for mangrove restoration using a choice experiment. We focus on the Large Xiamen Bay (LXB) in southeast China. On the one hand the LXB contains a highly degraded mangrove ecosystem, which is gradually targeted for extensive restoration actions from the local and the national government. Beyond these amenable conditions for mangrove restoration the LXB region is characterized by diverse a topography and demographic and socioeconomic circumstances, which make it an ideal context to explore the heterogeneity of public preferences for mangrove restoration. We collect primary data through 1600 household surveys across the LXB, and we apply the random parameter logit model to calculate the Willingness to Pay (WTP). We compare WTP for four respondent groups living in locations characterized by different distances to the seashore (i.e. coastal vs. inland) and existence of mangroves in their nearby sea areas (i.e. mangroves vs. no mangroves). We further use the latent class model to test how respondents' socio-demographic characteristics, interaction with the coastal environment, and knowledge about mangroves affect the heterogeneity of preferences. Section 2 outlines the study site, the choice experiment design, and the data collection and analysis methods. Section 3 presents the main results, followed by their critical discussion and implications for policy and practice (Section 4).

2. Methodology

2.1. Study site

The Large Xiamen Bay ecosystem (LXB) is a semi-closed subtropical bay on the west bank of the Taiwan Strait, at the southeast coast of China (Fig. 1). The bay covers an approximate sea area of 1288 km^2, and contains a 333 km-long tortuous coastline and an intertidal area of 305 km^2. The bay contains several scattered islands and islets, mainly under the jurisdiction of Xiamen City and Kinmen County. A significant part of the north and south areas of the LXB is administered by Quanzhou City and Zhangzhou City, respectively. The different jurisdiction of the LXB and its spatial distribution of natural resources makes this region appropriate to explore the heterogeneity of acceptability of mangrove restoration. For instance, areas governed by Longhai District of Zhangzhou City have the largest mangrove cover (> 400 ha) while some districts of Xiamen City and Quanzhou City do not have mangroves. The stages of socioeconomic development are also various across the 9 districts of the LXB, with the disposable per capita income in 2022 ranging from 48,094 CNY/year in Longhai District to 64,261 CNY/year in Haicang District of Xiamen City.

Historically, the Xiamen Bay contained approximately 320 ha of natural mangroves in the 1960s. However, by 2005 the natural mangrove stands shrank dramatically to a mere 21 ha due to the rapid urbanization, economic development and the expansion of aquaculture ponds (Lin et al., 2005). Although the artificial plantation of mangroves and the natural regeneration of degraded mangroves have somehow reversed the shrinking of mangrove habitats, the fact remains that they are still very fragmented (Zhang et al., 2021). The current mangrove habitats in the LXB span approximately 477 ha based on the satellite image on Google Earth (July 26, 2019). Following the national action plan for mangrove forest restoration (Section 1), a provincial government action plan was published in December 2020, which set a mangrove restoration goal of 424 ha in the LXB by 2025. The large scale of mangrove restoration needs community involvement to ensure both conservation and sustainability, which is current insufficient in mangrove restoration projects in China (Lushan, 2022). This study takes the first step to understand how residents would accept mangrove restoration and the possible heterogeneity of the acceptability. The results could help decision-makers better design community involvement in restoration projects.

2.2. Survey design

2.2.1. Choice experiment attributes and design

In order to understand the preferences of local residents about mangrove restoration, mangrove ecosystem services and willingness to pay, the choice experiment used seven attributes namely: the restoration area, four mangrove ecosystem services, one ecosystem disservice, and the payment. Such format has been common in choice experiments seeking to elicit the preferences of individuals for ecosystem conservation (Müller et al., 2020) and restoration (Hynes et al., 2021). Table 1 summarizes the attributes and levels included in the choice experiment, and below we justify their selection.

In terms of the restoration area attribute, and when considering the importance of tidal flats for biodiversity and ecosystem services (Murray et al., 2019), we assumed that the upper limit of the area for mangrove restoration is 20% of the available mudflat area (3600 ha). With that in mind we created a spectrum of restoration areas, namely: 72 ha, 180 ha, 360 ha, 720 ha, 1200 ha, 2400 ha, and 3600 ha.

Subsequently we based the selection of the four ecosystem services attributes on a recent study about the perception of coastal residents in LXB on mangrove ecosystem services (Su and Gasparatos, 2023). This study elicited the perceived importance of mangrove ecosystem services in the LXB, and found that the most important ecosystem services in each category were (a) food production (Fisheries) (for provisioning services), (b) climate regulation and coastal protection (for regulating services), and (c) aesthetic values (for cultural services).

Specifically, the mean biomass of fisheries production (i.e., fish, crab, shrimp) in restored mangroves was used to indicate the impact of different restoration levels on fish capture increases. According to Das (2017), mudflats planted and enriched with mangrove plantations could increase the average fish catch by 2.436 kg per day per fisherman. Climate regulation was expressed in terms of the equivalent number of cars taken off the road (He et al., 2017) in order to facilitate the respondents' understanding of this attribute. Here, the average vehicle CO_2 emission (EAA, 2020) and carbon accumulation rate in mangroves (Alongi, 2014) were used to estimate the levels of this attribute. For coastal protection we applied the average value of reduced property loss due to typhoon protection from mangroves (Huang, 2017) in Xiamen, Zhangzhou, and Quanzhou. Considering the lack of a suitable quantitative way to measure aesthetic values from ecosystems (Himes-Cornell et al., 2018), we assigned three qualitative levels of aesthetic view of mangrove restoration (Table 1).

In addition to the benefits of mangrove restoration (i.e. ecosystem services from restored mangroves), we also included one attribute depicting an unfavorable consequence of mangrove restoration. This was done to ensure that respondents fully understand the outcomes of mangrove restoration actions and underlying trade-offs (Friess et al., 2020) and reduce to some extent the hypothesis bias[1] (Fifer et al., 2014). As mangrove wetlands are often perceived to present a mosquito 'problem' and be a source of pests that affect nearby residential areas (Claflin and Webb, 2017), we used increases in mosquito population as an ecosystem disservice of mangrove restoration. Studies have been argued that the size and percentage of the mangrove stand have a positive effect on mosquito abundance (Claflin and Webb, 2017). As there is no straightforward way to provide quantitative estimates for this ecosystem disservices as it depends on many factors (Siwiendrayanti et al., 2020), we used three qualitative levels of mosquito increase (Table 1).

The last attribute is the payment for mangrove restoration, both in terms of payment level and vehicle. Regarding the latter, respondents are asked to pay for mangrove restoration through an increase in their household annual tax exclusively designed to conserve and restore the coastal and marine ecosystems. The selected payment vehicle was based on a previous study that concluded that earmarked taxes were perceived as fair and easy-to-understand economic instruments for financing climate change mitigation measures in the coastal and marine environment (Remoundou et al., 2015). We evaluated the proper range of costs using the reported mean values (USD 209,312.1 per ha in 2019 USD) of mangrove restoration as estimated in a recent meta-analysis (Su et al., 2021). To align with the governmental action plan, the cost for mangrove restoration per household in the upper limit of the restoration area (3600 ha) shall be 300 CNY $year^{-1}$ in the next five years, assuming that every household in the LXB is willing to pay for mangrove restoration. Hence, we chose 300 CNY as the upper limit for the costs. Subsequently we developed a spectrum of values ranging between 0 and 300 CNY $year^{-1}$ (i.e. 0, 20, 50, 100, 150, 200, 300 CNY $year^{-1}$), which are equivalent to other relevant studies (Khan and Zhao, 2019) (i.e., 0, 50, 100, 200, 300 CNY $year^{-1}$).

A choice set includes three alternatives. The first two represent scenarios of mangrove restoration, and the last one represents the status quo. The status quo depicted the current situation, which pertained to unvegetated tidal flats in the absence of mangrove restoration. The levels of attributes for the status quo were fixed to "Zero" for the restoration area and cost, and "No change" for restoration outcomes (i.e. the four ecosystem services and one disservice). The levels for the other two alternatives varied according to the experimental design plan. Bayesian efficient design on Ngene Software (Version 1.2.1)

[1] In choice experiments the hypothesis bias reflects the different choices made by individuals in hypothetical settings as opposed to those made in real life situations (Fifer et al., 2014). Hypothesis bias can influence estimates of WTP through underestimation when an initial amount is provided to the respondents (Moser et al., 2014) or overestimation when respondents do not make choice subject to the budget constraint (Iqbal, 2020).

Fig. 1. Map of the Large Xiamen Bay (China).

Table 1
Attributes and levels used in the choice experiment.

Attributes	Levels			
	Status quo	Low	Medium	High
Restoration area (*ha*)	72, 180, 360, 720, 1200, 2400, 3600			
Increase in fish capture (added kg/month/fisherman)	No change	36	73	146
Climate regulation (equivalent to CO_2 emission savings from *cars* per hour)	No change	65	130	260
Coastal protection from typhoon (billion CNY)	No change	1	2	4
Aesthetic value (qualitative)	No change	Average	Nice	Perfect
Increase in mosquito population (qualitative)	No change	Low	Moderate	Significant
Cost (CNY/household/year)	10, 20, 50, 100, 150, 200, 300			

(ChoiceMetrics, 2018) was used to generate the choice cards. Overall, twenty-eight choice sets were generated and randomly divided into four blocks, i.e., each respondent made seven choices with one of the four blocks. We added two constraints in the experimental design to avoid dominant alternatives (Johnson and Orme, 1996). If the restoration area in Alternative One is larger than in Alternative Two, then the restoration payment in Alternative One should be higher than in Alternative Two and vice versa. Prior estimates for each attribute were initially identified through relevant literature (He et al., 2017; Hynes et al., 2021).

Fifty pilot choice experiment surveys were conducted in August 2021 to verify and modify the prior estimates for the final experimental design. Feedback in the form of written comments was collected from respondents during the pilot survey to understand their acceptance and understanding of the design of choice experiment. Overall, the respondents of the pilot survey stated that the design of attributes and levels within the choice experiment were acceptable and easily understood. The final value of D-error for the choice experiment design was estimated at 0.076, which implies a good statistical efficiency of designs (Bhattarai et al., 2019).

