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ANALYSIS

Applying contingent valuation in China to measure the total economic value of restoring ecosystem services in Ejina region

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Abstract

This paper reports an attempt to apply the Contingent Valuation Method (CVM) in rural China. The CVM was used to obtain estimates of willingness to pay for restoring Ejina ecosystem services. In our survey, we used a payment card format and a 12-page survey booklet with maps depicting the reasons why Ejina ecosystem deteriorated, the means by which ecosystem services could be restored from their current level. We used an in-person interview along with the survey booklet. We employed a parametric model to estimate the benefits of restoring Ejina ecosystem. Results from 700 in-person interviews indicate that households would pay an average of 19.37 (RMB) per year with 20.78 per household for the main river area, and 16.41 per household for the rest of Hei basin. The aggregate benefit to residents of the Hei basin is 8.84 million annually for 20 years. Taking into account an environmental discount rate calculated by using respondent's equivalent utility between periodical payments and lump sum payments, the present value of aggregate benefit of restoring Ejina ecosystem is 55.33 million. These results suggest that the general public in Hei Valley would be willing to pay to restore the Ejina ecosystem, although this amount is substantially less than the estimated costs of restoration.

Keywords: Willingness to pay; Total economic value; Contingent Valuation Method; China

1. Introduction

Ecosystem services such as natural purification of water, erosion control and habitat for wildlife are public goods that have value to society but no relevant market where these values are expressed. When ecosystem degradation arises society has to

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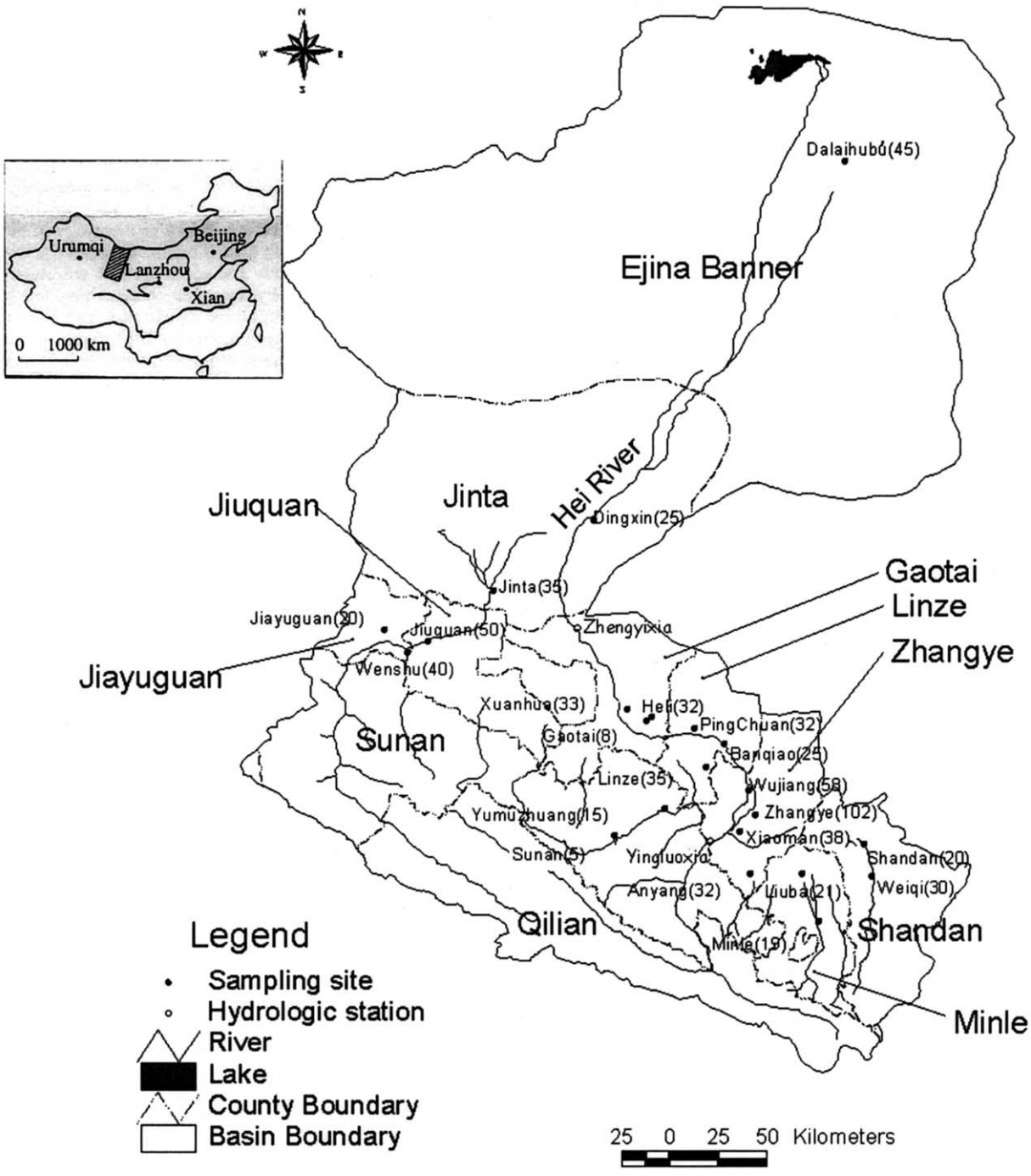

Fig. 1. Study area, sampling sites and sample sizes (given in parentheses along sampling site).

decide whether to incur a cost to restore them. Thus, it would be helpful in making rational social decisions if we could assess the economic value of these ecosystem services to compare to the opportunity cost of preventing degradation or the restoration costs.

