



# Spatial prioritization of willingness to pay for ecosystem services. A novel notion of distance from origin's impression

Sufyan Ullah Khan<sup>1</sup> · Guobin Liu<sup>2</sup> · Minjuan Zhao<sup>3</sup> · Hsiaoping Chien<sup>4</sup> · Qian Lu<sup>3</sup> · Arshad Ahmad Khan<sup>3</sup> · Muhammad Abu Sufyan Ali<sup>3</sup> · Misbahullah<sup>5</sup>

Received: 22 March 2019 / Accepted: 13 September 2019 / Published online: 14 December 2019  
© Springer-Verlag GmbH Germany, part of Springer Nature 2019

## Abstract

Valuation of environmental goods and services are frequently spatially heterogeneous, the significance of this heterogeneity for policy analysis is gradually recognized. For the valuation of environmental goods and services in the context of attaining a better environmental status across Heihe River basin (HRB), Northwest of China by 2020, a survey was conducted employing choice experiment approach across the entire river basin. In this research we estimate the impact of distance from inland rivers' origin (spatial attribute) on the inhabitants' willingness to pay for restoration of ecological attributes. A total of 11 ecological attributes were selected including 6 land related attributes and 5 water related attributes. The present study displays the outcomes of the research planned to examine differences in willingness to pay across different locations/distances. A total of five cities and 33 surround villages/townships were included to examine for location effect, while four ad hoc base distances split samples were recognized for distance effect i.e.  $\leq 100$  km,  $\leq 200$  km,  $\leq 300$  and  $> 300$  km from rivers' origin. The results of mixed logit model recognized that people living at different locations value the attributes differently. For instance the people of Zhangye region are willing to pay RMB 95.66 annually for improvements in biodiversity while in Gaotai the individuals' willingness to pay (WTP) for the same attributes was RMB 45.68. Similarly, the respondents' living nearer to the origin of river were willing to pay relatively higher amount for the upgradation in the degraded ecosystem services than the remainders. The results of willingness to pay obtained by Krinsky Robb method confirmed that the attributes quality of agricultural products and water quality were the most preferred attributes with the willingness to pay RMB 91.09 and 122.89 respectively. The significant results of willingness to pay may serve as a reference for sustainable improvements and uplifting of the degraded ecological attributes.

Responsible editor: Philippe Garrigues

**Electronic supplementary material** The online version of this article (<https://doi.org/10.1007/s11356-019-06538-4>) contains supplementary material, which is available to authorized users.

✉ Guobin Liu  
gbliu@ms.iswc.ac.cn

✉ Minjuan Zhao  
minjuan.zhao@nwsuaf.edu.cn

Sufyan Ullah Khan  
sufyan@nwafu.edu.cn

Hsiaoping Chien  
chienp@affrc.go.jp

Qian Lu  
xnluqian@126.com

Arshad Ahmad Khan  
arshadkhan@nwafu.edu.cn

Muhammad Abu Sufyan Ali  
Sufyanali@nwsuaf.edu.cn

Misbahullah  
drmisbah@aup.edu.pk

<sup>1</sup> College of Forestry, Northwest A&F University, Yangling 712100, Shaanxi, China

<sup>2</sup> Institute of Soil and Water Conservation, Northwest A&F University, Yangling 712100, Shaanxi, China

<sup>3</sup> College of Economics and Management, Northwest A&F University, Yangling 712100, Shaanxi, China

<sup>4</sup> Japan International Research Center for Agricultural Sciences, 1-1 Ohwashi, Tsukuba, Ibaraki 305-8686, Japan

<sup>5</sup> Department of Entomology, The University of Agriculture, Peshawar, Pakistan

**Keywords** Choice modeling · Ecological attributes · Spatial heterogeneity · Distance from origin, mixed logit · Willingness to pay · Heihe river basin

## Introduction

A growing literature discovers that spatial dimensions is interconnected to the elicitation, approximation, elucidation and combination of welfare measures of stated preference. The absence of perfect direction from microeconomic theory with regard to some of the ways in which impact of location on the significance of environmental goods is challenging in flowing in a direction towards a more inclusive and consistent behaviors of spatial dimensions in stated preferences research. In the literature theoretical expectations frequently match the Empirical patterns, though unambiguous theoretical expectancies might not always be existent. The absence of a consistent and inclusive theoretical base leads to inspire “proof of concept” or ad hoc behaviors of spatial measurements, with little consent standards to direct research applications. Therefore, in spite of a growing amount of different studies illustrating spatial features of stated preferences in realistic terms, there is still absence of a consistent framework by which practical spatial forms can be more reliably modeled and understood. (Glenk et al. 2019).

