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Value attributes and user preferences for the coastal wetland ecosystem in Caofeidian, China

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Abstract. The coastal wetland ecosystem in Caofeidian has undergone serious degradation over the past 50 years. The local government and policy makers need scientific information of integrating wetland protection and economic development. In this study, in order to evaluate the respondents' preference for the possible attribute change of biodiversity, wetland restoration, water quality, and tourism infrastructure, choice experiment is performed, and after comparing the conditional logit model, the random parameter logit model, and the random parameter logit model with interactions, the random parameter logit model with interactions is treated as the main model to estimate the unobserved and observed preference heterogeneity and marginal willingness to pay for the corresponding attributes. Results show that "more wetland restoration" is the highest valued attribute, respondents with a high education degree are inclined to conduct wetland restoration actions, and respondents who have visited the coastal wetland ecosystem before tend to pay a high price. Furthermore, a hypothetical option of wetland ecosystem management, which is defined in terms of "medium biodiversity," "more wetland restoration," "best water quality," and "more tourism infrastructure," is recommended, and it could be regarded as the main development pattern for the future construction and restoration of the coastal wetland ecosystem.

1. Introduction

Ecosystem service valuation is fundamental to management strategies and policies (MA, 2005). Related natural ecosystem attributes and user preferences should be determined to create welfare maximization-oriented decisions and requests. Choice Experiment (CE) is an effective valuation method of addressing the multi-functional and multi-dimensional nature of resources. This consumer-oriented approach transmits clear signals about preferences and willingness to pay for different attributes. Thus, CE allows researchers to value attributes as particular phenomenon changes and calculate compensating amounts in the case of damage to an attribute (*Hanley, Wright, and Adamowicz 1998; Mazzanti 2003; Christie, Hanley, and Hynes 2007*). Many researchers focus on the application of CE to assess natural resource problems and different users' preference. Some studies showed that the results of information choice experiments can be used as input to decide the management direction and subsequently construct a natural ecosystem with high social welfare and wide acceptance (*Shoyama, Managi, and Yamagata 2013; Doherty et al. 2014; Mejía and Brandt 2015*). Some researchers believe that CE can offer insights into the role of public preferences in explaining resistance to or acceptance of future nature ecosystem configurations, allowing the corresponding recommendations to become strongly feasible and practical (*Scarpa, Campbell, and Hutchinson 2007; Andreopoulos et al. 2015*). The cost effectiveness of CE renders this method popular among policy makers who must consider a wide range of management options for natural resources.

The coastal wetland ecosystem in Caofeidian has undergone remarkable disappearance and degradation over the last 20 years. According to statistics, more than 40% of the original coastal wetland ecosystem has converted into urban and industrial lands (*Gao et al. 2012; Zhang 2015*). Although the ability of the coastal wetland ecosystem to provide ecosystem services has considerably weakened, it still possesses immense potential in biodiversity protection, water supply, flood control, retention of nutrients, and erosion resistance and provides development opportunities for urban transformation and local economic transition (*Joss and Molella 2013*). Hence, the relevant attributes of the coastal wetland ecosystem in Caofeidian are identified and user preferences and marginal willingness to pay (MWTP) for these attributes are estimated on the basis of CE. The paper is organized as follows. Section 2 describes the study area. Section 3 introduces the CE method, the survey, and the random utility theory. Section 4 compares and analyzes the results of different models, and Section 5 concludes the paper.

2. Materials & Methods

2.1. Study Area

Caofeidian is located in Tangshan City, north China. This district is situated at the center of Bohai Gulf and has developed into the core area of the national coastal strategy in Hebei Province due to its location advantage (Figure 1). Caofeidian is an industrial zone where many industrial enterprises with main production of steel, electricity, chemical raw materials, and chemical fiber are distributed. Furthermore, several large farms are widely distributed in Caofeidian where rice planting and rice-crab planting and breeding are the main economic industries.