Valuation of ecosystem services has received much attention. Early examples include energy-based approaches of Costanza (1981) and Odum (1983), and Ecological Economics' special issue on this topic in 1995. After Costanza et al. (1997) estimated the value of the world's ecosystem services, attention to this field increased.

The Contingent Valuation Method (CVM) is considered one of the most commonly used methods to estimate an economic value for environmental goods (Mitchell and Carson, 1989; Bishop and Romano, 1998). Literally hundreds of contingent valuation studies have been completed in the USA and Western Europe (Bishop and Romano, 1998). Owing to institutional and cultural differences with western countries, Chinese research using CVM is in its infancy. Economic evaluation as a guide to public decisions has never been in fashion in China. Some environmental economics appraisal methods are introduced in university courses but they are hardly used as tools for actual government decisions. The reason for this situation is to be found in the deeply rooted suspicion toward economics by politicians and administrators: China is an exceedingly centralized government and correspondingly, centralized decision making as far as public expenditure is concerned. In the current stage of economic transformation from a centrally planned economy to a market economy, the Chinese people are used to administered prices, not market determined prices. Thus, officials in China are hesitant to accept what people say they would pay.

In this paper, we are following the approach of Loomis et al. (2000) to analyze the total economic value of restoring Ejina ecosystem services by adopting the CVM. One objective of this paper is to learn if CVM can be applied in a country and culture transitioning from a centrally planned economy to a market oriented economy. The paper is organized as following: the first part gives a general description of the Ejina oasis and ecological environment, the second and third sections illustrate the survey design and operational aspects of the study. In the fourth section the results of the analyses are presented and finally we finish with a brief conclusion.

2. Ejina oasis and its ecological environment

The Hei river basin located in the middle of Hexi Corridor of the Gansu Province, is one of the two largest inland river basins in China. Its watershed covers an area of 130×10^3 km^2, and its upper, middle and lower reaches stretch from the middle area of Heixi corridor in Gansu to Qinghai and western Inner Mongolia. Ejina lies in the lower reaches of Hei River (between 97°10′23″–103°7′15″ E and 39°52′20″–42°47′20″ N), is situated south of Monogolia and western Inner Mongolia (Fig. 1). The Ejina oasis covers an overall area of 3115.88 square kilometers, which is a detached island oasis encompassed by peripheral desert. With a current population of near 16 thousand, Ejina is one of the world's most sparsely populated district in the world's most populated country. The Ejina region also has an extreme and harsh natural environment. The climate of the area is characterized by frequent and severe droughts and large differences in temperature. Mean annual temperature at Ejina is 8.2 °C, with a maximum of 41 °C (July) and a minimum of −36.4 °C (January). Mean annual precipitation is only 36.6 mm. The Hei River's water resources are the basis of the Ejina environment, economic development and people lives. Water use has grown rapidly over the past 40 years due to economic growth and population increasing in the middle of the Hei River. The discharge of the Hei River at the mouth of mountain valleys (Yinluo Xia, as illustrated in Fig. 1) has remained at a level of 15.8×10^8 m^3 year^{-1} since the 1950s. However, the flow into the lower reaches in the Zhengyi Xia has decreased by 44.4%, from 11.90×10^8 m^3 year^{-1} in the 1950s to 6.9×10^8 m^3 year^{-1} or so in 1995. Generally, the water flows stop in the Ejina River from May to July, because this is the time period when the agriculture production peak water usage in the middle of Hei River occurs. From August to