2.2.2. Survey structure

The survey instrument consisted of three sections. The first section collected baseline information about (a) the respondents' travel time and frequency of visits to the seashore, (b) their knowledge about mangroves, and (c) their awareness of mangrove existence along the neighboring coast. Knowledge and awareness of mangroves were elicited through Likert-scale questions (e.g. score 1 = Not at all aware to 5 = Very aware), with higher scores indicating higher knowledge and awareness of mangroves.

The second section contained seven choice tasks, of which the first card was omitted from the econometric analysis in order to minimize the error variance and hence, maximize the statical power of the model (Carlsson et al., 2012). The third section contained questions about the respondents' socio-demographic characteristics, including education level and income.

In order to facilitate the understanding of mangrove ecosystems, respondents had to watch a 100-s introduction film and then answer a question from the film before making the choices. In the subsequent analysis we considered the surveys of only those respondents that answered this question correctly. The choice experiment rules, explanation of attributes, and reminders about budget constraints were presented before the choice cards. To make the restoration scenarios more understandable, we applied a picture-based approach to describe the different levels of restoration outcomes (Jeanloz et al., 2016). Fig. 2 shows an example of a choice card.

2.3. Data collection

The final survey was administered to a random sample of residents in

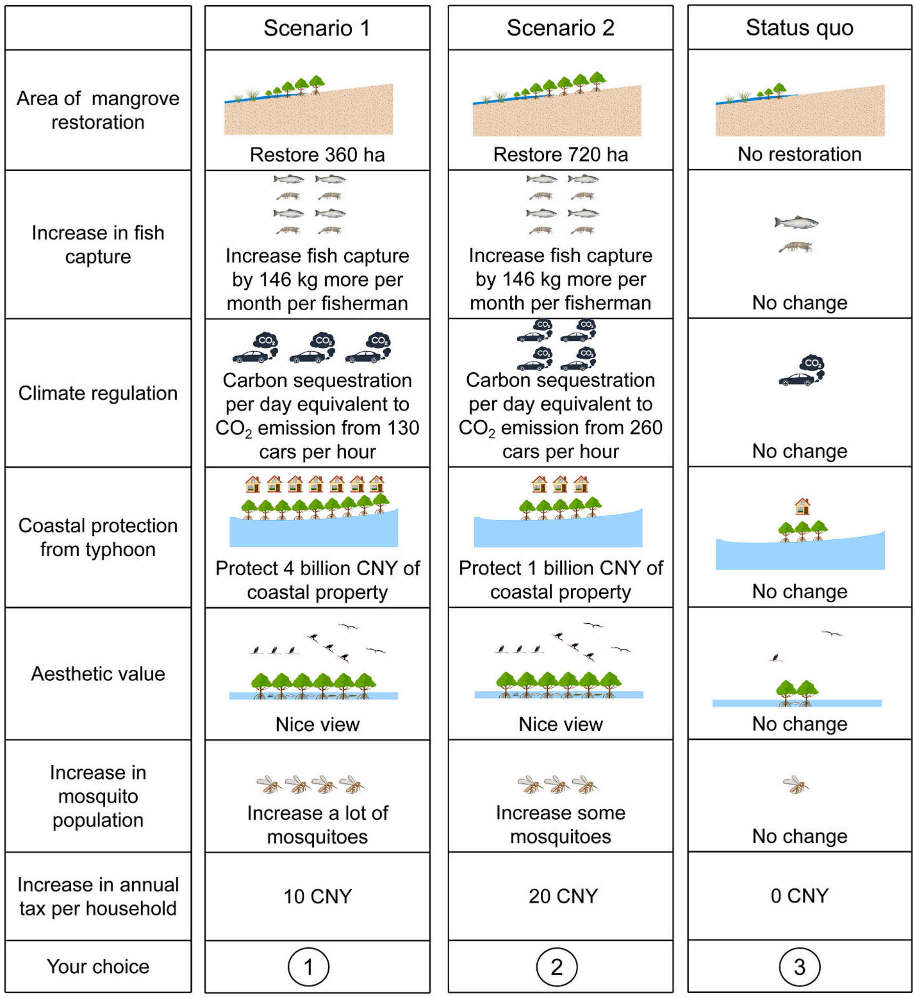

Fig. 2. Sample choice card used in the survey.

Xiamen City, Longhai City, Jinjiang City, and Nan'an City in September 2021 using an online survey platform due to the restriction posed by the COVID-19 pandemic. A total of 1600 questionnaires were disseminated, with 400 surveys per block (Section 2.2). Each of the four blocks was randomly assigned to a respondent.

To ensure the validity of our sample, we filtered participants with two exclusion criteria: (a) be at least 18 years of age, and (b) currently residing in Xiamen City, Longhai City, Jinjiang City, and Nan'an City. If a respondent did not meet any of these two criteria, they were not allowed to participate in the survey. Beyond that, we used the following criteria to filter invalid data: (a) response time of <120 s; (b) repetitive answers (e.g. A for all questions)[2]; (c) wrong answers after the introductory film; and (d) irrational or incompatible answers (e.g. illogically large number of household members).

In the end, 1029 samples met our criteria and were usable for the econometric analysis (Section 2.4). To investigate the spatial heterogeneity of the responses, we used the travel time to the seashore by car, to divide residents living in coastal or inland areas. Based on the preliminary analysis of samples (Table S1 in Supplementary Material), respondents who reported living in areas with a travel time < 15 min to the seashore were classified as coastal residents, whereas those who need >15 min were classified as inland residents. In addition, based on the district and presence of mangroves, we identified respondents as those living in (a) areas with mangroves (residents in Longhai, Haicang, Tong'an, Jimei and Xiang'an districts) and (b) without mangroves (Jinjiang, Nan'an, Siming, and Huli districts) (see Fig. 1).

2.4. Data analysis

The standard random utility modeling (RUM) framework (McFadden, 1974) and the Lancaster theory of value (Lancaster, 1966) form the analytical basis of choice experiments. Previous modelings of discrete choices have used the Multinomial Logit Model (MNL) (Hensher et al., 2005), which is built on the assumption that respondents have homogeneous preferences and that there is independence of irrelevant alternatives (IIA). However, the IIA assumption is generally rejected for the unobserved preferences heterogeneity among respondents (Louviere et al., 2010). To account for heterogeneity in preference and scale associated with uncertainties, we implemented here both the random parameter logit model (RPL) (Hensher and Greene, 2003) and the Latent Class Model (LCM) (Greene and Hensher, 2003), with and without interaction of socio-demographic variables.

2.4.1. Random parameter logit (RPL) model

The RPL takes preference heterogeneity into account and helps relax the IIA. Rather than calculating a single probability for each alternative,

[2] We only removed samples that chose the same option across all questions or had certain repetitive patterns. Considering that there are 32 questions in the survey instrument, the possibility of repetitive answers but valid responses could be very low. This issue of repetitive responses has been discussed in previous studies as "careless responding" (Ward and Meade, 2023), and can lead to a different results even for a small proportion of samples (e.g. 5%).

the RPL calculates the choice probability for each random draw taken from the assumed probability distributions. We estimate the RPL at 500 times MLHS draws (Hess et al., 2006) due to the fact that the number of attributes is higher than five.

We estimated two specifications for the RPL. In model 1, we included all attributes as random parameters and assumed that all attributes follow a normal distribution, except for cost, which is log-normally distributed to avoid theoretical inconsistencies of positive preferences for the payment (Dang Vu et al., 2022). In the second model, we included interaction terms between residents who live in the coast area (binary) and residents who live in areas with mangroves (binary) to test for the spatial heterogeneity (i.e. due to living environments) of preferences (Section 2.3).

An Alternative Specific Constant (ASC) is included in both models to capture preferences for the "no restoration" scenario (i.e. the status quo). The utility obtained by respondent *n* from the alternative *j* could be expressed as shown in Eq. (1):

$$U_{nj} = V_{nj} + \varepsilon_{nj} = \alpha_j ASC_j + \sum_k \beta_{nk} X_{njk} + \sum_k \gamma_{nk} X_{njk} C_n + \mu_{nj} ASC_{nj} C_n \epsilon_{nj} \quad (1)$$

where V_{ij} denotes the deterministic component of utility, ϵ_{ij} denotes the unobserved component, X_{njk} indicates the attributes, β_{nk} is the coefficient revealing the aggregate preference of an individual β_k. For the random portion of the utility, interactions of characteristics of individual C_n with attributes X_{njk} or alternative specific constants ASC_{nj}, γ_{nk} and μ_{nj} are interpreted as the explanation of the heterogeneity of preferences (Louviere et al., 2010).

We used estimated parameters from the model without interaction terms (Model 1) to derive the marginal willingness-to-pay (WTP) for mangrove restoration for the whole LXB. In addition, in order to estimate the heterogeneity of marginal WTP across attributes we divided the samples into four subgroups: (a) coast & mangroves, (b) coast & no mangroves, (c) inland & mangroves, and (d) inland & no mangroves (see Section 2.3 for the division criteria). Following Mariel et al. (2021) we used Eq. (2) to estimate the marginal WTP and employed the commonly applied delta model to compute the standard errors (Kruse and Atkinson, 2022):

$$MWTP_k = -\frac{\beta_k}{exp\left(\beta_{cost} + \frac{stde_{cost}^2}{2}\right)} \quad (2)$$

Compensating surplus (CS), measuring the welfare effects of changes (in this case, mangrove restoration), is a better and more appropriate instrument to guide policy decisions (Dias and Belcher, 2015). The CS for a change from the status quo x^0 (i.e. unvegetated tidal flat in this case) to a specified alternative x^1 (i.e. the chosen restoration area in this case) is following Hanemann utility difference formula (Hanemann, 1984) as per Eq. (3):

$$CS = -\frac{1}{\beta_{cost}} \left\{ ln\left[\sum exp\left(\beta_j x_{ik}^1\right)\right] - ln\left[\sum exp\left(\beta_j x_{ik}^0\right)\right] \right\} \quad (3)$$

here we considered a linear utility function and only change of one attribute, and hence the CS estimation in this study was given by Eq. (4):

$$CS = \frac{\beta_k}{exp\left(\beta_{cost} + \frac{stde_{cost}^2}{2}\right)} \left(A_k^1 - A_k^0\right) \quad (4)$$

where the CS represents the consumer surplus derived from changing from the current situation to a specific restoration scenario. This result indicates the mean WTP for mangrove restoration per household, while the total economic value of mangrove restoration in the LXB was estimated by multiplying this value with the number of households willing to pay for mangrove restoration. The total number of households willing to pay was estimated by multiplying the fraction of households willing to pay in our sample with the total number of households in the study areas.

