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Household Willingness to Pay for Forest Ecological Restoration in Giant Panda Habitats: A Discrete Choice Experiment

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Abstract: Rural households have played an increasingly significant role in the conservation and restoration process of natural habitats. This paper explores rural households' preference and willingness to pay for ecological restoration attributes in giant panda habitats using the discrete choice experiment (DCE). The DCE survey was conducted in and around giant panda habitats in Sichuan province with a sample size of 474. Using the mixed logit model, the results indicate that rural households have positive attitudes towards the improvement of ecological restoration functions, including forest vegetation restoration, biodiversity conservation, and giant panda corridor construction, but have a negative attitude towards payment, showing that rural households are inclined to pay less to gain better restoration outcomes. Among the ecological restoration attributes, forest vegetation restoration (4.44 RMB) wins the highest payment value, indicating households' preferences and priorities of ecological restoration. In general, rural households' willingness to pay could reach 34.28 RMB for the best choice option designed in DCE. This study emphasizes the awareness of payment among rural households to improve ecological restoration functions in giant panda habitats and indicates the importance of household participation in long-term adaptation and implementation of ecological conservation plans.

Keywords: ecological restoration; discrete choice experiment; willingness to pay; giant panda habitats

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1. Introduction

For an ecosystem that has been degraded, damaged, or destroyed, ecological restoration plays a vital role in halting and reversing degradation, maintaining ecosystem functions, and promoting biodiversity [1,2]. As an essential carrier of an ecosystem, habitats are a rich biodiversity base to protect wild animal and plant resources [3]. Strengthening the protection of natural habitats could increase vegetation cover, foster the integrity of the ecosystem, enhance biodiversity, and promote sustainability.

Participation and management of ecological restoration call for multi-stakeholders' efforts in the decision-making and implementation process. Both externally driven initiatives and self-organized local stakeholders are expected to be involved in an endeavor of ecological restoration [4]. As the most important externally driven authority, the government is a significant force to restore the ecosystem by implementing policy and ecological restoration projects. In China, policies include the "construction of Ecological Civilization" (fundamental tenets are to respect, protect and adapt to nature, low-carbon use, and sustainable development) and the "Protection and Restoration of Mountains, Water, Forest, Farmland and Grass" to promote the national level restoration goals [5,6]. Ecological restoration projects are more engineering feature projects such as environmental engineering and afforestation projects focusing on the regional ecological restorations [7,8]. Several papers have analyzed ecological restoration projects from beforehand designing to afterward evaluation [9,10].

Since natural habitats and the surrounding communities form a close unity, rural households are the most important local stakeholders to engage in ecological restorations [11,12]. However, local stakeholder reactions could range from passive information receivers to fully collaborative participators [13]. Generally, rural households have rarely participated in ecological restoration and have impeded the coordinating development of the ecosystem due to their conflicts in natural resource use, infrastructure construction, and comparatively low environmental protection awareness [14–16]. Although short-term government subsidies could stimulate local stakeholder behaviors in ecological restoration, these actions could disappear when locals no longer benefit from the subsidies [17]. Thus, active and collaborative participation from local stakeholders is of great importance to maintain the long-term goal of ecological restoration.

As the iconic species, giant panda's (Ailuropoda melanoleuca) natural habitat has improved significantly in China in recent years, and giant panda's extinction risk has been downgraded from "endangered" to "vulnerable" [18,19]. However, the species is still vulnerable, and human disturbance is still a major cause of habitat fragmentation of giant pandas. The Chinese government has launched the Giant Panda National Park to enhance giant panda habitat's connectivity and to establish a multi-level ecological protection system [20,21]. However, its effectiveness is still under evaluation.