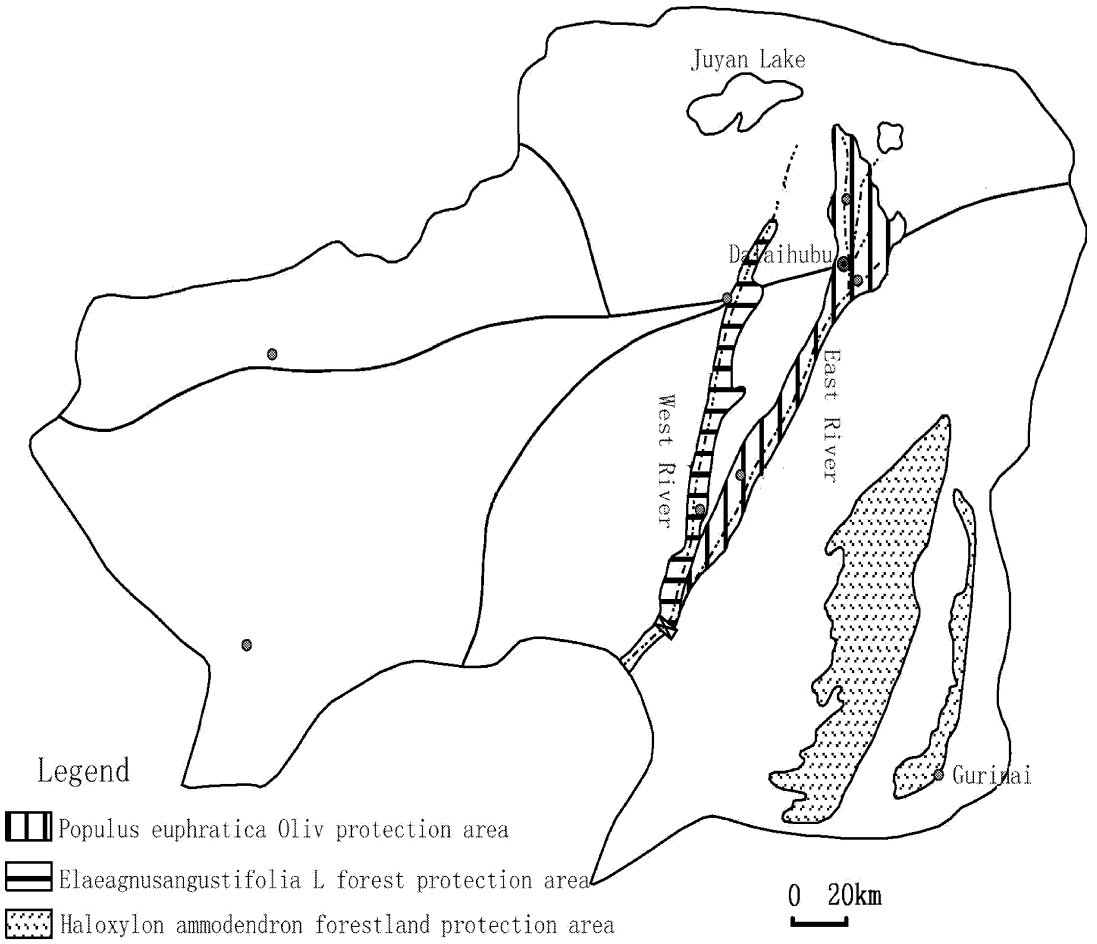

Fig. 2. Sketch of restoring Ejina ecosystem.

October, runoff in Ejina begins to increase due to increasing snow melt in the high mountains. Runoff then decreases and entirely disappears after November.

The drying up of runoff directly threatens the existence of Ejina ecosystem. 3.07×10^4 ha of cultivated land in 1960 has now been reduced to only 0.3×10^4 ha and the rest of the cultivated oasis has turned into desert. The area of degraded forest and harsh desert grassland has increased by 35.09×10^4 ha since 1960. The shape of the Ejina oasis has been reduced to three riverine areas: West River, East River and Gurinai (Fig. 1). Due to the desert area increasing and oasis area decreasing in Ejian, sandstorms have increased recently in the middle of the Hei River (Wang and Cheng, 1999; AIGW, 1996). This deterioration of the Ejina ecosystem has a huge influence on much of northern China. In the spring of 2000, an unprecedented heavy sandstorm event took place in Beijing, Tianjin and their neighboring areas. This storm had adverse effects on the environment, with very thick dust creating traffic problems and aversely affected other aspects of people's daily life and work. The dust mainly originated from mid-west Inner Mongolia (Ejina is an area located in mid-west Inner Mongolia) (Ye et al., 2000). The dust mainly consisted of soil dust from the origination area. This storm results in several types of economic losses including reduced sunlight to cultivated land resulting in decrease in its production; reduced visibility, thus increasing

traffic hazard and adversely affecting mental health of the population.

The Ejina oasis is the first barrier to sandstorms in the middle of the Hei River valley and northwestern China. As a result the government and the Hei River management bureau decided to adopt conservation measures to restore Ejina's ecosystem. These measures include restoring the natural vegetation to establish an effective ecological protective shield in Ejina and to reduce the magnitude of this problem. It is estimated that this restoration effort will cost approximately 600 million RMB in total over 5 years. Thus, the economic efficiency question is whether these costs are worth the benefits to Chinese people living in this area.

3. Survey design

Obtaining accurate benefit estimates using CVM requires detailed descriptions of the resource being valued (Loomis et al., 2000; Loomis and Walsh, 1997). During October 2000, we organized a 12-person investigation group consisting of 7 ecologists and 5 economists. Twenty days were spent in the region, visiting and learning about the Ejina ecosystem. After returning to our institute, it took the group 6 months to define what ecosystem services were being provided by the Ejina and how these could be conveyed in words and figures. Background data was acquired from our early research on Ejina and Hei River valley.