Many studies have reported that variations in willingness to pay across different geographical dimensions are affected by environmental change, thus taking into account distance-related effects in separate terms (Morrison and Bennett 2004; Johnston and Duke 2009; Brouwer et al. 2010; Martin-Ortega et al. 2012; Dallimer et al. 2014; Interis and Petrolia 2016) or distinguishing persistent effects of distance from discrete effects through formal frontiers (Bakhtiari et al. 2018). In these cases, it is presumed that spatial heterogeneity will fluctuate discretely across different dimensions or formal boundaries, usually related to the individuals’ living place. Mutually exclusive study area can be on identical executive or ecological level e.g. river basins, cities, villages/ counties or can be nested as e.g. societies, villages/counties, provinces and nations. Such dissimilarities can be closely related to numerous studies on the benefit transfer across different jurisdictions (Morrison et al. 2002; Morrison and Bennett 2004; Johnston and Duke 2009; Bateman et al. 2011; Martin-Ortega et al. 2012).

Findings of many studies revealed the identical theoretical expectations as those for continuous distance evaluations. For instance, ecological progresses employed over limited boundaries are expected to have further proximate effects than the similar scale ecological improvements conducted over large jurisdictions and therefore connected to higher willingness to pay (Johnston and Duke 2009). Inhabitants could also have much concerns for modifications and upgradations occur in their own jurisdiction (Hanley et al. 2003; Bateman et al. 2005; Bateman

et al. 2006), or may vary in their opinions of natural resources in different areas (Jacobsen and Thorsen 2010). Nevertheless, impacts on willingness to pay can fluctuate subject to the extent of ecological change (Brouwer et al. 2010). Variations in willingness to pay can also be observed through the differences in current endowments and availability of the alternatives across jurisdictions (Interis and Petrolia 2016).

To summarize, for the valuation of environmental assets the spatial heterogeneity of preferences should be included, otherwise negligence of these effects might lead to over or underestimation of welfare estimates. The existence of spatial heterogeneity for ecosystem services is determined by the previous studies, specifically the distance decay effect (Bakhtiari et al. 2018; Khan et al. 2018). This study add to this literature a novel and diverse spatial approach i.e. distance from the river’s origin and by applying this approach to a scattered ecosystem which provides numerous ecosystem services. To our knowledge the inclusion of distance from river origin variable has not yet been included before in spatial heterogeneity and environmental valuation studies.

The study take into account six land attributes and five water attributes namely cultivated land yield, quality of agricultural products, Ejinaqi oasis size, biodiversity, greenhouse gas emission reduction & farmland landscape (land attributes) and river water quality, farmland irrigation, sandstorm frequency, area of east Juyan Lake & conditions for leisure & entertainment (water attributes). An exploratory investigation of spatial distribution of preferences is also executed in this study. The detailed aims of the study are (1) to estimate the effect of distance from the origin on individuals’ willingness to pay (2) to estimate the peoples’ preference for water and land attributes.

The next section consists of methodological approach for the estimation of ecological attributes, data collection, followed by the results estimation. The final section is about conclusion of the results and discussion and practical implications of spatial preference heterogeneity for environmental policy.