Rural community and household participation are essential to maintain the well-functioning of the National Park System. Previously, the increasing human activity has disturbed giant panda habitats through various ways such as livestock grazing, road construction, and herb collection [22]. Human disturbances could hinder bamboo growth rate, cause fecal pollution as well as change giant panda behaviors [23,24]. The fragmentation of forest vegetation caused by human activities and natural disasters results in the complexity of landscapes in giant panda habitats, which further halted the migration and species exchange and seriously threatened the function and integrity of giant panda habitat [25]. Forest vegetation restoration, biodiversity conservation, and ecological corridor construction are considered effective ways to improve the status quo of giant panda habitats [26]. A win-win solution of ecological protection and community development is expected through the tight cooperation with rural households by the giant panda national park program. As the most important stakeholder, rural households are expected to bear part of ecological restoration costs and participate in constructing the habitat.

Previous research mainly focused on alleviating the contradiction between habitats and surrounding households [27,28], ensuring benefits and development of the habitat [29,30], and promoting rural socio-economic development [31,32]. Although households' willingness and preference for environmental protection has received research attention, only a particular aspect or performance of a specific environmental function has been focused on [33,34]. A comprehensive exploration of rural households' preferences and willingness-to-pay (*WTP*) for whole aspects of ecological functions is needed to deepen the understanding of rural household protection attitudes and behaviors, as they contribute a crucial significance to the sustainable development of natural habitats in the long run.

Hence, this study was designed to explore households' preferences for ecological restoration attributes and willingness to pay for ecological restoration using the discrete choice experiment (DCE). Specifically, this study aims to (1) analyze factors that affect households' preferences and willingness to pay for ecological restoration; (2) calculate households' marginal payment value of each ecological restoration attribute; (3) calculate the payment value of each choice option designed in DCE and select the best choice option that rural households preferred. This analysis could help to understand rural households' attitudes towards ecological restoration in and around giant panda national habitats and is of great significance to ecological protection and development of habitats.

2. Materials and Methods

2.1. Data

Giant panda national park involves 12 cities and 29 counties (districts) in Sichuan, Shanxi, and Gansu provinces with a total area of 27,134 km^2. The national park in Sichuan province is the largest part, covering an area of 20,100 km^2 (with 1205 wild giant pandas), accounting for 74.08% of the total areas (64.65% of the total wild giant pandas). In addition, giant panda habitats in Sichuan Province are also selected as one of the 25 global biodiversity hotspots by Conservation International. Based on this, we conducted a questionnaire survey around giant panda habitats in Sichuan province in 2019. The sampling method was a combination of stratified sampling and village-level random sampling. Specifically, 12 out of 46 giant panda nature reserves at the national, provincial, and municipal levels were selected based on stratified sampling. The selected giant panda nature reserves covered four cities (Chengdu, Mianyang, Deyang, and Ya'an) and 12 counties. Four villages in each nature reserve were selected, and in total 48 villages in and around giant panda habitats were investigated. Furthermore, 9–11 households were randomly selected in each village, constituting 500 households participating in our survey.

The valid sample size was 474, with an effective response rate of 96.8%. The data collection process encompassed a structured questionnaire in combination with a discrete choice experiment. The data collection team included six well-experienced Ph.D. students and 12 Master's Degree students. A clear explanation of the discrete choice experiment was guaranteed through the training and practices to ensure rural households understood their choices. On average, the completion of each survey would take 30–40 min on site. The main content of the questionnaire includes three parts: the demographic characteristics of household heads and their family, the environment protection attitude and cognition of household heads, and their response to the choice experiment. The study sites cover major areas where giant pandas' activities can be tracked as well as potential areas where giant pandas may occasionally visit.

2.2. Method

The choice experiment has been widely used in research on public needs and preferences of various natural resources such as cultivated land, wetlands, forests, and organisms to measure the marginal willingness to pay to reflect the ecological value of various attributes of natural resources [35–40]. Compared to other methods, the choice experiment provides a feasible way to quantify the non-market value of ecological products and exerts advantages in reducing measurement errors to obtain more concrete individual preferences. Primarily, the choice experiment provides interviewees the opportunity to weigh various evaluation indicators to make multi-indicator decisions. Hence, through the choice experiment, there is a chance to explore rural households' attitudes, preferences, even perceived values of each restoration function from their choices. In our choice experiment design, households' preferences heterogeneity is evaluated by asking individual respondents (n) with different socio-economic characteristics (S) to compare the utilities (U_{in}) of a given set (C) of alternative choices (i) [41,42]. Four steps are generally followed through the choice experiment design process: (1) definition of attributes and their levels; (2) experimental design; (3) questionnaire development; and (4) sampling strategy.