China is in the current stage of economic transformation from a centrally planned economy to a market economy. As a developing country, economic reform in China has led to remarkable economic growth with its gross domestic product growing at the average annual rate of approximately 10% over the period 1978–2000, amid many changes in its economic system. Since the adoption of a coastal development strategy in 1981, coastal provinces have been encouraged to grow faster and become wealthier than inland provinces. This has led to higher income disparities and huge difference in adoption of the market principles. The people living in the upland rural western area of China are still not familiar with the market prices. Therefore, a payment card (PC) approach was adopted. A further advantage offered by this approach is that it is simple for the respondent and the researcher.

The original questionnaire was pre-tested using a sample of 42 respondents from Hei River valley residents to uncover misinterpretation of the questions, ambiguity in response categories and clarity of visual aids, such as graphs and photos. We asked respondents to write down their own maximum amount and used these as a guide to arriving at the alternative values that were shown on the PC in the final questionnaire. The information was gathered through direct interviews.

The cover and first section of the survey provided a series of maps to remind respondents where the Ejina was and the condition of its ecosystem (Fig. 2). The first section showed the location of Ejina and discussed the history of the area. The respondents were told that their answers would be used as input by the government in its study of restoring Ejina ecosystem services.

Second, respondents were handed a card that listed the five key ecosystem services that restoring Ejina ecosystem could provide, which are (1) control soil erosion and reducing sandstorms, (2) provide habitat for wildlife, (3) natural purification of water, (4) dilution of wastewater, and (5) curb land salinization. The current state, restored level of each individual ecosystem service and current management methods were described and illustrated in detail in the survey questionnaire. At the same time, the means by which ecosystem services could be restored from their current level were also described in detail.

CVM is an interactive exchange between the researcher and the respondent, where the researcher's objective is to obtain a set of responses that reflect the individual's true value about the public program in the questionnaire. Many problems may arise from the information provided, the method of payment used, and over- or under-reporting of true values.

Restoration of Ejina ecosystem is a public good available to all Chinese households. Therefore the geographic extent over which benefits should be measured would ideally be national in scope. With a view to deciding the sample scope and sample

Table 1
Potential response effects and precautions in our case study

Type of effects	Precaution
Hypothetical	Using a 12-page paper with maps depicting the reason why Ejina ecosystem deteriorated, and the means by which ecosystem services could be restored from their current level. Providing a 2 RMB currency bill as a token of appreciation for participating in a 30-min interview. Responses were kept anonymous.
PC bid design	Deciding the bid range by pretest and adopting PC method
Strategic behavior	In the process of interviewing, we indicated to respondents that WTP in excess of his household's monthly income per capita would be classified as outliers.
Effect of survey mode	The questionnaire was printed on good quality paper, photo-reproduced and bound in booklet form. Use of in-person interviewer as a way to conduct a survey.
Scope effects or absence of embedding	Providing the overall context in which the Ejina ecosystem improvement takes place and a supplementary, relative measure of the improvement as well.

mode, we initially mailed 10 questionnaires including a 2 RMB bill attached as appreciation to the Lanzhou residents (our institute is in the city, choosing Lanzhou as a pretest city is for convenience). But the response was disappointing as we did not get any returned surveys during the next 2 weeks. Therefore we contacted these non-respondents by telephone to investigate the reason for non-respondence. The contacted individuals indicated that they had no time to deal with the questionnaire. To follow up, we went to their home. Here all of them gave an apology for their non-reply, expressed strong interest in restoring ecology of the Ejina because they have heard about the conditions of Ejina from TV. The response is particularly encouraging, as it meant that the respondents would be interested in the Ejina ecosystem restoration program. However, it was clear that an in-person interviewer would be required to obtain the responses. So we decided to localize our investigation to the Hei valley due to limited time and funding. Following the suggestion of Loomis and Walsh (1997) that the sample size should not be less than 200 households or individuals and upwards of 1000 may be desirable to provide sufficient precision in WTP estimation, we decided to sample 700 households in Hei valley. To save travel time we adopted randomized cluster sampling, randomly chose 24 villages and towns by region as our sampling site. The relative sample amount in each region is determined by population density.

The interviewee was asked to select his or her own maximum WTP from a PC, assuming the payment vehicle was the one he chose. In our questionnaire, three methods of payment such as donation, ecological protection tax, and water bill were presented to respondents who are familiar with these methods of payment. At the same time, the fourth option left as blank, respondents can fill in the blank by method of payment he or she liked. This was designed to overcome the problem of non-acceptance of the payment vehicle that may lead to protest responses due to perceptions of inequity regarding the means of payment. Since these different payment vehicles vary in their incentives for the respondent to reveal their true maximum willingness to pay and potential for free-riding behavior, the reader should keep this limitation in mind when reviewing the results that follow. Future research in China should focus on determining what are acceptable payment mechanisms for different types of public goods, so that all respondents would receive the same payment vehicle for a given type of public good.