## Methodology

### Case study description

The appearance of the river basins are intensely changed by the swift industrialization. Recently, the river ecosystems are considerably affected by social activities. The expansion of urban areas produced a serious dilapidation in the river network structure. Heihe River basin is situated in the central section of the Hexi Corridor Region i.e. in Gansu region and

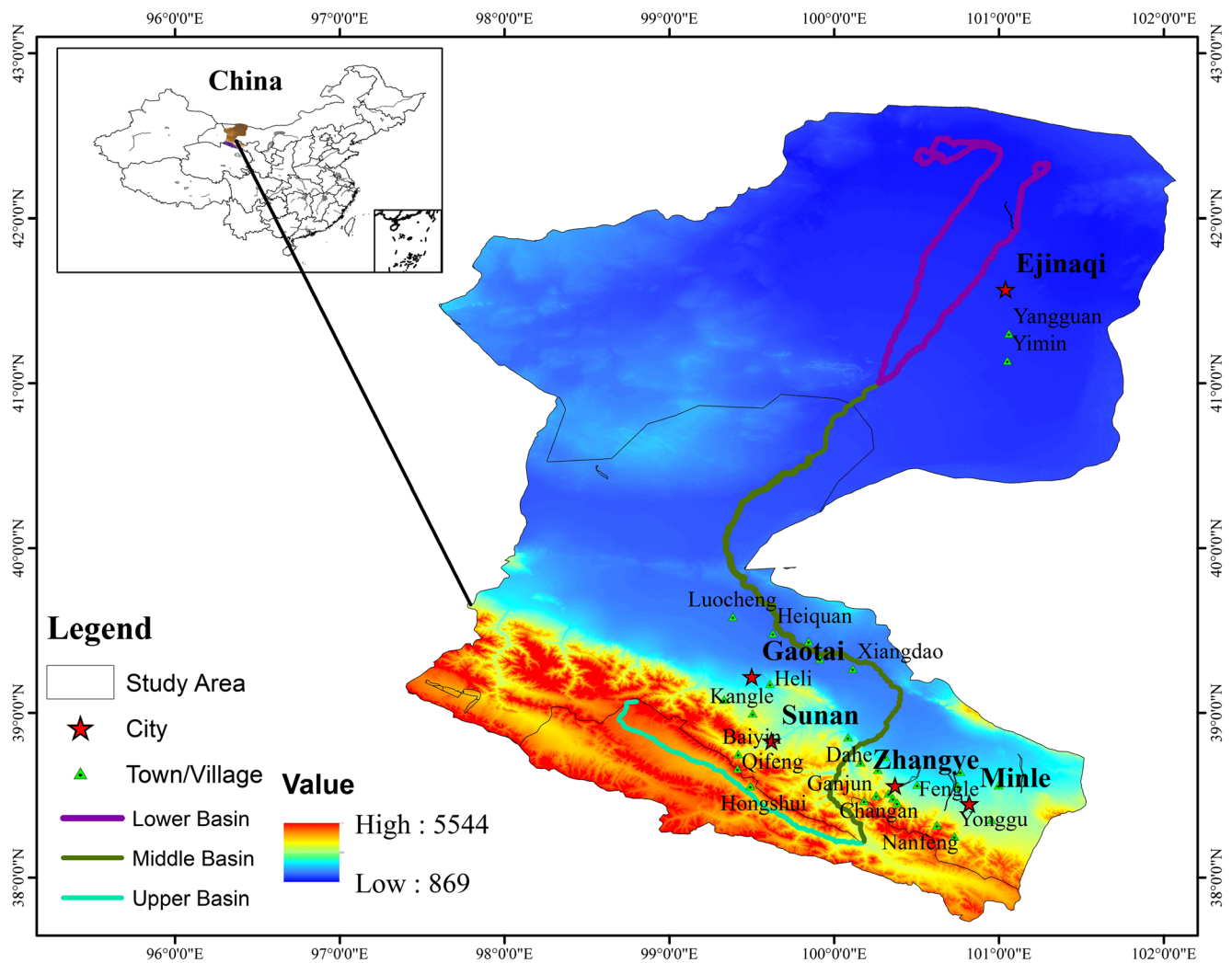


Fig. 1 Heihe River Basin (Arc GIS 10.3)

its origin is Qilian Mountains located in Qinghai and Gansu Province and the lower basin ends in the desert part of Inner Mongolia (Fig. 1). Heihe river is one of the bigger inland river in China which cover approximately an area of 128,000 Km<sup>2</sup> (Qi and Luo 2007). The upper reaches is located in Qinghai region, while the middle basin comprise of Zhangye city and some districts of Gansu region i.e. Sunnan, Minle, Gaotai, Shandan and Linze. Similarly, the lower basin reaches to the Ejinagi County located in the Inner Mongolia (Gao and Li 1991). In the total area of Heihe river basin covered 57.15% is covered by desert, while remaining area is covered by mountains and oasis with a contribution of 33.16% and 8.19% respectively (Cheng et al. 2006).