In our design, households need to choose between three ecological restoration alternative options. The attribute selection and its level settings are based on literature review and expert consultation in November 2018 in Forestry Bureaus of Sichuan Province. Four primary ecological restoration means were defined as attributes: forest vegetation restoration, biodiversity conservation, giant panda corridor construction, and one-time willingness to pay. In addition, household respondents were asked to answer several follow-up questions regarding their personal and family status and their protection attitude and cognition through open questions or the Likert Scale [43]. Detailed descriptions of attribute levels and descriptive statistics of other demographic and attitude variables are presented in Table 1 below. Male respondents dominated the sampled households, accounting for 66.6%. In terms of age, more than 70% of respondents are over 40 years old, representing mainly the middle-aged and elderly group. Half of the respondents have a primary school education, and the overall education level is comparatively low. The demographic condition is basically in line with the rural population structure of Sichuan province. In addition, the average household income is between 20,000 and 50,000 RMB, and the average forest size is about 6–30 mu (1 mu = 0.067 hectares) in our sampled households.

Generally, two 3-level attributes and two 4-level attributes produce 144 (= 4 × 3 × 3 × 4) possible alternatives (as the full factorial experimental design). To choose as many effective alternative combinations as possible, D-optimal main-effects fractional factorial design was conducted, and finally, 16 choice options were selected [44]. These choice options are randomly allocated into eight choice sets (i.e., option A and Option B in each choice set). In addition, the third option is always the status-quo option in each choice set. In our questionnaire design, households are randomly allocated to four choice sets to make their choices (A choice set example see Table 2). The design and choice set definition steps followed the guide of Aizaki et al. [45].

We estimated a mixed logit model based on random utility theory [46]. In the model, the utility for alternative (*i*) for individual (*n*) is assumed to be:

$$U_{in} = V_{in}(C_i, S_n) + \varepsilon_{in}(C_i, S_n) \quad (1)$$

where V_{in} is the deterministic component, or indirect utility function; ε_{in} is the random unobservable error term. C_i refers to the chosen attribute (*i*) from ecological restoration choice sets (*C*), such as forest vegetation restoration, biodiversity conservation, ecological corridor construction, and willingness to pay for participation. S_n refers to individual respondents' (*n*) socio-economic characteristics (*S*), such as gender, age, education level, etc.

The linear function can be expressed as:

$$U_{in} = \alpha_1 + \beta_0 Price_{in} + \sum_{k=1}^{K} \beta_{ik} C_{ink} + \sum_{m=1}^{M} \gamma_{nm}\, S_{nm} + \varepsilon_{in} \quad (2)$$

where C_{ink} is the level of attribute k from alternative i and β_{ik} is the corresponding utility coefficient. S_{nm} is the m characteristics of respondent *n* and γ_{nm} is the corresponding utility coefficient.

The probability that an individual will choose alternative (*i*) over the alternative (*j*) can be expressed as the probability that the utility for (*i*) is larger than the utility for (*j*) and is expressed as:

$$P_{in} = \frac{\exp(V_{in})}{\sum_{j=1}^{J} \exp(V_{jn})} \quad (3)$$

The households' willingness to pay for ecosystem restoration is the price premium that one is willing to pay for the required level of restoration attributes. For example, if a respondent is expected to care more about forest vegetation restoration than biodiversity conservation, then its *WTP* is a price premium that a respondent is willing to pay for improving forest vegetation rather than improving biodiversity. Based on the mixed logit regression, the *WTP* for improving the level of ecological restoration attributes is calculated as follows:

$$WTP = -\frac{\beta_r}{\beta_p} \quad (4)$$

where β_r and β_p represent the estimated parameters of specific environmental restoration attributes r and price attributes p, respectively. *WTP* represents the marginal willingness to pay (marginal utility) of each attribute level and based on that the value change caused by the marginal change of each attribute level can be obtained [47].

Table 1. Variable definition and description.