2.4.2. Latent Class models (LCM)

While the RPL captures heterogeneity at the individual level, the Latent Class Model (LCM) accommodates preference heterogeneity at the group level (Kruse and Atkinson, 2022). It assumes that the population consists of groups of individuals who have homogeneous preferences within each class, but differ between them. Characterizing such groups can be particularly valuable in assessing the magnitude of support for specific policy characteristics in democratic decision-making processes to inform policy designs (Kruse and Atkinson, 2022).

For the LCM, we hypothesized that two socio-demographic characteristics (i.e. income and education), the visit frequency to the seashore and the knowledge of mangroves, would be relevant for determining class membership. The two socio-demographic characteristics were mostly used to explain the variation in ecosystem service values (Quintas-Soriano et al., 2018). The last two factors reflect the interaction between humans and nature to explore the impacts of these interactions on their preferences for mangrove restoration (Pedersen et al., 2019).

To identify the number of classes, we used those with the lowest Bayesian Information Criterion (BIC) and Akaike Information Criterion (AIC) (Boxall and Adamowicz, 2002). The estimation of preferences was calculated using a computationally simpler MNL (Greene and Hensher, 2003). Both RPL and LCM analyses were conducted using the Apollo package (Hess and Palma, 2019) in R version 4.1.2.

2.5. Limitations

The main limitation of this study is that data was collected through an online survey due to the constraints posed by the COVID-19 pandemic, it is possible that there is a bias toward people more likely to use the online survey platform. For example, the respondents in our sample tend to be relatively younger and have a higher level of education (Section 3.1), than the average population. Other studies in the field of ecosystem services or ecosystem conservation have made similar observations when using online survey tools (Hynes et al., 2021). This may cause bias in our results, and should be taken into consideration when generalizing the results of this study.

Furthermore, there is a possibility of uncertainty in how respondents understand the qualitative levels of mosquito population increase and aesthetic value considering different individuals may interpret these attributes and levels differently. Although we believe that both attributes can be understood intuitively and despite providing an introducing video, in-text explanations before the choice tasks, and picture-based choice cards, there is still likelihood of uncertainty that should be considered when generalizing findings.

3. Results

3.1. Descriptive statistics

The proportion of collected data by area is 70.4% in Xiamen City, 10.1% in Longhai City, 10.5% in Jinjiang City, and 9.0% in Nan'an City, which reflects well the relative population size and geographic characteristics of the three cities. Table 2 provides an overview of the summary statistics for the overall valid sample ($n = 1029$). Of the 1029 respondents included in the analysis, 48% were males and the most prevalent age group was 25–34 years old. The average income in the study sample is 17,243.4 CNY/household/month. We further compare in Table 2 the descriptive statistics of the sample with the general population statistics for the LXB collected during the Seventh National Population Census of China in 2021. Overall, although the respondents in this study are on average slightly younger with higher education level (Section 2.5), the samples reflect well the population of the LXB.

Of all respondents, 25% were aware of the presence of mangroves in

Table 2
Socio-demographic profile of the respondents.

	Sample Mean (s. d.)	General Population*
Gender (female = 0)	0.48 (0.5)	0.53
Age (years)	31.58 (9.48)	36.6
Location of residence (urban = 1)	0.79 (0.41)	0.84
Household size (number of members)	3.97 (1.29)	2.42
Education level (years)	15.52 (2.25)	11.37
Income (CNY/household/month)	17,243 (13664)	
Individual income (CNY/month)	4343.3	5121.5
Distance to seashore by vehicle (min)	18.48 (13.31)	
Frequency of visits to seashore (number/ year)	21.54 (29.45)	
Knowledge about mangrove	1.99 (0.92)	
Awareness of mangrove existence	0.25 (0.76)	
Support for mangrove restoration	4.31 (0.82)	
No. of observations	1029	

* Data from The Seventh National Population Census of China (2021).

the LXB, while 17.2% claimed to have a higher than moderate knowledge of mangroves. Overall, 96.4% of all respondents were willing to pay for mangrove restoration, and only 3.6% ($n = 37$) chose the status quo alternative through all choice tasks (see Section 2.2.1).

Tables S2 and S3 in the Supplementary Material summarize the basic characteristics of the coastal/inland and mangrove/no mangrove groups. The sample sizes for those living in a district with mangroves or those living in a coastal area are around half and half, respectively. Those living in an area with mangroves are significantly more aware of mangrove presence in the LXB (0.39 vs 0.12 for no mangrove group, $p < 0.001$). However, they did not have significantly higher knowledge about mangroves (2.02 vs 1.96). When compared to inland residents, the coastal respondents visited the seashore significantly more frequently (31.53 times per year for coastal residents vs 10.55 for inland residents, $p < 0.001$), were significantly more aware of the presence of mangroves (0.33 vs 0.17, $p < 0.001$) and had significantly higher knowledge about them (2.08 vs 1.89, $p < 0.001$). Interestingly, there were no significant differences in support for mangrove restoration between respondents living in coastal or inland areas, or areas containing or not containing mangroves.

3.2. Random parameter logit model results

A total of 6174 choice observations were included in the analysis, of which 10.5% represented the "Zero restoration" option. The results of the Random Parameter Logit (RPL) model are reported in Table 3. Model 1 contains only the non-fixed attributes (i.e. without interactions), and Model 2 includes interactions with the characteristics of the respondents. The coefficients for the ASC in both models representing the preference for "Zero restoration" option are significantly negative, suggesting that respondents preferred restoring mangroves over the "Zero restoration" option. Furthermore, as expected, we observe negative coefficients for the mangrove disservice and payment attributes, while positive coefficients for the four mangrove ecosystem services.

We use Model 1 to inform the economic value of mangrove restoration. Respondents are willing to pay 0.35 CNY/household/year to increase the area of restored mangroves by 1 ha. According to the 7th national census report, there are approximately 3.71 million households in the LXB. When considering the total number of households willing to pay for mangrove restoration in the LXB, the marginal economic value of mangrove restoration is 12,519.4 CNY ha^{-1} yr^{-1} (equivalent to 1941.0 USD ha^{-1} yr^{-1} using the 2021 average exchange rate). The compensating surplus (CS) for mangrove restoration in the LXB is 148,589.08 CNY ha^{-1} yr^{-1} (equivalent to 23,037.1 USD ha^{-1} yr^{-1} in 2021).

When considering the effect of the household location (Model 2), we observe that respondents living in the coastal areas or areas with mangroves are more willing to pay for mangrove restoration (Table 3). When

Table 3
Random Parameter Logit Model results.

Variable	Model1	Model 2
ASC	−10.6703*** (0.8996)	−10.6546*** (0.8125)
Restoration area (km^2)	0.0098** (0.0050)	0.0063* (0.0042)
Increase in fish capture (kg)	0.0025*** (0.0009)	0.0012** (0.0007)
Climate regulation	0.0031*** (0.0005)	0.0020*** (0.0004)
Coastal protection	0.1548*** (0.0257)	0.0827*** (0.0217)
Aesthetic value	0.1428*** (0.0367)	0.0564** (0.0308)
Increase in mosquito population	−0.3832*** (0.0453)	−0.1441*** (0.0379)
Cost	−5.6584*** (0.1725)	−5.8213*** (0.1744)
Restoration area × Coast		0.0097 (0.0097)
Increase in fish capture × Coast		−0.0022*(0.0017)
Climate regulation × Coast		0.0010 (0.0010)
Coastal protection × Coast		0.0345 (0.0509)
Aesthetic value × Coast		−0.0084 (0.0750)
Increase in mosquito population × Coast		−0.1200*(0.0888)
Cost × Coast		0.0028***(0.0010)
Restoration area × Mangrove		−0.0148* (0.0095)
Increase in fish capture × Mangrove		0.0025*(0.0017)
Climate regulation × Mangrove		−0.0026*** (0.0010)
Coastal protection × Mangrove		−0.0510 (0.0505)
Aesthetic value × Mangrove		0.0627 (0.0747)
Increase in mosquito population × Mangrove		−0.0824 (0.0864)
Cost × Mangrove		0.0016* (0.0011)
sd. ASC	8.0663*** (0.6344)	8.1313***(0.6058)
sd. Restoration area	−0.0967*** (0.0078)	−0.0471*** (0.0037)
sd. Increase in fish capture	−0.0035 (0.0066)	−0.0029**(0.0013)
sd. Climate regulation	−0.0047*** (0.0013)	−0.0015*(0.0010)
sd. Coastal protection	−0.1010 (0.1556)	0.0640*(0.0437)
sd. Aesthetic value	−0.4258*** (0.0762)	0.2171***(0.0469)
sd. Increase in mosquito population	−0.4458*** (0.0965)	−0.2361*** (0.0433)
sd. Cost	2.0425*** (0.1210)	1.6666***(0.1190)
No. of choice sets/respondents	6174/1029	6174/1029
Log likelihood	−4508.85	−4493.34
AIC	9049.69	9046.68
BIC	9157.34	9248.52

1. ***, **, * indicate significance at 1%, 5%, 10% level.
2. sd. indicates the standard deviation from the average preference in the RPL.

it comes to the specific non-payment attributes, the respondents living in inland areas or areas without mangroves had a higher preference for increased fish capture through mangrove restoration. We also see that the respondents living in areas without mangroves are more likely to support large-scale mangrove restoration and have a higher preference for climate regulation services, while they are less likely to have high preference for the aesthetic values provided by mangrove restoration.