Table 1 illustrates the steps taken to reduce common biases in contingent valuation.

Note, like most CVM studies we were not able to conduct a cash validity experiment or formal scope test to measure the degree to which our precautions were successful at reducing these effects.

The actual valuation portion of the survey has three elements: (1) portrayal of the ecosystem to be

valued, (2) description of the particular mechanism to be used to pay for the ecosystem, (3) the question format used to elicit the respondent's RMB amount of WTP.

The exact wording of the CVM question section is as follows (a complete Chinese copy of the survey will be provided upon request to the senior author):

If the majority of households vote in favor of restoring Ejina ecosystem, the Ejina's ecosystem will be restored to the level of the early age of 1980s.

If a majority vote against, the Ejina ecosystem will remain the conditions and deteriorated as current tendency, at last, it has the likelihood to disappear in the world like the historic country 'LouLan'.

If the project of restoring Ejina ecosystem is at the stage of raising capital, if you vote in favor of it, please draw a circle around the maximum amount your household would vote for and draw a line under the lowest amount your household will switch (i.e. to a no) each year in the following 20 years.

0 2 5 10 20 35 50 75 100 200 300

If current raising capital is a ***lump-sum payment****, would your household be in favor of cost _____(yuan) to restoring the Ejina's ecosystem. (Please fill in the blank).*

Finally, there is a series of personal questions, aimed at knowing respondents' reactions to the interview and at obtaining respondents' socio-economic information.

4. Survey implementation

4.1. Response rate and reasons why some respondents would not pay

The sampling frame were households living within Hei valley. We performed a random sample of these households. Sufficient funds were available to allow for us to use in-person interviews of 700 households. During July 2001, our group took 1 month to finish our in-person investigation. The 700 households to be sampled were split into 24 smaller groups of 20–35 people each. To identify households for sampling, random digit dialing was used in cities and towns that have the telecommunication network to choose a total of 324 households. In regions that have no telephones, we collected the names of the head of household and recorded them on a slip of paper. Then a random drawing of household names from the box was used to choose a total of 376 households. After choosing the households, we assigned a person to interview each household. The initial contact phase involved briefly explaining the general topic of the survey and soliciting agreement to complete an in-depth in-person interview at the appointed time that was usually in the afternoon or evening. With a view to increasing the response rate, examples provided by Dillman were used for developing the questionnaire's cover, including an original signature, and 2 RMB bill (Chinese currency, $1 equal to 8.3 RMB) was presented as a token of appreciation (before beginning the interview).

Before directly asking how much respondents would pay for restoring the ecosystem services at Ejina, we gave the respondent 5 minutes to reflect on why they might care about restoring Ejina

Table 2
Distribution of survey willingness to pay responses (vote for)

Response	Percent of respondents (%)	
	Main valley	Surrounding district
Willing to pay some amount	92.37(448)	92.09(198)
'Restoring ecosystem service is not worth this money to me'	0.00(0)	0.00(0)
'I can't afford to pay this amount'	1.03(5)	0.93(2)
'It is unfair to expect me to pay for increasing ecosystem services'[a]	2.06(10)	3.26(7)
'Restoring Ejina ecosystem services cannot get expected effect'[a]	1.65(8)	0.00(0)
'I am opposed to paying for this government program'[a]	2.27(11)	2.79(6)
Other reasons[a]	0.62(3)	0.93(2)
Total[b]	100.00(485)	100.00(215)
Deleted as protest	6.60	6.98

[a] Classified as a protest response.
[b] Due to numeric rounding, the totals do not equal to one hundred percent.

ecosystem services. Residents of Hei valley have been exposed to extensive sandstorms resulting from the ecosystem degradation in Ejina. In addition, dissension on how to allocate water resources between the middle of Hei River and Ejina, for economic and ecological purposes had been greatly increased since 1980. Thus, we believe that Hei valley residents have some knowledge about the trade-off ecosystem services and have had some opportunity to reflect on what these ecosystem services mean to them. At the same time, household members selected an individual to answer on behalf of their household. We made a requirement that the respondent's age be older than 18 years, so that the respondent would have enough knowledge about his household values and choice experience with respect to purchasing of commodities.

Adopting in-person interviews resulted in high response rates to our survey. Response rates were beyond 99% among main valley and Surrounding District. The two sampling strata and sample sizes are listed in Table 2. Out of 700 contacts, 695 questionnaires were completed. The high response rate may be attributed to our follow-up efforts involved, on the other hand, the social setting may have had an important influence on higher response rates. In the process of interviewing, in addition to the contacted respondent, many of their friends or family waited around our interview room expressing intense interest in our work. This may be due to the fact that the government has never solicited opinions from grassroots on some public affairs.