Variables	Abbreviation	Definition and Description		Percentage (%)	Mean	Std.Dev.	Min	Max
Explained variable	Y	Choice option selection result: selected = 1, unselected = 0						
Explanatory variable (Attributes)	FV	Forest vegetation restoration: 1 = Maintaining the current status 2 = Ban in logging/deforestation 3 = Forest restoration actions 4 = Ban in logging/deforestation + Forest restoration actions						
	BD	Biodiversity conservation: 1 = Maintaining the current status 2 = Preventing species loss 3 = Improving biodiversity						
	CC	Giant panda corridor construction: 1 = Maintaining the current status 2 = Preventing fragmentation of giant panda habitat 3 = Building panda corridor and strengthening population exchanges						
	WTP	One-time willingness to pay: 1 = 0 RMB, 2 = 50 RMB, 3 = 100 RMB, 4 = 200 RMB						
	ASC	Substituting constant variables: choose option C = 0, choose option A, B = 1						
Explanatory variable (Non-attributes)	Gen	Gender	male = 1	66.57	0.726	0.446	0	1
			female = 0	33.43				
	Age	Age	1 = $\leq$ 29 years old	6.26	3.479	1.019	1	5
			2 = 30~39 years old	18.43				
			3 = 40~49 years old	37.43				
			4 = 50~59 years old	20.23				
			5 = $\geq$ 60 years old	17.65				
	Edu	Years of education: measured value	$\leq$ 6 years	48.72	6.937	2.864	0	15
			6~9 years	37.13				
			9~12 years	9.07				
			$\geq$ 12 years	5.08				

Table 1. *Cont.*

Variables	Abbreviation	Definition and Description		Percentage (%)	Mean	Std.Dev.	Min	Max
	Inc	Household annual income:	1 = ≤ 20,000 RMB	11.60	2.869	1.497	1	8
			2 = 20,001~50,000 RMB	22.74				
			3 = 50,001~80,000 RMB	24.07				
			4 = 80,001~110,000 RMB	14.92				
			5 = 110,001~140,000 RMB	12.06				
			6 = 140,001~170,000 RMB	5.91				
			7 = 170,001~200,000 RMB	2.53				
			8 = ≥ 200,000 RMB	7.17				
	Eoa	Forest size	1 = 5 mu and below	18.32	2.380	1.381	1	5
			2 = 6 to 30 mu	20.45				
			3 = 31 to 55 mu	31.76				
			4 = 56 to 80 mu	19.21				
			5 = over 80 mu	10.26				
	Mri	Whether household operates or participates in tourism and related industries: 1 = Yes, 0 = No			0.278	0.448	0	1
Household protection attitude and cognition	Erc	Compared with ecological protection, economic development: 1 = less important, 2 = same important, 3 = more important			1.979	0.787	1	3
	Rid	Times of contact with the management personnel of nature reserve per year: 1 = no contact, 2 ≤ 10 times, 3 = 11–99 times, 4 ≥ 100 times			1.983	0.703	1	3
	Uig	Willingness to participate in environmental governance: 1 = generally willing, 2 = relatively willing, 3 = very willing			1.762	0.588	1	3
	Und	Knowing the relevant laws and regulations: 1 = do not know well, 2 = understand, 3 = understand very well			1.362	0.632	1	3
	Par	Having conflicts between household livelihood and nature reserve management: 1 = disagree, 2 = general agree, 3 = strongly agree			1.454	0.622	1	3
Specific variables	PID	Respondent's number: 474 (valid questionnaire)						
	CID	Selection choice set number: 1896						

Table 2. Choice set example.