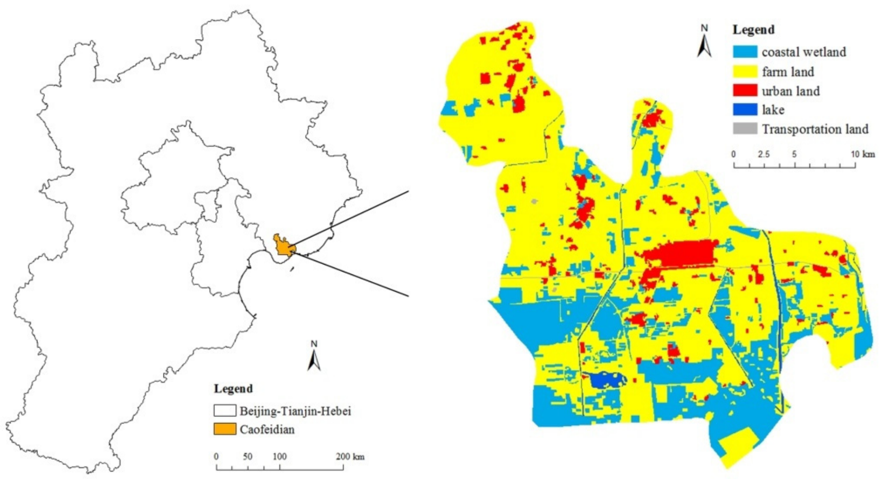

Figure 1. Location and land use patterns in 2015 of Caofeidian

The coastal wetland ecosystem of Caofeidian serves as a key habitat and stopover for migrant birds of East Asian–Australasian. Millions of wildlife move in this place to rest and hunt for food every year. Aside from the important attribute of biodiversity protection, the coastal wetland ecosystem also provides other important ecosystem services, such as water supply, soil formation, hydrological regulation, and fishery development, which are beneficial to the improvement of social wellbeing (*Zhang, Zhang and Yang 2006; Wang 2010; Wang et al. 2013*).

Regional development in Caofeidian is facing dual pressure from industrial development and environmental protection. On the one hand, industrial production inevitably produces large amounts of waste gas and water. On the other hand, living condition improvement and ecotourism development have a strong demand for minimizing the pollution. Thus, the government aims to realize win–win situation through the restoration and protection of the coastal wetland ecosystem.

Breakthroughs in the ecotourism development can be achieved based on the coastal wetland ecosystem. However, problems in ecotourism construction and development arise. First, tourism infrastructures such as traffic system, recreational facilities, hotels, and shopping centers are not in sufficient quantities to satisfy tourist demand. Second, deterioration of water quality and lack of wetland vegetation badly affect people's wetland tourism experience. Their desire for diving, yachting, water skiing, and enjoying the cool under trees cannot be realized. Third, inadequate promotion and marketing strategies and indistinctive tourism products hamper the sustainable development of coastal wetland ecotourism. Shrinkage in wetland area and damage to the ecological environment are becoming extremely tough problems for the local government.

2.2. Choice Experiment

CE is an effective method to estimate the implicit value of the environmental resource attributes and levels that influence the choice behavior of respondents. CE presents respondents a series of questions with a baseline scenario and two alternative options of potential management to elicit responses that allow estimation of preferences over attributes (*Adamowicz et al. 1998; Carson and Czajkowski 2014*). The economic theory of demand underlies this technique and indicates that the demand for some goods or services is effectively influenced by the specific combination of attributes.

2.3. Survey

Some preliminary work was performed in the process of questionnaire design. Planners and experts were consulted to create a feasible survey plan. On the basis of the general plan of Caofeidian from 2008 to 2020, the integrated development plan of Beijing, Tianjin municipalities, and Hebei Province and the ecotourism plan of Tanghai wetland and birds nature reserve, four attributes on the future development of the coastal wetland ecosystem in Caofeidian were finally recognized. They are biodiversity, wetland restoration, water quality, and tourism infrastructure.

Three levels of the four coastal wetland attributes mentioned above and five payment levels were recognized for the CE study. Thus, a complete design of factorial survey includes 320 combinations. The orthogonal test was employed to generate reasonable choice sets (*Caussade et al. 2005*).After eliminating some unrealistic combinations, 32 alternatives were developed and paired into 16 choice sets. Each set contained a status quo alternative. Thus, every respondent should choose eight times in two blocks of choice sets.