A series of follow-up check questions were asked after the WTP question to determine if those refusing to pay represent a valid representation of their value or reflect a protest about some feature of the simulated referendum (Mitchell and Carson, 1989, Loomis, 1996). As shown in Table 2, the check question had five response categories plus an 'other' category. The first two categories were, 'restoring ecosystem service is not worth this money to me' and 'I cannot afford to pay the amount'. The two categories represent valid reasons for indicating why they would not pay and are not considered to be a protest response against the survey. About 2% of all respondents stating they would not pay any amount and checked inability to pay as the reason. The third, fourth, and fifth categories are often classified as protest or scenario rejection responses. These included, 'It is unfair to expect me to pay for increasing ecosystem services', 'Restoring Ejina ecosystem services cannot get expected effect', 'I am opposed to paying for this government program'. The percentage of each of the two samples selecting each reason is summarized in Table 2. Among these gathered questionnaires, there were 49 responses, which had a zero WTP (that is to say, the respondent draws a line and a circle around zero) and have been classified as protest response. After deletion of these samples, we have a total of 646 observations.

The Main Valley included these regions along Trunk River like Sunnan country, Zhangye country, Linze country, Gaotai country and Ejina. Surrounding District included Jiayuguan city, Jiuquan city, Jinta country, Minle country and Shandan country. Dingxin town is located along Trunk River region in the Surrounding District, but in our analysis it was classified into Main Valley.

4.2. Characteristics of the interviewees

As mentioned above, in the third part of the questionnaire, we collected respondents' demographic data on income, age, and the like. About 20% of the respondents were within the range 18–24 years. The most frequent age class is between 25 and 35 years (50.1%). Almost 26.9 and 3.4% of the cases fall within the age-range 36–50 years and above 50 years, respectively. The average age is just above 32 years. The level of education shows a profile of 29.1% of the interviewees declared that they obtained a high school diploma and 46.9% have attended a university for 3–4 years. At the same time, 24% of the interviewees have acquired a junior certificate. The most frequent family income bracket is below RMB 5 thousand (34.5%); 33.3% indicated the range RMB 5–10 thousand and 26.2% the bracket RMB 10–20 thousand, and only 6% above 20 thousand. Sixty eight percent of the interviewees are male. In terms of domicile

Table 3
Frequency distribution of respondents by bid amount they would vote in favor

WTP amount (RMB)	0	2	5	10	20	35	50	75	100	200
Frequency(%)	7.3	8.5	10.4	22.4	17.2	8.2	11.8	2.3	8.5	3.4

class, 68.1% of interviewees live in urban areas and 31.9% live in rural areas in our survey.

5. Results

In the PC format, respondents are confronted with an ordered sequence of bids where they choose the maximum amount they are willing to pay. In the PC format maximum WTP is elicited directly. Following Welsh and Poe (1998) and Bonato et al. (2001), we expanded the PC format beyond the traditional PC format by letting respondents consider each monetary amount and allowing them to express uncertainty. Therefore, additional thresholds and likelihood of voting yes are included and WTP responses are elicited in form of intervals instead of point valuations. T_L is defined as the maximum amount that the respondent would vote for and T_U to be the lowest amount that she would switch to a no rather than yes response. WTP then lies somewhere in the switching interval (T_L,T_U) where individual WTP values are estimated by using parametric models. In the parametric model, a functional relationship between the WTP values and the characteristics of respondents or the public good are estimated. Since the distribution of WTP values is often skewed, the lognormal distribution is chosen as Eq. (1) (Cameron and Huppert, 1989):

$$\text{Ln WTP} = X'\beta + \mu \tag{1}$$

where X are the characteristics of a respondent or the public good and $\mu$is normally distributed with zero mean and standard deviation σ, and β are regression coefficients.

However, by simply setting the expected WTP values equal to the interval midpoints, biased WTP values may result. Therefore, we use a multiple bounded likelihood model where WTP becomes a random variable (Welsh and Poe, 1998). The probability that a respondent will vote yes, is:

$$\Pr(\text{yes}) = \Pr(\text{WTP} \geqslant T_L) = 1 - G_{\text{WTP}}(T_L) \tag{2}$$

where $G_{\text{WTP}}(T_L)$ is the cumulative distribution function of the random WTP variable. The probability that WTP falls between any two price thresholds is $G_{\text{WTP}}(T_U) - G_{\text{WTP}}(T_L)$, resulting in the corresponding log-likelihood function for all n respondents:

$$\text{Ln}(L) = \sum_{i=1}^{n} \text{Ln}[G_{\text{WTP}}(\eta T_U - \gamma X_i) - G_{\text{WTP}}(\eta T_L - \gamma X_i)] \tag{3}$$

Where $\gamma = \beta/\sigma$ and $\eta = 1/\sigma$. By using the estimated values of β and σ we can calculate values of Ln WTP. The conditional mean of the Ln WTP for any given vector of variables will be βX, and the mean of the untransformed WTP variable is $\exp(\beta X + \sigma^2/2)$ and the median is $\exp(\beta X)$ (Dudewicz and Mishra, 1988). Because the mean as a welfare measure is more sensitive to the disturbance standard deviation σ, in our analysis, the median of WTP was calculated.