We further compare the marginal WTP across different attributes among the four subgroups: (a) "coast & mangroves", (b) "coast & no mangroves", (c) "inland & mangroves", and (d) "inland & no mangroves" (Fig. 3, Table S4 in Supplementary Material). We observe that respondents living in "coast & mangroves" areas had significant marginal WTP for mangrove restoration. In addition, consistent with Model 2, respondents living in "inland & mangroves" areas are significantly more likely to pay for an increase in fish capture from mangrove restoration. For the regulating services, we observe that except for respondents living in "inland & mangroves" areas (that did not have a significant marginal WTP for climate regulation), the respondents in other three subregions had positive and significant marginal WTP for the regulating services. Compared to other subregions, respondents living in the "inland & no mangroves" areas had significantly higher marginal WTP for climate regulation and typhoon protection. We observe that

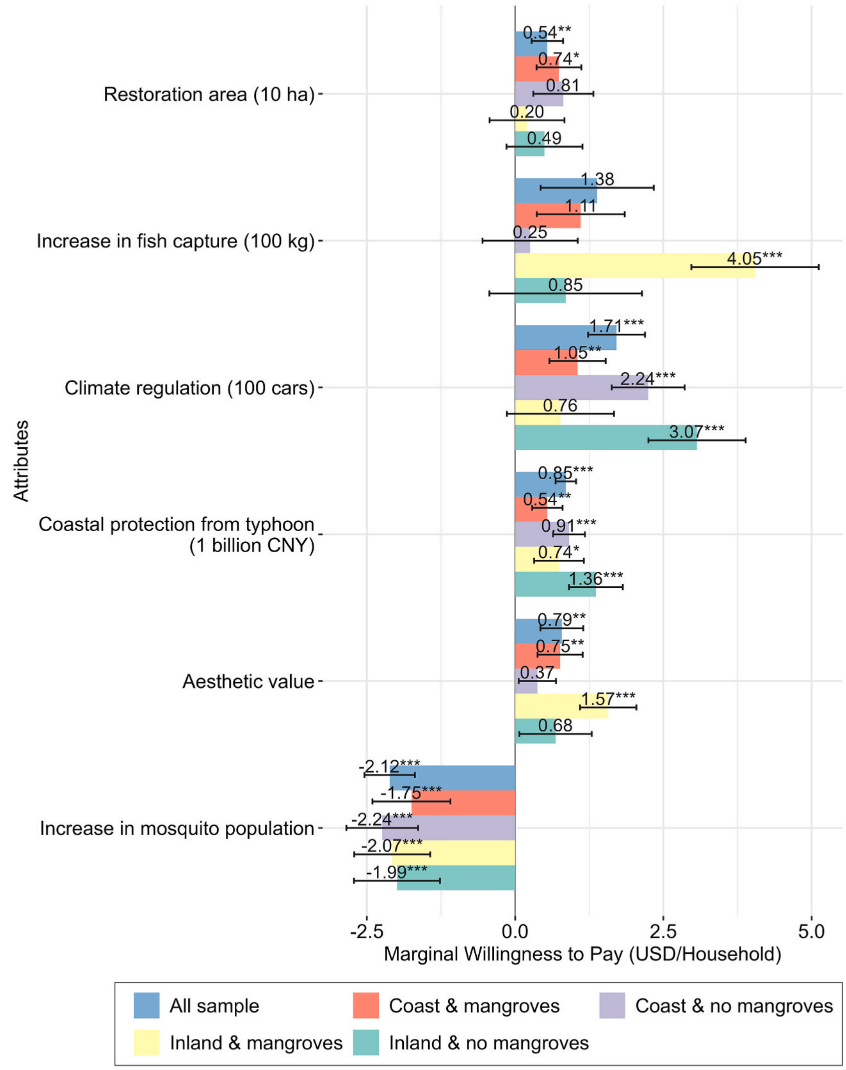

Fig. 3. Marginal Willingness To Pay (MWTP) per household for the six attributes across subgroups. Notes: ***, **, * indicate significance at 1%, 5%, 10% level.

only residents in the areas with mangroves have significant marginal WTP for the aesthetic values of restored mangroves, while all four subgroups have significant and negative marginal WTP for the increase of mosquitos due to mangrove restoration. Respondents living in "coastal & no mangroves" areas had the lowest absolute coefficient among all groups, suggesting their relatively lower dislike.

3.3. Latent class model results

According to Table 4 the latent class model identifies five classes using the AIC and BIC criteria (Table S5 in Supplementary Material). The first three classes contain a relatively similar fraction of the total sample (32.8%), while the last two classes contain relatively smaller segments of the overall sample.

Respondents in Class 1 have the highest positive preference for climate regulation and aesthetic values provided from mangrove restoration. Respondents in this class can be characterized by higher income levels and visiting the seashore frequently. Respondents in Class 2 are more likely to have higher education and a middle-income level, and Class 2 is the only segment that has a preference for increased fish capture from mangrove restoration. Although this class has a positive preference for all mangrove ecosystem services, it demonstrates opposition to larger-scale mangrove restoration.

Respondents in Class 3 can be characterized by higher knowledge about mangroves, a middle-income level, and frequent visits to the seashore. They prefer a higher level of mangrove restoration, which could provide substantial typhoon protection services. However, the respondents in this class expressed opposition to other services, such as increases in fish capture, climate regulation, and aesthetic value. The respondents in Class 4 are against higher levels of mangrove restoration, and do not have significant preferences for mangrove ecosystem services. They are less likely to be knowledgeable about mangroves and can be characterized as middle-income and higher educated. The smallest segment, Class 5, can be characterized by lower income, lower education, and less frequent visits to the seashore. They have the strongest preference for coastal protection, while they oppose increases in fish capture and aesthetic value from mangrove restoration. Finally, it should be mentioned that despite their heterogeneity, the respondents from all classes have significant opposition to increases in mosquito population from mangrove restoration.

4. Discussion

When considering the ambitious mangrove restoration targets established by international organizations and coastal countries, it is important to understand the heterogeneity of its acceptability to inform the design of efficient and context-specific restoration actions. Although various studies have evaluated mangrove restoration using choice

Table 4
Result of the latent class model.

Variable	Class 1	Class 2	Class 3	Class 4	Class 5
ASC	−3.6300*** (0.1592)				
Restoration area (km^2)	0.1340*** (0.0230)	−0.0214*** (0.0037)	0.0294*** (0.0091)	−0.0383*** (0.158)	0.0116 (0.0325)
Increase in fish capture	−0.0008 (0.0025)	0.0032*** (0.0008)	−0.0095*** (0.0025)	0.0009 (0.0032)	−0.0282*** (0.0076)
Climate regulation	0.0106*** (0.0024)	0.0015*** (0.0005)	−0.0036** (0.0016)	−0.0013 (0.0021)	0.0068** (0.0039)
Coastal protection	0.1652*** (0.0563)	0.1180*** (0.0270)	0.2199** (0.0989)	0.1522 (0.1311)	1.2288*** (0.3343)
Aesthetic value	0.2056*** (0.0834)	0.1369*** (0.0359)	−0.7190*** (0.1052)	0.1511 (0.1687)	−1.1850*** (0.3049)
Increase in mosquito population	−0.2997*** (0.0879)	−0.1657*** (0.0390)	−0.9851*** (0.1372)	−0.3957*** (0.1534)	−1.1461*** (0.2873)
Cost	0.0019** (0.0011)	−0.0075*** (0.0007)	0.0010 (0.0014)	−0.0297*** (0.0034)	−0.0907*** (0.0172)
Education	0.0040 (0.0617)	0.1364*** (0.0580)	0.0310 (0.0871)	0.1497** (0.0910)	
Income	0.2759*** (0.0759)	0.1515** (0.0709)	0.1466* (0.0985)	0.1494* (0.0980)	
Frequency of visits to seashore	0.2086** (0.1196)	0.0323 (0.1139)	0.1971* (0.1505)	0.1261 (0.1588)	
Knowledge about mangroves	0.2321 (0.1196)	0.1257 (0.1829)	0.7465*** (0.2217)	−0.2819 (0.3135)	
Constant	−1.1662 (0.9958)	−0.9239 (0.9294)	−3.2278** (1.3977)	−2.7653** (1.5690)	
Mean probability of class allocation	32.8%	32.8%	32.8%	1.6%	0.00%
Log likelihood	−4527.81				
AIC	9167.62				
BIC	9544.4				

Notes: ***, **, * indicate significance at 1%, 5%, 10% level.

experiments (de Rezende et al., 2015; Wang et al., 2021a), such studies have not contained critical information on the heterogeneity of preferences. As already outlined in Section 1 this is a broader observation from the wider ecosystem restoration literature (Sinclair et al., 2021). To overcome this gap, in this study, we applied a choice experiment to quantify the public acceptability of mangrove restoration, further investigating the heterogeneity of preferences across different locations, individual socio-demographic characteristics, and their interaction with the coastal environment and mangrove knowledge. Below we critically discuss some of the main findings of the random parameter logit model and latent class models (Section 4.1–4.2) and the main implications for policy and practice in the Large Xiamen Bay, and beyond (Section 4.3).