Table 1. Coastal wetland attributes and levels in choice experiment

Attribute	Description	Levels
Biodiversity	Amount of rare wild animals and plants, such as white stork and bustard.	Low, medium, high
Wetland restoration	Area of wetland restoration and ratio of wetland ecosystem in land use.	Current size and ratio More, most
Water quality	Standard of water and its supply that can satisfy different requirements.	Current situation, Better, best
Tourism Infrastructure	Amount of traffic road, restaurants, hotels, recreational facilities, and shopping centers.	Few, more, most
Price	Total price individuals have to pay if an alternative is chosen.	20, 50, 100, 200, 500 Yuan

The whole questionnaire consisted of three parts. The first part explained the purpose of the survey. Respondents were told that the possible construction of coastal wetland ecosystem in Caofeidian was aimed at improving the overall level of social wellbeing. The second part involved some questions about the socio-economic status, including gender, age, and education, of respondents and whether they ever visited the coastal wetland ecosystem or not. The last part was regarding the choice experiment. The respondents were provided with eight choice sets with each including three alternatives where they were asked to select their preferred options. The first two alternatives indicated some improvements upon the coastal wetland attributes, and the third alternative was the base alternative. The information about the attribute and levels is presented in Table 1.

2.4. Random Utility Model

Random utility theory is always employed in CEs to analyze the user choices within the discrete choice environment (*Boxall and Adamowicz 2002; Lancsar and Savage 2004*). The utility individual obtains from choosing an alternative can be specified as

$$U_{ij} = V_{ij} + \varepsilon_{ij} \tag{1}$$

Where V_{ij} is the observable attributes of the latent utility and ε_{ij} is the random and unobserved component of the individual choice.

If the respondents' preferences depend on the observable attributes, the conditional logit model in which all coefficients are treated as fixed should be used to estimate the probability of choosing an alternative from the choice sets (*McFadden 1973*):

$$V_{ij} = \alpha_{ij} + \beta_i X_{ij} \tag{2}$$

Where X_{ij} is a vector of observed variables, α_{ij} is the intercept representing the intrinsic preference for the alternative, and β_i is the coefficient vector of tastes.

The conditional probability of selecting from alternatives A, B, or C could be estimated as:

$$P(A) = \frac{\exp(\sigma_i V_A)}{\sum_{j=1}^{J} \exp(\sigma_i V_j)} \tag{3}$$

Where σ_i is a scale parameter that is normalized to 1 and ε_{ij} is assumed to be homoscedastic.

If unobserved preference heterogeneity exists among individuals is assumed, that is, allowing the coefficients in the model to vary across individuals, the random parameter logit model that consists of a systematic part and a stochastic part should be applied (*Hensher and Greene 2003*).

In this condition, the choice probability of A, B, or C is given by:

$$P(A) = \int \frac{\exp(\beta_i X_A)}{\sum_{j=1}^{J} \exp(\beta_i X_{ij})} f(\beta|\theta) d\beta \tag{4}$$

Where $f(\beta|\theta)$ is the density function of β.

For comparison, three model specifications are tested in the analysis of which value components are significantly affecting the choices. These models are the conditional logit model (CLM), the random parameter logit model (RPL), and the random parameter logit model with interactions (RPLI). The variable of price is treated as a fixed parameter on account of the MWTP for an attribute is equivalent to the distribution of the attribute's coefficient. The MWTP can be calculated as follows:

$$MWTP_i = -\frac{\beta_i}{\beta_{price}} \tag{5}$$

3. Results & Discussion

The survey was conducted in a random sampling from June to August 2016 when it is the high season for the coastal wetland tourism in Caofeidian. Local people and visitors were the focus respondents as they may be greatly affected by the change in the coastal wetland ecosystem. After screening out invalid questionnaires with incomplete or wrong information, 138 valid questionnaires, 1104 choices, and 3312 observations were collected for the statistical analysis in total. Table 2 summarizes the socio-economical status information of the random samples.

Table 2. Socio-economical information statistics of respondents

Variable	Description	Mean	Standard Deviation	Min	Max
Gender	= 1 if male	0.56	0.47	0	1
Age	Age of respondent	39.2	11.5	19	71
Education	= 1 if respondent has a university degree or higher	0.34	0.51	0	1
Ever-visited	= 1 if respondent has ever visited the coastal wetland ecosystem before	0.63	0.34	0	1

Stata 14 was used to conduct the estimations of the models. The estimation results are presented in Table 3 and Table 4. In the CLM, all factors except the "most tourism infrastructure" are significant for the possible establishment of a coastal wetland ecosystem. However, the CLM could not capture the preference heterogeneity among respondents and may lead to unrealistic predictions. Thus, the RPL and RPLI, which consider unobserved sources of heterogeneity, were evaluated. In the RPL and RPLI, the "most tourism infrastructure" variable was held as a fixed parameter because of its insignificance in CLM. The results of these two models show that the "most tourism infrastructure" variable is still insignificant, which indicates that it is homogeneous among the respondents. The RPL shows that "medium biodiversity,""high biodiversity,""more wetland restoration," "most wetland restoration,""better water quality," "best water quality," and "more tourism infrastructure" are significant random parameters, which indicate that respondents prefer changes rather than current situation in these parameters. The coefficient of the variable "price" is negative, which indicates that the more money people have to pay, the lower utility they would obtain from the change in coastal wetland attributes.