	Attributes	Option A	Option B	Status Quo
Choice Set 1	Forest vegetation restoration	Maintaining the current status	Forest restoration actions	Maintaining the current status
	Biodiversity conservation	Preventing species loss	Maintaining the current status	Maintaining the current status
	Giant panda corridor construction	Building panda corridor and strengthening population exchanges	Preventing fragmentation of giant panda habitat	Maintaining the current status
	Willingness to pay	100 RMB	50 RMB	0 RMB
	Your choice (please choose one only)	**Option A** □	**Option B** □	**Status quo** □

3. Results

The results from the mixed logit model are presented in Table 3 below. In Model 1, all attribute parameters designed in the experimental choice set are significant. Forest vegetation restoration, biodiversity protection, and giant panda corridor construction positively impact households' utility, showing an active attitude towards the improvement of ecological restoration functions. The one-time willingness to pay is significantly negative, indicating a decreasing utility of choice set with a higher payment. Hence, rural households generally tend to pay fewer costs to obtain better habitat ecological restoration functions in their choices.

Table 3. Estimation results from mixed logit regression.

Independent Variables	Model 1			Model 2		
	Coefficient	Std.Error	Z Value	Coefficient	Std.Error	Z Value
Attributes						
FV	0.3005 ***	0.0671	4.48	0.3240 ***	0.0721	4.49
BD	0.2435 ***	0.0547	4.45	0.2600 ***	0.0560	4.64
CC	0.1604 ***	0.0506	3.17	0.2134 ***	0.0510	4.18
WP	−0.1033 ***	0.0389	−2.65	−0.0730 *	0.0394	−1.85
ASC	−0.1142 **	0.0631	−1.81	−0.9024 ***	0.2453	−3.68
Household characteristics						
Gen				−0.4047	0.2478	−1.63
Age				0.2276 **	0.1074	2.12
Edu				0.1378 ***	0.0443	3.11
Inc				0.1723 *	0.1035	1.66
Eoa				0.0950	0.0836	1.14
Household protection attitudes and cognition						
Mri				0.0561	0.2664	0.21
Erc				−0.3045 **	0.1340	−2.27
Rid				0.0141	0.1816	0.08
Uig				0.5408 ***	0.1805	3.00
Und				−0.2045	0.1984	−1.03
Par				−0.3632 *	0.1984	−1.83
Log-likelihood		−1986.8064			−1907.921	
Wald chi2		92.81			180.38	
Prob > chi2		0.0000			0.0000	

Note: ***, **, * indicate the significance level of 1%, 5%, and 10%, respectively.

In Model 2, household characteristics indicators, their environmental attitudes, and cognitions are included. The results show that household head's age, education level, and annual household income positively impact household utility. In addition, willingness to participate in environmental governance also has a positive impact on households' utility, whereas the cognition of the importance of economic development rather than ecological protection and a conflict between household livelihood and nature reserve management would negatively impact on household's utility.

Based on the estimation results from the mixed Logit model, this paper further calculated the marginal value of each attribute of ecological restoration relative to the baseline level (status-quo). The calculated marginal value is the willingness to pay for improving the attribute by households (see Table 4). From Model 1, the marginal value of forest vegetation restoration (2.91 RMB) is higher than the marginal value of biodiversity protection (2.36 RMB) and giant panda corridor construction (1.55 RMB). Although the calculation of the unit marginal value is higher in Model 2, there are no logical differences comparing to the results from Model 1.

Table 4. The marginal value of ecological restoration attributes.

Attribute Variable	Expression	Model 1 (RMB)	Model 2 (RMB)
Forest vegetation restoration (Z1)	$MWTPZ1 = -\beta1/\beta4$	2.91	4.44
Biodiversity conservation (Z2)	$MWTPZ2 = -\beta2/\beta4$	2.36	3.56
Giant panda corridor construction (Z3)	$MWTPZ3 = -\beta3/\beta4$	1.55	2.92

Furthermore, based on 16 identified choices options, this paper calculated the improvement of the attribute status of each choice option compared with the status-quo, as well as the relative value change of each choice option (see Table 5). Choice option 5 is the best choice option for households among all choice options. Households would prefer to restore forest vegetation and increase biodiversity but maintain the current status of corridor construction. In model 1, households would be willing to pay 21.81 RMB for the best choice option (and would be willing to pay for 34.28 RMB in model 2). Since the least willingness to pay is 0 RMB in initial settings, the household's willingness to pay could reach 34.28 RMB for the best combination choice option of ecological restoration.

Table 5. Value accounting results of all choice options of ecological restoration.