4.1. Preferences for choice experiment attributes

Our results clearly show that the respondents have positive preferences for all mangrove ecosystem services and negative preferences for the disservice (Table 3 and Fig. 3). The sole focus of many choice experiment studies on the ecosystem services benefits of ecosystem/mangrove restoration (de Rezende et al., 2015; Iqbal, 2020) belies the potential negative influences and perceptions that mangroves can have on the surrounding population (Friess et al., 2020), which would induce certain hypothetical bias (Fifer et al., 2014). To the best of our knowledge, this is the first study that has included a mangrove disservice as an attribute in a choice experiment, with the findings indicating a significant negative preference for the potential increase of mosquitoes from mangrove restoration (Table 3 and Fig. 3). This strongly suggests that it is not enough to only consider the beneficial ecosystem services from mangroves (whether natural or restored), but need to provide a balanced view of also the negative aspects if we are to obtain a comprehensive picture of how humans relate to and interact with coastal ecosystems (Friess et al., 2020). We should point that although the addition of this disservice can help us appreciate a bit better the trade-offs inherent in ecosystem/mangrove restoration preferences, we cannot conclusively say that it eliminated hypothetical bias. This would have likely needed a different design with some control group to estimate possible effects on hypothetical bias, which should be explored in future studies.

However, despite the inclusion of this mangrove disservice, the WTP estimates suggest a high prospective demand for mangrove restoration among the respondents throughout the study site. The mean WTP of 23,037.1 USD ha^{-1} year^{-1} for mangrove restoration falls within the range of the estimated total value of restored mangroves (155.2 to 541,351.6 in 2021 USD ha^{-1} yr^{-1}) and is comparable to the mean value (20,658.9 in 2021 USD ha^{-1} yr^{-1}) as identified in a recent meta-analysis of the economic benefits of mangrove restoration (Su et al., 2021). However, this value is lower than the total value of mangrove ecosystem services from natural mangroves in Xiamen City (56,884.6 in 2021 USD ha^{-1} yr^{-1}) (Su and Peng, 2021). Although this discrepancy is in line with the reported evidence that the economic values of restored mangroves are lower than those of natural mangroves (Su et al., 2021), the result suggests possible underestimation in our study. This underestimation may be due to the fact that the overwhelming majority of the population in the LXB does not rely on mangroves for their livelihoods. In addition, the marginal WTP (2013.5 USD ha^{-1} yr^{-1}) is lower than the average WTP, suggesting decreasing returns to scale from mangrove restoration. This result is consistent with expectations in the literature about the relationship between marginal and average values in the context of ecosystem conservation (Salem and Mercer, 2012).

4.2. Preference heterogeneity due to location and respondent characteristics

Our research focuses on regional-scale restoration where respondents shared similar institutional and cultural contexts. Preferences were not significantly different for all attributes between respondents in different locations (Table 3). However, our findings suggest that both the location (i.e. living in coastal or inland areas, living in areas that contain or do not contain mangroves) and characteristics of the respondents have significant effects for some preferences (Table 3).

In more detail, respondents living closer to the seashore tend to be more willing to pay for mangrove restoration (Fig. 3), which is in line with previous research on distance decay effects on ecosystem valuation estimates (Danley et al., 2021). However, we do not observe a clear pattern when comparing the marginal WTP for other attributes between coastal and inland residents, which may be attributed to another factor such as the existence of mangroves in nearby sea areas (Fig. 3). For instance, we observe that respondents living in areas that contain mangroves would have higher WTP to increased fish capture and aesthetic values. This finding is consistent with recent research that local communities living near mangroves rely more on provisioning services than those far away from mangrove boundaries (Nyangoko et al., 2020). Furthermore, the aesthetic value could influence real estate prices (Vo et al., 2012), which may incentivize preference for this cultural service. A good example of this benefit is a previous mangrove restoration project in Wuyuan Bay, Xiamen City (Chen et al., 2012). A large business circle formed after the restoration around Wuyuan Bay, including the business sector, financial sector, real estate, etc., which boosted a huge development of real estate in Xiamen City (Xue and Dong, 2010). On the contrary, respondents living in coastal areas without mangroves would prefer climate regulation and typhoon protection, which shows the opportunity to establish blue carbon credits as a means of raising funds for mangrove restoration or other similar actions (Friess et al., 2022).

Beyond the effects of location on preference heterogeneity, we also investigated how socio-demographic characteristics of the respondents affect heterogeneity. Overall, higher-income respondents (i.e. members of Class 1) are more willing to support and pay for mangrove restoration, which conforms to similar studies that household income has a positive impact on the protection of the mangrove forest (Iqbal, 2020) or acceptance of general ecosystem restoration initiatives (Martínez-Paz et al., 2021). In addition, our findings show that even though the education level of members in Class 2 and 4 is higher than that of members in Class 3, the preference for restoration areas in Class 2 and 4 is not as positive as in Class 3. This disparity may be due to the generally higher mangrove knowledge among the members of Class 3. This suggests that mangrove-related education is imperative and more important than regular education when it comes to mangrove restoration in our case, something that has been identified in other ecosystem restoration (Garzón et al., 2020) and conservation (Ardoin et al., 2020) contexts. A higher frequency of visiting the seashore (i.e. Class 1 members) would also motivate respondents to pay for mangrove restoration, as such frequent visits can offer opportunities to directly experience, closely observe and establish connections with the coastal environment, thereby influencing respondent preferences (Hua et al., 2021).

Overall, we found large heterogeneity in preferences for mangrove restoration. Respondents in Class 1 and 3, by virtue of having a higher visitation frequency to the seashore and more knowledge about mangroves, were more likely to support a larger scale of restoration. This suggests the importance of mangrove-related education and interactive activities to enhance the support for mangrove restoration (Owuor et al., 2019). In addition, Classes 2 and 4 preferred the increases in fish capture, while the other three classes opposed it. Class 1 also had the strongest preference for climate regulation and aesthetic values, while Class 3 and 5 opposed aesthetic value. Only the preference for typhoon protection is relatively homogeneous between classes (significant and positive value), except for Class 4. This implies a common preference by respondents throughout the LXB to promote mangrove restoration as a nature-based solution to protect the coastal communities from typhoons and other related natural hazards (Kumar et al., 2021).

4.3. Implications for policy and practice

The results reported in this paper can have important implications both for ecosystem/mangrove restoration locally (i.e. in the LXB) and more broadly (i.e. other regions), as well as choice experiment applications more widely.

In terms of local implications, we find that residents in the LXB have a high prospective demand for mangrove restoration. This gives certain justification for the extensive mangrove restoration plans undertaken by the local and national governments in the region (see Section 2.1). Below we expand on two important findings that can inform restoration actions at the local level.

First, the estimated WTP for mangrove restoration can be considered as the economic value of restored mangroves in the LXB (Hynes et al., 2021). This can be used to inform the design and implementation of local incentive-based conservation approaches for mangrove restoration, such as payment for ecosystem services (PES) schemes, as proposed in other choice experiments for ecosystem restoration (Pérez-Rubio et al., 2021). However, further research would be needed to actually design critical PES components for the LXB such as the payment structures, markets or incentives (Thompson and Friess, 2019). Coordinated policies and a conducive institutional environment will also be needed as the ecosystem is managed by multiple sectors who may often have contradictory political objectives (Afroz et al., 2016).

Second, the result of this study, combined with findings from the same region about the residents' preferences for mangrove ecosystem services (Su and Gasparatos, 2023) and priority areas for restoration (Su et al., 2022), can inform in a tangible manner the ongoing restoration efforts and related local decision-making processes to ensure that restoration actions meet ecological realities and human needs (Zimmer, 2018). For instance, the homogenous need across respondents with different individual characteristics and from different locations to restore mangroves against coastal hazards, gives strong signals to restoration practitioners to identify appropriate areas (Su et al., 2022) and landscape design features (e.g. in terms of tree density and size, forest width) (Lee et al., 2021) to ensure the delivery of wave attenuation functions from the restored mangroves. However, there is a need to also understand the priorities and vested interests of other powerful actors such as the government, businesses, and the private sector. Furthermore, our results suggest the strong effect of mangrove disservices (increased mosquito populations in this study), which is in line with other non-mangrove studies using choice experiments (Toledo--Gallegos et al., 2022) or other techniques (Wilson et al., 2019). Such disservices should be accounted in mangrove restoration planning and implementation in the LXB, and mitigated to the extent possible, e.g. through buffer zones between restored mangrove habitats and residential areas to reduce mosquito nuisance (Dworrak et al., 2022).[3] We also find that respondents reporting a higher visitation frequency to the seashore and more extensive knowledge about mangroves, are more likely to support larger-scale restoration actions. This implies the critical need for local decision-makers to promote mangrove-related education and awareness-raising activities,[4] as a means of enhancing public support for mangrove restoration in the LXB.

In terms of implications for mangrove restoration in other regions, our study adds to the currently limited literature on preference heterogeneity in mangrove restoration (see Gap 1, Section 1). It is widely recognized that public acceptability affects significantly the ability to achieve ecosystem restoration goals (Walpole et al., 2020), and it is for this reason that the delineation of the heterogeneity of public preferences for mangrove restoration are valuable. For instance, our finding that WTP preferences both in terms of overall sum and justification (i.e.

[3] We must point that decisions over possible mitigation plans of disservices should be evidence-based and reflect not only the ecological and socioeconomic context of the restoration area, but also the acceptability of different stakeholders and economic aspects such as the costs of construction and maintenance, as well as possible opportunity costs (Knight et al., 2017).

[4] Such activities should reflect the cultural, demographics and socioeconomic realities of the LXB. Promising examples from other mangrove restoration contexts include mangrove education-based ecotourism (Khakhim et al., 2021) and environmental education (Sigit et al., 2019).

attribute preferences), varied widely by location (Section 3.2) and socio-economic characteristics (Section 3.3) could be useful in other geographical contexts that share similar characteristics. For example, under the right conditions (and while mindful of local contexts) the WTP estimates can be possibly used in restoration valuations for benefit transfer functions to inform restoration actions in other regions (Iftekhar et al., 2017). Furthermore, the factors affecting the heterogeneity of social acceptability could be used to foresee to some extent the acceptability of mangrove restoration in other regions, e.g. anticipate that residents who are wealthier and/or visit the seashore frequently are more likely to support mangrove restoration, especially for climate regulation and aesthetic value (Table 4). These could be particularly insightful for mangrove restoration actions in heavily urbanised contexts such as the LXB. Such insights could inform large-scale mangrove restoration during the United Nations Decades on Ecosystem Restoration and the implementation of the post-2020 Global Biodiversity Framework.