Table 3. Conditional logit model estimations

Fixed parameters	CLM
Medium biodiversity	0.536(5.48)***
High biodiversity	0.403(2.82)**
More wetlandrestoration	0.415(7.11)***
Most wetland restoration	0.704(4.09)***
Better water quality	0.595(5.43)***
Best water quality	0.646(5.39)***
More tourism infrastructure	0.409(3.83)***
Most tourism infrastructure	-0.170(-1.57)
Cost	-0.018(-6.40)***
Constant	-0.731(-1.65)
Log likelihood	-1753.59
LR chi2	244.83
Rho-square	0.174
Observations	3312
Individuals	138

To detect the sources of observed preference heterogeneity, the RPLI introduced the interactions between respondents' socio-economic status and specific coastal wetland attributes into estimation. While the variables of "gender" and "age" did not have significant impacts on coefficient estimates, only two interacted variables of "education" and "ever-visited" were incorporated in the model. The interaction coefficients were positive and significant. The respondents with a higher education degree were inclined to ask for more wetland restoration, and those who have ever visited the coastal wetland system previously were prone to pay a higher price for the possible wetland construction. The dramatic change arose the sign of the coefficient of the variable "high biodiversity," which changes from positive to negative. Thus, high biodiversity may not be the chief concern to local people and respondents. People always consider peace and harmony as the most attractive factors for a coastal wetland ecosystem. Thus, wetland restoration and water quality weigh more than high biodiversity in their opinion. The coefficient of "most wetland restoration" changes from significant to insignificant, which indicates that no significant heterogeneity exists among respondents when considering the interactions. By comparison, the increase in likelihood ratio and ρ^2 indicates that the RPLI is more appropriate to estimate the preference variation than the two other models. The significance of the coefficients of "medium biodiversity," "high biodiversity," "more wetland restoration," "better water quality," "best water quality," and "More tourism infrastructure" indicates that they are significant random parameters, and significant heterogeneity can be found among the respondents. Considering that RPLI can pick up preference variation in terms of both latent and observed heterogeneity, it is treated as the main model to estimate the marginal willingness to pay.

Table 4. Results of RPL, RPLI and the MWTP of corresponding attributes

	RPL	RPLI	MWTP(¥)
Fixed parameters			
Most tourism infrastructure	-0.217(-1.80)	-0.445(-1.93)	-18.54
Cost	-0.021(-6.72)***	-0.024(-6.88)***	
Constant	-0.478(-1.03)	-0.483(-1.37)	
Random parameters			
Medium biodiversity	0.548(4.84)***	0.346(2.57)***	14.42
SD (Medium biodiversity)	0.569	0.558	23.25
High biodiversity	0.334(1.86)*	-0.171(-2.05)**	-7.13
SD (High biodiversity)	0.990	0.959	39.96
More wetland restoration	0.713(5.34)***	0.724(4.27)***	30.17
SD (More wetland restoration)	0.948	0.976	40.67
Most wetland restoration	0.433(4.17)***	0.000(0.00)	0
SD (Most wetland restoration)	0.077	0.175	7.29
Better water quality	0.602(4.98)***	0.312(2.43)**	13.0
SD (Better water quality)	0.466	0.454	18.92
Best water quality	0.674(5.46)***	0.458(3.55)***	19.08
SD (Best water quality)	0.029	0.039	1.63
More tourism infrastructure	0.425(3.66)***	0.445(3.52)***	18.54
SD (More tourism infrastructure)	0.352	0.308	12.83
Interactions			
More wetland restoration *Education		1.723(2.01)**	71.79
Price*Ever-visit		0.901(2.31)**	37.54
Log likelihood	-1983.02	-1935.19	
LR chi2	352.25	391.78	
Rho-square	0.218	0.249	
Observations	3312	3312	
Individuals	138	138	