5.1. Analysis of stated willingness to pay

This section discusses the willingness to pay stated by the respondents. Among the valid questionnaires, there were 47 respondents that drew a circle around zero RMB as the amount that their household would vote for. Table 3 presents the distribution frequency of interviewees at each bid amount that they will vote for. We discovered that, usually the lowest amount respondents would switch to a no vote was only one response category higher in the PCs than what he would vote for.

Table 4
The parametric model of willingness to pay and estimated results

Coefficient(*t* statistic)			
Variable	Whole valley	Main valley	Surrounding district
Constant	1.671(8.04*)	1.550(6.67*)	1.556(3.435*)
Urban	0.177(2.79**)	0.460(2.768**)	−0.510(2.217**)
Education	0.057(2.97**)	0.061(2.781**)	0.082(2.196*)
Income	0.179E−03(7.151*)	0.154E−03(5.727*)	0.243E−03(3.737*)
Log likelihood	−1094.610	−751.883	−332.662
Standard deviation	1.345	1.317	1.342
Sample size	646	448	198
Median WTP	19.37	20.78	16.41

Urban equals one if a person lives in an urban/suburban area; it equals zero if the person lives in a rural/farm area. *Education* specifies years of schooling the respondent has undertaken. *Income* is household's annual income.

* Significant at the 0.01 level.

** Significant at the 0.05 level.

On the average, WTP amounts of 20 and 100 represent 1 and 5% of per capita yearly income, respectively.

Three full statistical models including all survey demographic and attitude variables were estimated by maximum likelihood regression. To conserve space, only the models with independent variables significant at the 0.05 level or better are presented. Demographic variables such as age, sex or whether the respondent said they were an environmentalist were consistently insignificant and these were not included in the final model. Table 4 shows the results of maximum likelihood regressions for both groups of respondents.

The empirical results in Table 4 show that (1) respondents' education and income level were positively correlated with WTP and were significant. The higher the income and education of respondents, the higher is the WTP for restoring Ejina ecosystem services; (2) suburban and urban residents have higher willingness to pay for restoring Ejina ecosystem services than rural/farm residents, except those in the Surrounding District.

Using the statistical model in Section 5.1, using means of the independent variables, we calculated willingness to pay for restoring Ejina ecosystem services for the three geographic districts. The results are reported in Table 4 as well. The median WTP is 19.37 RMB in Hei valley per year, per household, 20.78 in Main Valley and 16.41 in the Surrounding District. The results showed that residents in Main Valley have higher WTP than residents in the Surrounding District. Owing to Ejina ecosystem's severe degradation, government has promulgated statutes on how to deal with the water allocation among users in the Main Valley. At present, of greatest local concern is the water allocation. In some sense, improvements to the Ejina ecosystem service will reduce the stress of water shortages in the middle of Hei River.

A likelihood ratio (LLR) test is used to determine if the valuation behavior across the two geographic regions is similar. The LLR test involves comparing the individually estimated coefficients in Table 4 for the two geographic regions with the coefficient from a single maximum likelihood regression estimated by pooling the data across the two regions (i.e. the whole valley). If the coefficients are similar across regions, similar valuation behavior is implied. The LLR test statistic is calculated as

$$\mathrm{LLR} = -2[\mathrm{LLR}_p - (\mathrm{LLR}_1 + \mathrm{LLR}_2)] \quad (4)$$

Where LLR_p is the log likelihood for the single pooled equation and LLR_1 and LLR_2 are the log likelihoods for each of two equations estimated separately. The test statistic is distributed χ^2, with degrees of freedom equal to the number of coefficient equality restrictions (4 variables times 2 equations or 8 total coefficient restrictions) minus the number of variables in the pooled equation. The results indicate that we should reject equality of valuation behavior across the two regions (calculated $\chi^2 = 20.13$ while the critical χ^2 with 4 degrees of freedom is 13.27). Hence, the median WTP of people living in different areas is best estimated by reliance on the two separate equations rather than one pooled equation. Part of the reason for differences in maximum likelihood equations and WTP between Main Valley and Surrounding District may relate to water resources utilization as mentioned above. The LLR test analysis results provide evidence that people living in different areas view the services provided by the Ejina ecosystem somewhat differently.

5.2. Time discount for WTP

Economic theory requires that respondents distinguish between lump sum and periodic payments with implicit discount rates of reasonable magnitude. We resolve the problem of time discount in dealing with aggregate of annual payment in the following.

According to economic theory there should be a discount rate whereby the utility of a lump sum payment and a series of annual payments should be equal. The average WTP of lump sum amount given by respondents is 248 RMB per household. For purposes of calculating the discount rate we use the data of annual payment using the mean value monetary amount that respondent would vote for calculated as 32.18 RMB per household, per year.

From the viewpoint of aggregate utility, the present value of annuities (periodical payment) and lump sum should equal. In term of financial management (Lu and Jiang, 1997), the present value of annuities can be shown as Eq. (5).

$$PV_0 = A(PVIFA_{ei,n}) \tag{5}$$

where PV_0 is the present value of the future sum of money; A is the annuity payment at the end of each year; $PVIFA_{ei,n}$ is the present value interest factor for an annuity for ei and $n(n = 20)$, ei is the interest rate of environment goods.