### Choice experiment

The random utility model is applied in our study which becomes prevalent in valuation of non-market goods since the study by (Bockstael et al. 1987). Fundamentally, for the valuation of ecological attributes the facts and figures regarding ecological

attributes were processed. A discrete choice experiment was employed to obtain stated preferences for the estimation of random utility model (Shi et al. 2016; Chen et al. 2018; Khan et al. 2019c). The benefits of applying stated preferences comprise of a decrease in the problem of collinearity in the attribute levels and probability of ex-ante modeling of fresh/novel aspects of ecological improvements which are currently unavailable i.e. attribute levels that are beyond the range of existing levels. Moreover, the problem of endogenous levels can also be avoided (Hanley et al. 2002; Von Haefen and Phaneuf 2008; Whitehead et al. 2008).

Most spatial choice models resulting from the perception regarding utility is central to the decision rules. Typically it is supposed that households practicing a compensatory assessment framework where the lower level of an attribute can be compensated by higher levels of other attributes, which show the attraction of an alternative consist of a set of attributes by this scalar concept of utility (Ben-Akiva et al. 1985). Then the respondent can assign the utility level to each possible choice set yielding the maximum level of utility.

### Econometric specification and estimation of choice model

Econometric estimation is carried out in a two-stage of modeling. In the initial stage a choice model basis on the replies of the sample respondents to the queries of the choice experiment is carried out, while in the second stage we employ this model to calculate the marginal willingness to pay (MWTP) for ecosystem services.

For empirical analysis of sample respondents responses mixed logit model can be applied in different ways (Hensher and Greene 2003; Train Kenneth 2003). A model consists of random parameters is found to be suitable for the parametric analysis of the current study. Mixed logit model lacks main deficiencies of the conditional logit model. Significantly, it precisely adjusts the repeated choices and unobserved taste heterogeneity i.e. random taste variations across respondents but not across observations from the same respondent, and is not restricted by the Independence of the Irrelevant Alternatives (IIA) property ((Revelt and Train 1998; Hensher and Greene 2003; Train Kenneth 2003). Moreover, mixed logit model is practically measureable and manageable that can estimate any random utility model (McFadden and Train 2000).

By following (Scarpa et al. 2005) an Alternative Specific Constant (ASC) is specified for the status quo alternative for capturing the systematic component of a potential status quo effect. To capture the persistent residuals part of the status quo effects an additional error term which is normally distributes is included to the econometric model and specifically allotted to the two alternative. With the specification of the common error component across the alternatives, the utility’s correlation patterns in these alternatives are induced. It therefore captures any additional variance connected with the rational effort of assessing experimentally-designed hypothetical alternatives (Greene and Hensher 2007; Scarpa et al. 2007; Scarpa et al. 2008). The common structure of utility is as follows:

$$U_{ntj} = V(X_{ntj}, \beta_n, U_n) + \varepsilon_{ntj} \quad \{j = 1, 2\} \tag{1}$$

$$U_{ntj} = V(ASC, x_{ntj}, \beta_n) + \varepsilon_{ntj} \quad \{j = Status\ quo\} \tag{2}$$

V Shows indirect utility which consists of the function of vectors of independent variables,  $X_{ntj}$  and the vectors of individual-specific random parameters  $\beta_n$ . The error component  $U_n$  is included for the two policy alternatives which is substituted by ASC (alternative specific constant) for capturing the status quo effect. The Gumbel-distribution is assumed for the unobserved error term  $\varepsilon_{ntj}$ . The individuals are designated to as  $n$ , while  $j$  and  $t$  are the alternative and the choice set respectively.

In the current study, the all the associated parameters with ecological attributes are supposed to be normally distributed random parameters. That permits for both negative and positive preferences that could be predicted on the basis of focus

group interviews and a pilot test. For the estimation of stable log-likelihood results a 500 draws is found to be appropriate number.