Using Formula (5), MWTP of every parameter representing a different management attribute of the coastal wetland ecosystem is calculated. As shown in Table 4, the most important coastal wetland management option is "more wetland restoration," worth ¥30.17on average per person per year. The MWTPs for the "best water quality" and "more tourism infrastructure" are at the same level, estimated at ¥19.08 and ¥18.54, respectively. Thus, good water quality is particularly important to respondents

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and for the development of coastal wetland ecotourism. To manage the coastal wetland ecosystem, “medium biodiversity” and “better water quality” should also be considered. However, they do not have to be preoccupations because the respondents estimate that the number of some rare species could spontaneously increase with the gradual recovery of the coastal wetland ecosystem and the improvement of water quality. The average MWTP for “high biodiversity” is - ¥7.13, which indicates that a high density of biodiversity may lower the utility. Therefore, the amount of biodiversity should maintain an appropriate level.

Education interacting with more wetland restoration shows a strong positive correlation with MWTP, with a coefficient of 1.723 and a mean of ¥71.79. Therefore, respondents with a higher education degree generally foster the awareness of taking some proactive actions for wetland protection. Results also demonstrate that the respondents who have previously visited the coastal wetland ecosystem of Caofeidian are inclined to pay a higher price with a mean of ¥37.54.

According to the MWTP of every attribute, two options of coastal wetland ecosystem management are finally constructed. The first one consists of “medium biodiversity,”“more wetland restoration,”“better water quality,” and “more tourism infrastructure.” The second one includes the factors “medium biodiversity,” “more wetland restoration,” “best water quality,” and “more tourism infrastructure.” Their total MWTPs are ¥ 76.13and ¥ 83.11 per person per year, respectively. The difference between these two management potions is derived from their levels of water quality improvement. Results coincide with the regional development reality. Water quality is gradually becoming a tricky problem with industrial development and currently threatens the recovery of biodiversity, ecotourism, and coastal wetland ecosystem. Thus, aside from the three other attributes at the same level, the management of the coastal wetland ecosystem should pay attention to different scenarios of water quality improvement, which are the concerns of the respondents.

The total MWTP that was estimated could provide a baseline for the authors to assess the value of coastal wetland ecosystem service. Given that some core services about coastal wetland ecosystem can generate additional benefits, such as shoreline protection, flood control, and climatic regulation, decision makers should consider this information seriously when developing regional plans, management policies, and financing strategies.

4. Conclusion

In this study, the CE method was used to estimate respondent preferences and MWTP for the relevant attributes of the coastal wetland ecosystem in Caofeidian. The coastal wetland ecosystem has undergone considerable degradation in the recent years. Thus, managers and decision makers need scientific and timely information to help them with the potential construction and restoration of the coastal wetland ecosystem. Three levels of biodiversity were identified, namely, wetland restoration, water quality, and tourism infrastructure. The results of the CLM, RML, and RMLI were compared. The obtained results of the superior model RMLI indicate that preferences for “medium biodiversity,” “high biodiversity,” “more wetland restoration,” “better water quality,” “best water quality,” and “more tourism infrastructure” are significantly heterogeneous. “More wetland restoration” is the highest valued attribute. “Best water quality” and “more tourism infrastructure” are nearly at the same valued level, similar to “medium biodiversity” and “better water quality.” “High biodiversity” is valued negative. As to the interactions, respondents with a higher education degree are inclined to adopt some actions for wetland restoration, and respondents who have previously visited the coastal wetland ecosystem tend to pay a higher price.

According to the MWTP for the different attributes, we recommend two options of management coastal wetland ecosystem. The difference between these two options lies in the level of water quality. From the welfare economic approach, the management option constructed by “medium biodiversity,” “more wetland restoration,” “best water quality,” and “more tourism infrastructure” is regarded as more favorable. Furthermore, the value revealed in this paper could be the lower bound of the coastal wetland ecosystem services. Only four attributes of the coastal wetland ecosystem are considered. Some of the other values for the coastal wetland ecosystem services are excluded. These values are shoreline protection, flood control, erosion resistance, and climatic regulation. The total welfare benefit may increase notably if the value of these services value is considered. This research can serve as a useful tool for the potential construction and restoration plan of the coastal wetland ecosystem in Caofeidian and as a foundation for subsequent studies in this area.

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