Similarly, the present value of lump sum (PVLS) can be calculated as Eq. (6).

$$PVLS = FV_{n1}(PVIF_{r,n1}) \tag{6}$$

where PVLS is the present value of lump sum; FV_{n1} is the future value lump sum investment at the beginning or end of $n1$ year; $PVIF_{r,n1}$ is the present value interest factor for r and n, r is risk-free interest rate (2.25%) and $n1$ is the time lump sum investment provided.

On the average, the households in Hei Valley have lower income per year. So, in our survey, the lump sum investment is allowed as well as the annual payment during the 20 years. In our calculation, for simplicity, we hypothesized that the lump sum would be provided at the beginning of the first year or at the end of the 20th year. If the lump sum provided at the end of the 20th year, then we can get the following equation:

$$32.18 \times (PVIFA_{ei,20}) = FV_{20}(PVIF_{2.25\%,20}) \tag{7}$$

These symbols in Eq. (7) have been expressed above.

From Eq. (7), we can get ei = 19.8%. Following this, the interest rate of environment good is ranged from 11.5 to 19.8% depending on whether the lump sum payment is the first year or the 20th year, respectively.

The high discount rate for environmental goods encourages public to underestimate the importance of future benefit, and also demonstrates that humans should take action on environmental restoring and protection as soon as possible (Daly and Ehrlich, 1992). At the same time, we have realized that the higher environmental discount rate may be a temporal embedding influence (Stevens et al., 1997). This being the first CVM survey in the region, we consider these results as approximations and subject to further analysis and refinement.

Table 5
Total benefits of households in Hei valley

Regions	Household annual median WTP	Number of households	Number of households which have WTP	Annual aggregate WTP (millions)	Discount rate (%)	Time scale (year)	Present value aggregate benefits (millions)[a]
Main valley	20.78	223 895	222 187	4.62	15	20	28.90 (RMB)
Surrounding district	16.41	259 328	257 277	4.22	15	20	26.43 (RMB)
Total				8.84			55.33 (RMB)

[a] Calculated by compound interest.

5.3. *Expanding from sample to population estimated of aggregate WTP*

Accurately expanding the sample values to the population is dependent on the representativeness of the sample frame and the survey response rate. We calculate a conservative estimate of WTP by assuming that non-respondents and protests would have a zero WTP. It is very unlikely that such an extreme assumption is true, but this procedure does provide a lower bound on estimated WTP. We treat the median WTP of Main Valley and Surrounding District as the best estimate of what the average household of the two regions. In our survey, the districts interviewed were determined to be pertinent areas to which the preservation benefits pertain. Annual WTP estimation applied the median only to the proportion of households that responded to the survey multiplied by the number of households in respective regions. We aggregate WTP on time scale by adopting the mean environment discount rate (15%). The resulting median annual WTP is 4.62 and 4.22 millions for Main Valley and Surrounding District residents, respectively. The aggregate present value of the benefits is 55.33 millions. The benefit results are listed in Table 5.

The costs of restoring the Ejina ecosystem services is estimated to be a total of 600 million RMB over 5 years. If this investment is evenly spread over the 5-year period it equals a present value of 400 million RMB at the 15% discount rate used to calculate the present value of benefits. Given that the present value of benefits is 55.33 million RMB, this indicates the economic efficiency benefits are less than the restoration costs. This result has several implications including: (1) the limitations of using a willingness to pay based measure in less developed countries; (2) the need to determine if there are additional benefits received by residents in other regions.

6. Conclusions

The total value of restoring ecosystem services represents important information about the consequences of changes in the condition or quality of

an ecosystem. The valuation process reduces multidimensional information to a single number. This can make understanding of the result obtained much easier for the decision maker.

Three conclusions can be made from this study. First, owing to institutional and cultural differences with western developed countries, some are suspicious of whether the CVM can be applied in China. The empirical study demonstrated that carefully designed and pre-tested CVM could be applied in China. Second, the study illustrates that there is a substantial non-market willingness to pay for restoring Ejina ecosystem services. The mean annual value per household in Main Valley and Surrounding District was 20.78 (RMB) and 16.41 (RMB) respectively. Meanwhile, the environment interest discount rate ranged from 11.5 to 19.8%, calculated by using utility equal between periodical payments and lump sum payment. Taking into account geographic regional differences and a 20-year time period into account, the aggregate present value of the benefit of restoring Ejina ecosystem service is 55.33 million (RMB). The valuation information can be used by the government bureau of Hei Valley in its evaluation of the restoration actions. It may be that the scale of restoration should be re-evaluated in light of our finding that willingness to pay based benefits are less than the costs. Nonetheless, this research suggests that contingent valuation (perhaps using willingness to accept rather than willingness to pay) may be a potentially useful direction for future research on the environment valuation in China.

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