### Marginal willingness to pay (MWTP)/implicit price estimation

The estimated coefficients ( $\beta$ ) are used for the estimation of the MWTP of every attribute. For any upgradation in the current quality of ecological attributes the MWTP can be calculated as given below:

$$MWTP_k = -\beta_k / \beta_p \tag{3}$$

For the estimation of the 95% confidence intervals of the marginal willingness to pay, the preliminary tool is to identify the willingness to pay distribution. The delta and the Krinsky–Robb technique can be employed for an estimation of the 95% confidence intervals. In delta method, the willingness to pay estimated values are normally distributed, and variance can be calculated as by taking first-order Taylor expansion around the average values of the variables. The confidence interval (CI) can be calculated as follows:

$$WTP_k = Z_{\alpha/2} \sqrt{var(WTP_k)} \tag{4}$$

Where  $Z/2$  is the inverse of the cumulative normal distribution and  $100(1-\alpha)\%$  is the confidence level. The delta method may not be appropriate if the willingness to pay distribution is not normal for the reason of unrevealing the skewness of the willingness to pay distribution. In these conditions, the application of the non-parametric Krinsky–Robb technique can be useful, because for estimation of confidence interval of willingness to pay there is no requirement of normal distribution. We apply both delta and Krinsky Robb method for willingness to pay in our study.

### Survey design and application

To assess the present status of the environmental humiliation in Heihe river basin, a detailed assessment survey was organized among a randomly selected sampled respondents in the whole river basin from key cities and surrounding rural area. The rural areas were chosen for the fact to imitate the ecological and economic features of the reference cities. Moreover, the urban areas were preselected on the basis of equidistance principle while the counties, townships and villages were selected by applying stratified random sampling technique. Four to nine townships were randomly chosen from each county, similarly two to eight villages were chosen from each county. Lastly, ten to thirty households were chosen from each village through proportional allocation procedure. A primary data of 1680 respondents is collected from five main cities and 33



surrounding rural areas. Out of total respondents 199 are interviewed from Ejinaqi region, 304 respondents from Gaotai region, 280 respondents from Minle region, 201 respondents from Sunnan region and 695 respondents are interviewed from Zhangye region. Following previous studies (Khan et al. 2018; Kosenius and Markku 2015) and by applying proportional allocation technique, it is argued that the current sample size is sufficient to represent the targeted region.

### Estimation of distance decay effect

Generally, the studies do not use respondent's valuations of the route distance. They may be less accurate while better reflect the choice perceptions. Some studies validate dummy variable for zones (ranges around the administrative zones in km) especially for certain goods which have local importance to specify whether an individual is the local residence of the province/district or county where the good is located (Schaafsma et al. 2013). However, respondents' willingness to pay for the confirmation of the spatial heterogeneity of preferences have rarely been employed, although only applying pre-selected, ad hoc distance ranges. For example, to investigate the quantity of woodland, (Yao et al. 2014) applied ad hoc distance bands of 10, 10–50, and 50–100 km from each household. Similarly, Using ad hoc distance bands, (Khan et al. 2018) distributed the respondents into five main groups, which are  $\leq 5$  km,  $\leq 10$  km,  $\leq 20$  km,  $\leq 30$  km, and  $> 30$  km. The mentioned ad hoc band zones were considered as explanatory variables to describe the heterogeneity in willingness to pay for developments in river ecosystem.

To assess the distance decay effect the corresponding data is redistributed into 4 ad-hoc base distance bands (distance from origin of Heihe River) i.e. in zone 1 consist of the respondents living within  $\leq 100$  Km away from the Heihe river's origin, zone 2 comprise of the respondents living within  $\leq 200$  Km away from the Heihe river's origin, zone 3 include those respondents who are living within  $\leq 300$  Km away from the Heihe river's origin and zone 4 contain respondents living within  $> 300$  km away from the Heihe river's origin. A total of 141 respondents are in zone 1, 551 respondents in zone 2, 747 respondents in zone 3 and 182 respondents are in zone 4. The empirical analysis of mixed logit model was carried out by using an econometric software Stata. Whereas, to account for directional differences in locations, we collected the data from five major cities namely Ejinaqi, Gaotai, Minle, Sunnan & Zhangye and surrounding counties and villages (already discussed with details in 2.5).