Finally, in terms of the broader application of choice experiment for ecosystem restoration, by including a disservice as an attribute and observing the very distinct preferences for the different services and disservices, our study arguably emphasizes the importance of providing a balanced view of restoration actions. By solely presenting and considering the benefits of ecosystem restoration and by omitting possible negative outcomes such exercises may end up being biased and propagate incomplete information for decision-making. In this sense we argue for the need to consider both ecosystem services and disservices when eliciting the acceptability of ecosystem restoration actions (including through choice experiments) to enable more comprehensive and sustainable planning (Wilson et al., 2019).

5. Conclusion

Our study provides important insights into public acceptability and preferences for mangrove restoration. By accounting for heterogeneity in the elicited preferences through the random parameter logit model and latent class model, our results reveal that the respondents' location, socio-demographic characteristics, interaction with the coastal environment, and knowledge about mangroves significantly affect their acceptability and preference for mangrove restoration. Decision-makers should consider this heterogeneity in preference when designing, planning, and implementing mangrove restoration actions on the ground. Furthermore, in the context of the expanding mangrove restoration projects and related efforts in China and other countries under the UN decade on Ecosystem Restoration and the post-2020 Global Biodiversity Framework, these findings highlight the necessity for upscaling awareness-raising and education activities (including interactive activities) to enhance the public awareness and knowledge of mangroves. Albeit the significant heterogeneity in preferences, we also found that residents across the LXB have a uniform preference for coastal protection services from restored mangroves, emphasizing the need to ensure this function when designing restoration projects in the region. Overall, this study attempted to address two major knowledge gaps, namely the inadequate consideration of heterogeneity and ecosystem disservices in choice experiments for ecosystem restoration in general and mangrove restoration in particular. The findings of this study unravel the factors that have significant effect on the acceptability and preferences for mangrove restoration between the general population, which have implications for the design and implementation of mangrove restoration in local and broader contexts. The significant effects of ecosystem disservices on acceptability and preferences emphasizes the critical need of the comprehensive consideration alongside actual benefits in ecosystem restoration studies (including through choice experiment) and implementation.

Although this study has explored the underlying sources of the heterogeneity in the preferences of the respondents, it is still unclear how these multiple and heterogeneous values and preferences can be incorporated meaningfully to set rational restoration objectives. Future studies could explore how to integrate these diverse values and preferences to set mangrove restoration objectives. In addition, although here we elicited the perceptions of residents across the LXB coming from different geographical, demographic and socio-economic backgrounds, future research could further identify the preferences in specific communities (e.g. fisherfolk, aquaculture farmers) using other social science methods (e.g. surveys, focus group discussions, deliberative methods), to further understand their preferences, needs and expectations from mangrove restoration in order to tailor future restoration programs in the actual localities where they will be implemented.

CRediT authorship contribution statement

Jie Su: Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Project administration, Validation, Visualization, Writing – original draft, Writing – review & editing. **Alexandros Gasparatos:** Conceptualization, Funding acquisition, Software, Supervision, Writing – review & editing.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

Data will be made available on request.

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Appendix A. Supplementary data

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References

Afroz, S., Cramb, R., Grünbühel, C., 2016. Ideals and institutions: systemic reasons for the failure of a social forestry program in South-West Bangladesh. Geoforum 77, 161–173. https://doi.org/10.1016/j.geoforum.2016.11.001.

Alba-Patiño, D., Carabassa, V., Castro, H., Gutiérrez-Briceño, I., García-Llorente, M., Giagnocavo, C., Gómez-Tenorio, M., Cabello, J., Aznar-Sánchez, J.A., Castro, A.J., 2021. Social indicators of ecosystem restoration for enhancing human wellbeing. Resour. Conserv. Recycl. 174, 105782 https://doi.org/10.1016/j.resconrec.2021.105782.

Alongi, D.M., 2014. Carbon cycling and storage in mangrove forests. Annu. Rev. Mar. Sci. 6, 195–219. https://doi.org/10.1146/annurev-marine-010213-135020.

Ardoin, N.M., Bowers, A.W., Gaillard, E., 2020. Environmental education outcomes for conservation: a systematic review. Biol. Conserv. 241, 108224 https://doi.org/10.1016/j.biocon.2019.108224.

Aronson, J., Alexander, S., 2013. Ecosystem restoration is now a global priority: time to roll up our sleeves: news report from CBDCOP11. Restor. Ecol. 21, 293–296. https://doi.org/10.1111/rec.12011.

Aronson, J.C., Blatt, C.M., Aronson, T.B., 2016. Restoring ecosystem health to improve human health and well-being: physicians and restoration ecologists unite in a common cause. E&S 21, art39. https://doi.org/10.5751/ES-08974-210439.

Beharry-Borg, N., Smart, J.C.R., Termansen, M., Hubacek, K., 2013. Evaluating farmers' likely participation in a payment programme for water quality protection in the UK uplands. Reg. Environ. Chang. 13, 633–647. https://doi.org/10.1007/s10113-012-0282-9.

Bhattarai, N., Mcmeekin, P., Price, C.I., Vale, L., 2019. Preferences for centralised emergency medical services: discrete choice experiment. BMJ Open 9, e030966. https://doi.org/10.1136/bmjopen-2019-030966.