Option	Attribute Status Descriptions			Value Accounting (RMB)	
	Forest Vegetation Restoration	Biodiversity Conservation	Giant Panda Corridor Construction	Model 1	Model 2
1	3	3	1	17.35	26.92
2	1	3	1	11.53	18.05
3	4	1	3	18.65	30.08
4	2	2	3	15.19	24.77
5	4	3	2	21.81	34.28
6	2	2	1	12.09	18.92
7	3	2	1	14.99	23.36
8	1	1	1	6.82	10.92
9	4	1	1	15.55	24.24
10	2	1	2	11.28	18.28
11	3	1	3	15.74	25.65
12	1	2	2	10.73	17.41
13	4	2	3	21.01	33.65
14	2	3	1	14.44	22.48
15	3	1	2	14.19	22.72
16	1	2	1	9.18	14.48

4. Discussion and Conclusions

Ecosystem restoration requires not only scale-up efforts to halt and reserve the degradation, but also to provide sustainable goods and services that people need [48]. Hence, the active participation of locals is crucially important to maintaining the long-term restoration goals. This paper explores the households' preference for ecological restoration attributes and willingness to pay for ecological restoration using the discrete choice experiment. Three ecological restoration attributes and one monetary attribute were considered in the study. The analysis indicates that all ecological restoration attributes have a significant positive impact on rural household utility, whereas the payment has a negative impact, indicating that rural households are inclined to pay less to gain more restoration benefits. In addition, the household head's age, education level, household income, as well as households' positive attitudes and behaviors toward environmental protection have a positive impact on households' utility in improving ecological restoration functions.

Regarding the attribute value calculations, rankings of households' marginal willingness to pay are forest vegetation restoration, biodiversity protection, and giant panda corridor construction. The result shows the high consensus on the importance of forest vegetation restoration among rural households. It could be explained by the fact that about 60% of households have a forest size of more than 2 hectares and the forest vegetation restorations are directly related to their daily interests. In addition, the sample areas of our research have long traditions in economic/medical crop plantations, so restoration and protection of forest vegetation are beneficial to the growth of medicinal crops. Hence, households have the highest willingness to pay for forest vegetation restoration in the analysis.

Although households are generally willing to pay for ecological restoration, the payment amount is not very high, especially to the attribute of giant panda corridor construction (only 2.92 RMB). It could be explained by the fact of unrelatedness of the attribute to rural households' daily life as well as their limited education level and lack of cognition on giant panda behaviors. Thus, it could be a future research direction to in-depth explore the rural household heterogeneity in preferences and *WTP* for ecological restoration. In addition, although the choice experiment expends ways to quantify and evaluate the non-market value of natural resources, rural households still make choices under hypothetical scenarios without actual payments. Therefore, there is a possibility of overestimating or underestimating the *WTP* of ecological restoration. Hence, introducing more effective error control methods into questionnaire design and field surveys would also be a direction in future research.

From the policy implication perspective, this paper shows an understanding of rural households' attitudes towards ecological restoration, which is a fundamental requirement to effectively adopt or implement any long-term ecological conservation plan. Since giant panda habitat covers large areas and couples with complex natural conditions and populations, the government needs to fully consider the needs of rural households who live in or around giant panda habitat to improve the applicability of relevant policies. The lack of recognition of the giant panda corridor indicates the need to strengthen the promotion of ecological restoration and further enhance rural households' understanding of the service attribute of giant panda corridor construction to actively promote the restoration participation of rural households. Moreover, rural households' *WTP* for different ecological restoration attributes reflect the underlying value and utility differences that direct their practical conservation behaviors. Hence, this paper highlights the need to explore the distinction between notional ecological policy and practical local participation in planning and implementing conservation plans. A better understanding of rural attitudes will foster the support of giant panda habitat protection and trigger rural household behavioral changes towards active, collaborative, and sustainable in the future. However, we have to admit that rural households' ecological requirement is beyond the basic livelihood needs, so increasing household income levels, improving social securities, and creating local livelihood possibilities are still extremely important to consolidate the foundation of ecological development in giant panda habitats.

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