### Description of the selection of attributes and their levels

For identification of the relevant ecological attributes and their corresponding levels, a pilot survey was initially organized

with the involvement of 70 local households of the study area. The pilot survey helped in the inhabitants views about the existing conditions and problems with ecosystem services. Some valuable additions come through the discussions with local ruling bodies and detailed review of previous studies. Based on previous literatures (Khan et al. 2019a, b) and thorough discussions with local authorities the environmental attributes and corresponding levels were selected and then included in our choice experiment. Following this procedure, 6 land related attributes namely cultivated land yield, Quality of agricultural products, Ejinaqi Oasis Size, biodiversity, greenhouse gas emission reduction and Farmland Landscape along with payment attribute as well as a payment attribute along with five water related attributes namely river water quality, farmland irrigation, frequency of the sand storms, increase in the area of east Juyan Lake, and conditions for leisure and entertainment are also chosen.

After the selection of the relevant attributes, the other important step in choice experiment was to decide the corresponding levels of the selected attributes. The designated levels of the attributes must be realistic and applicable to the public preferences for ecosystem services. Supplementary Table. A & B indicates the selected attributes and their levels. By using Ngene 1.1.1 software and D-efficiency design, a total of 60 choice sets have been generated, which are further divided into 20 blocks, the D error is 0.006939 and A error is 1.420521. Thus, each respondent was questioned to answer 3 choice sets.

### Individuals' characteristics

Supplementary Table. C and supplementary Fig. A signifies the socio economic characteristics, their means and standard deviation of the sample respondents located in the Heihe river basin. Out of total respondents 54.4% were males and 45.5% were females' respondents. The mean age of the respondents was 41.24 years, mean annual income was 47,970.26 RMB per year. Similarly regarding household size (HHS) it was observed that minimum HHS was 1 while maximum was 11 members in the study area. The results also indicates that majority of the respondents were having junior school education level i.e. 27.9% while only 14.4% of the respondents were having college degree. Similarly, regarding profession the results proposed that majority of the sample respondents were farmers (34.5%) while only 3.3% of the respondents were unemployed.

### Results and discussion

This section discusses the results that were obtained from the analysis of different econometric models through an econometric software Stata. The first section discusses the result by employing mixed logit model.

**Table 1** Estimated results of the mixed logit model for land attributes (spatial heterogeneity)

Choice	Ejinaqi		Gaotai		Minle		Sunnan		Zhangye		Pooled data	
	Coef.	S.E	Coef.	S.E	Coef.	S.E	Coef.	S.E	Coef.	S.E	Coef.	S.E
<b>Mean</b>												
Pay	-0.02***	0.01	-0.02***	0.00	-0.02***	0.00	-0.01***	0.00	-0.01***	0.00	-0.01***	0.00
ASC	-2.60***	0.96	-1.05*	0.62	-1.85**	0.80	-1.76**	0.72	-1.58***	0.44	-1.67***	0.25
Cultivated land yield	0.02***	0.01	0.03***	0.01	0.01	0.01	0.02***	0.01	0.02**	0.01	0.02***	0.00
Quality of agricultural products	0.87*	0.52	0.95***	0.34	1.51***	0.41	0.44	0.35	0.76***	0.26	1.18***	0.14
Oasis	0.00	0.00	0.00	0.00	0.00*	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Biodiversity	0.73***	0.23	0.16***	0.08	0.48**	0.23	0.22***	0.08	0.15	0.15	0.17**	0.08
Greenhouse effect landscape	1.50***	0.52	0.97***	0.37	1.32***	0.35	1.48***	0.41	0.75***	0.22	0.61***	0.12
landscape	1.59***	0.52	0.92***	0.31	0.65***	0.31	0.93***	0.35	0.45***	0.22	0.56***	0.15
<b>SD</b>												
Cultivated land yield	0.03***	0.01	0.17***	0.02	0.11***	0.02	0.07***	0.02	0.09***	0.01	0.10***	0.01
Quality of agricultural products	-1.51***	0.60	2.94***	0.59	3.09***	0.79	1.74**	0.92	2.54***	0.43	2.43***	0.23
Oasis	0.00***	0.00	0.00***	0.00	0.00***	0.00	0.00***	0.00	0.00***	0.00	0.00***	0.00
Biodiversity	-0.82***	0.31	0.35***	0.10	0.88***	0.28	0.31***	0.13	1.25***	0.23	-1.27***	0.14
Greenhouse effect landscape	2.89***	0.78	2.42***	0.51	-2.77***	0.49	-3.32***	0.80	1.90***	0.35	2.38***	0.20
landscape	-2.04***	0.77	0.61	0.86	-2.18***	0.73	2.52***	0.81	2.05***	0.46	1.84***	0.25
<b>Summary statistics</b>												
No. of Obs	1013		2736		2520		1791		6264		14,324	
LR $\chi^2(6)$	94.12		384.2		251.4		170.8		372.6		1629.8	
Log likelihood	-251.6		-697.0		-664.3		-494.6		-1011.2		-4043.5	
Prob > $\chi^2$	0.000		0.000		0.000		0.000		0.000		0.000	