Boxall, P.C., Adamowicz, W.L., 2002. Understanding heterogeneous preferences in random utility models: a latent class approach. Environ. Resour. Econ. 23, 421–446. https://doi.org/10.1023/A:1021351721619.
Bryan-Brown, D.N., Connolly, R.M., Richards, D.R., Adame, F., Friess, D.A., Brown, C.J., 2020. Global trends in mangrove forest fragmentation. Sci. Rep. 10, 7117. https://doi.org/10.1038/s41598-020-63880-1.
Buckley, M.C., Crone, E.E., 2008. Negative off-site impacts of ecological restoration: understanding and addressing the conflict. Conserv. Biol. 22, 1118–1124. https://doi.org/10.1111/j.1523-1739.2008.01027.x.
Cai, Y., Zhao, M., Shi, Y., Khan, I., 2020. Assessing restoration benefit of grassland ecosystem incorporating preference heterogeneity empirical data from Inner Mongolia Autonomous Region. Ecol. Indic. 117, 106705 https://doi.org/10.1016/j.ecolind.2020.106705.
Carlsson, F., Mørkbak, M.R., Olsen, S.B., 2012. The first time is the hardest: a test of ordering effects in choice experiments. J. Choice Model. 5, 19–37. https://doi.org/10.1016/S1755-5345(13)70051-4.
CBD, 2022. Kunming-Montreal Global Biodiversity Framework. UNEP, Montreal, Canada.
Chen, B., Yu, W., Liu, W., Liu, Z., 2012. An assessment on restoration of typical marine ecosystems in China – achievements and lessons. Ocean Coast. Manag. 57, 53–61. https://doi.org/10.1016/j.ocecoaman.2011.11.007.
Chen, W.Y., Hua, J., Liekens, I., Broekx, S., 2018. Preference heterogeneity and scale heterogeneity in urban river restoration: a comparative study between Brussels and Guangzhou using discrete choice experiments. Landsc. Urban Plan. 173, 9–22. https://doi.org/10.1016/j.landurbplan.2018.01.010.
ChoiceMetrics, 2018. Ngene [Computer software]. https://www.choice-metrics.com/index.html.
Claflin, S.B., Webb, C.E., 2017. Surrounding land use significantly influences adult mosquito abundance and species richness in urban mangroves. Wetl. Ecol. Manag. 25, 331–344. https://doi.org/10.1007/s11273-016-9520-0.
Cummings, A.R., Shah, M., 2018. Mangroves in the global climate and environmental mix. Geogr. Compass 12, e12353. https://doi.org/10.1111/gec3.12353.
Dang Vu, H.N., Nielsen, M.R., Jacobsen, J.B., 2022. Conserving rhinos by legal trade: insights from a choice experiment with rhino horn consumers. Ecol. Econ. 193, 107287 https://doi.org/10.1016/j.ecolecon.2021.107287.
Danley, B., Sandorf, E.D., Campbell, D., 2021. Putting your best fish forward: investigating distance decay and relative preferences for fish conservation. J. Environ. Econ. Manag. 108, 102475 https://doi.org/10.1016/j.jeem.2021.102475.
Das, S., 2017. Ecological restoration and livelihood: contribution of planted mangroves as nursery and habitat for artisanal and commercial fishery. World Dev. 94, 492–502. https://doi.org/10.1016/j.worlddev.2017.02.010.
De Groot, R.S., Blignaut, J., Van Der Ploeg, S., Aronson, J., Elmqvist, T., Farley, J., 2013. Benefits of investing in ecosystem restoration: investing in ecosystem restoration. Conserv. Biol. 27, 1286–1293. https://doi.org/10.1111/cobi.12158.
de Rezende, C.E., Kahn, J.R., Passareli, L., Vásquez, W.F., 2015. An economic valuation of mangrove restoration in Brazil. Ecol. Econ. 120, 296–302. https://doi.org/10.1016/j.ecolecon.2015.10.019.
Dias, V., Belcher, K., 2015. Value and provision of ecosystem services from prairie wetlands: a choice experiment approach. Ecosyst. Serv. 15, 35–44. https://doi.org/10.1016/j.ecoser.2015.07.004.
Dworrak, T.V., Sauer, F.G., Kiel, E., 2022. Wetland conservation and its effects on mosquito populations. Wetlands 42, 96. https://doi.org/10.1007/s13157-022-01613-y.
EAA, 2020. Average CO2 emissions from newly registered motor vehicles in Europe — European Environment Agency [WWW Document]. European Environmental Agency (accessed 6.16.21). https://www.eea.europa.eu/data-and-maps/indicators/average-co2-emissions-from-motor-vehicles/assessment-2.
Fifer, S., Rose, J., Greaves, S., 2014. Hypothetical bias in stated choice experiments: is it a problem? And if so, how do we deal with it? Transp. Res. A Policy Pract. 61, 164–177. https://doi.org/10.1016/j.tra.2013.12.010.
Fischer, J., Riechers, M., Loos, J., Martin-Lopez, B., Temperton, V.M., 2021. Making the UN decade on ecosystem restoration a social-ecological Endeavour. Trends Ecol. Evol. 36, 20–28. https://doi.org/10.1016/j.tree.2020.08.018.
Friess, D.A., Yando, E.S., Alemu, J.B., Wong, L.-W., Soto, S.D., Bhatia, N., 2020. Chapter 3 Ecosystem Services and Disservices of Mangrove Forests and Salt Marshes.
Friess, D.A., Howard, J., Huxham, M., Macreadie, P.I., Ross, F., 2022. Capitalizing on the global financial interest in blue carbon. PLOS Clim. 1, e0000061 https://doi.org/10.1371/journal.pclm.0000061.
Garzón, N.V., Rodríguez León, C.H., Ceccon, E., Pérez, D.R., 2020. Ecological restoration-based education in the Colombian Amazon: toward a new society–nature relationship. Restor. Ecol. 28, 1053–1060. https://doi.org/10.1111/rec.13216.
Goldberg, L., Lagomasino, D., Thomas, N., Fatoyinbo, T., 2020. Global declines in human-driven mangrove loss. Glob. Chang. Biol. 26, 5844–5855. https://doi.org/10.1111/gcb.15275.
Greene, W.H., Hensher, D.A., 2003. A latent class model for discrete choice analysis: contrasts with mixed logit. Transp. Res. B Methodol. 37, 681–698. https://doi.org/10.1016/S0191-2615(02)00046-2.
Hanemann, W.M., 1984. Welfare evaluations in contingent valuation experiments with discrete responses. Am. J. Agric. Econ. 66, 332–341. https://doi.org/10.2307/1240800.
He, J., Dupras, J., Poder, G.T., 2017. The value of wetlands in Quebec: a comparison between contingent valuation and choice experiment. J. Environ. Econ. Policy 6, 51–78. https://doi.org/10.1080/21606544.2016.1199976.
Hensher, D.A., 2010. Hypothetical bias, choice experiments and willingness to pay. Transp. Res. B Methodol. 44, 735–752. https://doi.org/10.1016/j.trb.2009.12.012.
Hensher, D.A., Greene, W.H., 2003. The mixed logit model: the state of practice. Transportation 30, 133–176. https://doi.org/10.1023/A:1022558715350.
Hensher, D.A., Rose, J.M., Greene, W.H., 2005. Applied Choice Analysis: A Primer. Cambridge University Press, Cambridge, New York.
Hess, S., Palma, D., 2019. Apollo: a flexible, powerful and customisable freeware package for choice model estimation and application. J. Choice Model. 32, 100170 https://doi.org/10.1016/j.jocm.2019.100170.
Hess, S., Train, K.E., Polak, J.W., 2006. On the use of a modified Latin hypercube sampling (MLHS) method in the estimation of a mixed logit model for vehicle choice. Transp. Res. B Methodol. 40, 147–163. https://doi.org/10.1016/j.trb.2004.10.005.
Himes-Cornell, A., Grose, S.O., Pendleton, L., 2018. Mangrove ecosystem service values and methodological approaches to valuation: Where do we stand? Front. Mar. Sci. 5, 376. https://doi.org/10.3389/fmars.2018.00376.
Hua, J., Chen, W.Y., Liekens, I., Cho, F.H.T., 2021. Partial attribute attendance in environmental choice experiments: a comparative case study between Guangzhou (China) and Brussels (Belgium). J. Environ. Manag. 285, 112107 https://doi.org/10.1016/j.jenvman.2021.112107.
Huang, Z., 2017. Measuring the Value of Coastal Wetland for Typhoon Protection: A Case Study of China (MAster thesis). Xiamen University.
Hynes, S., Chen, W., Vondolia, K., Armstrong, C., O'Connor, E., 2021. Valuing the ecosystem service benefits from kelp forest restoration: a choice experiment from Norway. Ecol. Econ. 179, 106833 https://doi.org/10.1016/j.ecolecon.2020.106833.
Iftekhar, M.S., Polyakov, M., Ansell, D., Gibson, F., Kay, G.M., 2017. How economics can further the success of ecological restoration: economics and ecological restoration. Conserv. Biol. 31, 261–268. https://doi.org/10.1111/cobi.12778.
Iqbal, Md.H., 2020. Valuing ecosystem services of Sundarbans mangrove forest: approach of choice experiment. Glob. Ecol. Conserv. 24, e01273 https://doi.org/10.1016/j.gecco.2020.e01273.
Jeanloz, S., Lizin, S., Beenaerts, N., Brouwer, R., Van Passel, S., Witters, N., 2016. Towards a more structured selection process for attributes and levels in choice experiments: a study in a Belgian protected area. Ecosyst. Serv. 18, 45–57. https://doi.org/10.1016/j.ecoser.2016.01.006.
Jin, J., He, R., Wang, W., Gong, H., 2018. Valuing cultivated land protection: a contingent valuation and choice experiment study in China. Land Use Policy 74, 214–219. https://doi.org/10.1016/j.landusepol.2017.09.023.
Johnson, R.M., Orme, B.K., 1996. How Many Questions Should you Ask in Choice-Based Conjoint Studies?.
Khakhim, N., Musthofa, A., Wicaksono, A., Lazuardi, W., Pratama, D.N.D., Marfai, M.A., 2021. Adaptation of mangrove ecotourism management to coastal environment changes in the special region of Yogyakarta. J. Environ. Manag. Tourism 12, 754–765. https://doi.org/10.14505/jemt.12.3(51).14.
Khan, I., Zhao, M., 2019. Water resource management and public preferences for water ecosystem services: a choice experiment approach for inland river basin management. Sci. Total Environ. 646, 821–831. https://doi.org/10.1016/j.scitotenv.2018.07.339.
Knight, J., Dale, P., Dwyer, P., Marx, S., 2017. A conceptual approach to integrate management of ecosystem service and disservice in coastal wetlands. Facult. Sci. Med. Health Pap. Part A, 431–442. https://doi.org/10.3934/environsci.2017.3.431.
Kruse, T., Atkinson, G., 2022. Understanding public support for international climate adaptation payments: evidence from a choice experiment. Ecol. Econ. 194, 107321 https://doi.org/10.1016/j.ecolecon.2021.107321.
Kumar, P., Debele, S.E., Sahani, J., Rawat, N., Marti-Cardona, B., Alfieri, S.M., Basu, B., Basu, A.S., Bowyer, P., Charizopoulos, N., Gallotti, G., Jaakko, J., Leo, L.S., Loupis, M., Menenti, M., Mickovski, S.B., Mun, S.-J., Gonzalez-Ollauri, A., Pfeiffer, J., Pilla, F., Pröll, J., Rutzinger, M., Santo, M.A., Sannigrahi, S., Spyrou, C., Tuomenvirta, H., Zieher, T., 2021. Nature-based solutions efficiency evaluation against natural hazards: modelling methods, advantages and limitations. Sci. Total Environ. 784, 147058 https://doi.org/10.1016/j.scitotenv.2021.147058.
Kunwar, S.B., Bohara, A.K., Thacher, J., 2020. Public preference for river restoration in the Danda Basin, Nepal: a choice experiment study. Ecol. Econ. 175, 106690 https://doi.org/10.1016/j.ecolecon.2020.106690.
Lancaster, K.J., 1966. A new approach to consumer theory. J. Polit. Econ. 74, 132–157. https://doi.org/10.1086/259131.
Lee, S.Y., Primavera, J.H., Dahdouh-Guebas, F., McKee, K., Bosire, J.O., Cannicci, S., Diele, K., Fromard, F., Koedam, N., Marchand, C., Mendelssohn, I., Mukherjee, N., Record, S., 2014. Ecological role and services of tropical mangrove ecosystems: a reassessment: reassessment of mangrove ecosystem services. Glob. Ecol. Biogeogr. 23, 726–743. https://doi.org/10.1111/geb.12155.
Lee, W.K., Tay, S.H.X., Ooi, S.K., Friess, D.A., 2021. Potential short wave attenuation function of disturbed mangroves. Estuar. Coast. Shelf Sci. 248, 106747 https://doi.org/10.1016/j.ecss.2020.106747.
Lin, P., Zhang, Y., Wang, Z., 2005. Protection and restoration of mangroves along the coast of Xiamen. J. Xiamen Univ. (Nat. Sci.) 44, 1–6.
Louviere, J.J., Hensher, D.A., Swait, J., Adamowicz, W.L., 2010. Stated Choice Methods: Analysis and Applications, 7. printing. ed. Cambridge Univ. Press, Cambridge.
Lushan, H., 2022. China Explores Involving Communities in Mangrove Restoration. China Dialogue. URL. https://chinadialogue.net/en/nature/china-explores-involving-communities-in-mangrove-restoration/ (accessed 9.10.23).
Mariel, P., Hoyos, D., Meyerhoff, J., Czajkowski, M., Dekker, T., Glenk, K., Jacobsen, J.B., Liebe, U., Olsen, S.B., Sagebiel, J., Thiene, M., 2021. Environmental Valuation with Discrete Choice Experiments: Guidance on Design, Implementation and Data Analysis, SpringerBriefs in Economics. Springer International Publishing, Cham. https://doi.org/10.1007/978-3-030-62669-3.
Martínez-Paz, J.M., Albaladejo-García, J.A., Barreiro-Hurle, J., Pleite, F.M.-C., Perni, Á., 2021. Spatial effects in the socioeconomic valuation of peri-urban ecosystems

restoration. Land Use Policy 105, 105426. https://doi.org/10.1016/j.landusepol.2021.105426.
McFadden, D., 1974. Conditional Logit Analysis of Qualitative Choice Behavior. Academic Press, New York.
Morán-Ordóñez, A., Hermoso, V., Martínez-Salinas, A., 2022. Multi-objective forest restoration planning in Costa Rica: balancing landscape connectivity and ecosystem service provisioning with sustainable development. J. Environ. Manag. 310, 114717 https://doi.org/10.1016/j.jenvman.2022.114717.
Moser, R., Raffaelli, R., Notaro, S., 2014. Testing hypothetical bias with a real choice experiment using respondents' own money. Eur. Rev. Agric. Econ. 41, 25–46. https://doi.org/10.1093/erae/jbt016.
Müller, A., Olschewski, R., Unterberger, C., Knoke, T., 2020. The valuation of forest ecosystem services as a tool for management planning – a choice experiment. J. Environ. Manag. 271, 111008 https://doi.org/10.1016/j.jenvman.2020.111008.
Murray, N.J., Phinn, S.R., DeWitt, M., Ferrari, R., Johnston, R., Lyons, M.B., Clinton, N., Thau, D., Fuller, R.A., 2019. The global distribution and trajectory of tidal flats. Nature 565, 222–225. https://doi.org/10.1038/s41586-018-0805-8.
Mursyid, H., Daulay, M.H., Pratama, A.A., Laraswati, D., Novita, N., Malik, A., Maryudi, A., 2021. Governance issues related to the management and conservation of mangrove ecosystems to support climate change mitigation actions in Indonesia. Forest Policy Econ. 133, 102622 https://doi.org/10.1016/j.forpol.2021.102622.
Nyangoko, B.P., Berg, H., Mangora, M.M., Gullström, M., Shalli, M.S., 2020. Community perceptions of mangrove ecosystem services and their determinants in the Rufiji Delta, Tanzania. Sustainability 13, 63. https://doi.org/10.3390/su13010063.
Owuor, M.A., Mulwa, R., Otieno, P., Icely, J., Newton, A., 2019. Valuing mangrove biodiversity and ecosystem services: a deliberative choice experiment in Mida Creek, Kenya. Ecosyst. Serv. 40, 101040 https://doi.org/10.1016/j.ecoser.2019.101040.
Pedersen, E., Weisner, S.E.B., Johansson, M., 2019. Wetland areas' direct contributions to residents' well-being entitle them to high cultural ecosystem values. Sci. Total Environ. 646, 1315–1326. https://doi.org/10.1016/j.scitotenv.2018.07.236.
Pérez-Rubio, I., Flores, D., Vargas, C., Jiménez, F., Etxano, I., 2021. To what extent are cattle ranching landholders willing to restore ecosystem services? Constructing a Micro-scale PES scheme in southern Costa Rica. Land 10, 709. https://doi.org/10.3390/land10070709.
Pueyo-Ros, J., Ribas, A., Fraguell, R.M., 2019. A cultural approach to wetlands restoration to assess its public acceptance. Restor. Ecol. 27, 626–637. https://doi.org/10.1111/rec.12896.
Quintas-Soriano, C., Brandt, J.S., Running, K., Baxter, C.V., Gibson, D.M., Narducci, J., Castro, A.J., 2018. Social-ecological systems influence ecosystem service perception: a programme on ecosystem change and society (PECS) analysis. E&S 23, art3. https://doi.org/10.5751/ES-10226-230303.
Remoundou, K., Diaz-Simal, P., Koundouri, P., Rulleau, B., 2015. Valuing climate change mitigation: a choice experiment on a coastal and marine ecosystem. Ecosyst. Serv. 11, 87–94. https://doi.org/10.1016/j.ecoser.2014.11.003.
Salem, M.E., Mercer, D.E., 2012. The economic value of mangroves: a meta-analysis. Sustainability 4, 359–383. https://doi.org/10.3390/su4030359.
Sigit, D.V., Miarsyah, M., Komala, R., Suryanda, A., Fadrikal, R., Ichsan, I.Z., 2019. Improvement of knowledge and attitude in conservation of mangrove and coral reefs through environmental education community network model. J. Phys. Conf. Ser. 1317, 012201 https://doi.org/10.1088/1742-6596/1317/1/012201.
Sinclair, M., Vishnu Sagar, M.K., Knudsen, C., Sabu, J., Ghermandi, A., 2021. Economic appraisal of ecosystem services and restoration scenarios in a tropical coastal Ramsar wetland in India. Ecosyst. Serv. 47, 101236 https://doi.org/10.1016/j.ecoser.2020.101236.
Siwiendrayanti, A., Anggoro, S., Nurjazuli, N., 2020. Literature review: the contribution of mangrove ecosystem condition to mosquito population. E3S Web Conf. 202, 05016. https://doi.org/10.1051/e3sconf/202020205016.
Su, J., Gasparatos, A., 2023. Perceptions about mangrove restoration and ecosystem services to inform ecosystem-based restoration in Large Xiamen Bay, China. Landsc. Urban Plan. 235, 104763 https://doi.org/10.1016/j.landurbplan.2023.104763.
Su, J., Peng, B., 2021. Evaluating the trade-offs between alternative coastal policies: evidence from Xiamen's ICM programme. Ocean Coast. Manag. 207, 104516 https://doi.org/10.1016/j.ocecoaman.2018.05.012.
Su, J., Friess, D.A., Gasparatos, A., 2021. A meta-analysis of the ecological and economic outcomes of mangrove restoration. Nat. Commun. 12, 5050. https://doi.org/10.1038/s41467-021-25349-1.
Su, J., Yin, B., Chen, L., Gasparatos, A., 2022. Priority areas for mixed-species mangrove restoration: the suitable species in the right sites. Environ. Res. Lett. https://doi.org/10.1088/1748-9326/ac6b48.
Thompson, B.S., Friess, D.A., 2019. Stakeholder preferences for payments for ecosystem services (PES) versus other environmental management approaches for mangrove forests. J. Environ. Manag. 233, 636–648. https://doi.org/10.1016/j.jenvman.2018.12.032.
Toledo-Gallegos, V.M., My, N.H.D., Tuan, T.H., Börger, T., 2022. Valuing ecosystem services and disservices of blue/green infrastructure. Evidence from a choice experiment in Vietnam. Econom. Analys. Pol. 75, 114–128. https://doi.org/10.1016/j.eap.2022.04.015.
Treves, A., Naughton-Treves, L., Shelley, V., 2013. Longitudinal analysis of attitudes toward wolves: attitudes toward wolves deteriorated. Conserv. Biol. 27, 315–323. https://doi.org/10.1111/cobi.12009.
UNEP, 2023. UN Decade on Ecosystem Restoration: 10 Flagship Initiatives Boosting Nature and Livelihoods Around the world [WWW Document]. URL. https://www.unep.org/interactive/flagship-initiatives-boosting-nature-livelihoods/?gclid=CjwKCAjwjOunBhB4EiwA94JWsKDUIrT2jLPAg7wT50XA3oR3vTS6qpFTAIBPWw1ipmJ2-7oHJLs89BoCFzEQAvD_BwE#1 (accessed 9.10.23).
Vo, Q.T., Kuenzer, C., Vo, Q.M., Moder, F., Oppelt, N., 2012. Review of valuation methods for mangrove ecosystem services. Ecol. Indic. 23, 431–446. https://doi.org/10.1016/j.ecolind.2012.04.022.
Walpole, E.H., Toman, E., Stidham, M., Wilson, R., 2020. The science and practice of ecological restoration: a mental models analysis of restoration practitioners. Environ Syst Decis 40, 588–604. https://doi.org/10.1007/s10669-020-09768-x.
Wang, Y., Chao, B., Dong, P., Zhang, D., Yu, W., Hu, W., Ma, Z., Chen, G., Liu, Z., Chen, B., 2021a. Simulating spatial change of mangrove habitat under the impact of coastal land use: coupling MaxEnt and dyna-CLUE models. Sci. Total Environ. 788, 147914 https://doi.org/10.1016/j.scitotenv.2021.147914.
Wang, N., Li, J.-M., Xu, Z.-H., 2021b. Public preference for the ecological restoration of coastal wetlands in Jiaozhou Bay in China based on a choice experiment. Mar. Policy 128, 104487. https://doi.org/10.1016/j.marpol.2021.104487.
Ward, M.K., Meade, A.W., 2023. Dealing with careless responding in survey data: prevention, identification, and recommended best practices. Annu. Rev. Psychol. 74, 577–596. https://doi.org/10.1146/annurev-psych-040422-045007.
Wetlands International, 2021. Guidance on Mangrove Indicators in the Post-2020 Global Biodiversity Framework. Wetlands International.
Wilson, K.A., Davis, K.J., Matzek, V., Kragt, M.E., 2019. Concern about threatened species and ecosystem disservices underpin public willingness to pay for ecological restoration. Restor. Ecol. 27, 513–519. https://doi.org/10.1111/rec.12895.
Xue, X., Dong, M., 2010. Ecological restoration in Xiamen Sea. In: 2010 4th International Conference on Bioinformatics and Biomedical Engineering. Presented at the 2010 4th International Conference on Bioinformatics and Biomedical Engineering (iCBBE). IEEE, Chengdu, China, pp. 1–4. https://doi.org/10.1109/ICBBE.2010.5516400.
Zabala, J.A., Martínez-Paz, J.M., Alcon, F., 2021. A comprehensive approach for agroecosystem services and disservices valuation. Sci. Total Environ. 768, 144859 https://doi.org/10.1016/j.scitotenv.2020.144859.
Zhang, J., Yang, X., Wang, Z., Zhang, T., Liu, X., 2021. Remote sensing based spatial-temporal monitoring of the changes in coastline mangrove forests in China over the last 40 years. Remote Sens. 13, 1986. https://doi.org/10.3390/rs13101986.
Zimmer, M., 2018. Ecosystem Design: When Mangrove Ecology Meets Human Needs. In: Makowski, C., Finkl, C.W. (Eds.), Threats to Mangrove Forests, Coastal Research Library. Springer International Publishing, Cham, pp. 367–376. https://doi.org/10.1007/978-3-319-73016-5_16.