**Estimation of location effect and MWTP for land attributes**

Table 1 describes the results of mixed logit model for land attributes. Before doing a proper welfare assessment all the protest responses and zero willingness to pay respondents were omitted from the surveyed data. The monetary attribute i.e. payment was given non-random distribution, while a random normal distribution was allocated to all the ecological attributes. The results indicate that the coefficient of monetary attribute along with ASC is negative and significant in all cities and corresponding surroundings, suggesting that as the prices increases people will pay less due to the decrease in their level of utility, while significant coefficient for ASC determines that typically people get utility from upgradation of environmental quality (Khan et al. 2019b). The results also indicates the attributes and their significance, all the attributes are significant and of expected signs in the selected locations with the exception of oasis in Ejinaqi, Gaotai, Sunnan and Zhangye and cultivated land yield, quality of agricultural products and biodiversity in Minle, Sunnan and Zhangye respectively. While the results for pooled data indicate that all the attributes are statistically significant except oasis. In the lower portion of the table the standard deviation of mean indicates the existence of heterogeneity of preferences for all

ecological attributes with the exception of biodiversity in Ejinaqi and landscape in Gaotai. The results for willingness to pay are presented in Table 2 and are calculated through Krinsky Robb method (Krinsky and Robb 1986) with 500 draws.

The willingness to pay results suggest that the 95% confidence intervals overlap between all the land related ecological attributes confirming that due to spatial heterogeneity willingness to pay are unequal in the sample areas (Kosenius and Markku 2015; Khan et al. 2018). Differences in socio economics characteristics of the

**Table 2** MWTP for land attributes

	Ejinaqi	Gaotai	Minle	Sunnan	Zhangye	Pooled data
Cultivated land yield	1.16	1.41	0.70	1.38	2.29	1.54
Quality of agricultural products	40.98	44.84	88.43	34.58	96.36	91.09
Oasis	0.02	0.00	0.06	0.03	0.01	0.02
Biodiversity	34.43	7.54	28.04	17.30	19.58	13.53
Greenhouse effect landscape	70.55	45.68	77.19	116.23	95.66	47.47
landscape	74.86	43.40	37.99	73.12	57.38	44.07

sampled population and their preferences for ecological attributes play a vital role in their stated willingness to pay for developments in ecological attributes (Brouwer and Spaninks 1999). Similarly, the location, type of population and their attitude towards environmental goods and services also play an important role in the valuation of the environmental amenity (Rolfe et al. 2000). The highest willingness to pay was noticed for quality of agricultural products, biodiversity, greenhouse gas emission reduction effect and for landscape in all selected areas, while all the selected sampled areas share a low willingness to pay for cultivated land yield and oasis. The individuals' willingness to pay and their preferences regarding degraded ecological attributes signifies that restoration of river's ecological environment is of vigorous importance (Li et al. 2013).

### Estimation of location effect and MWTP for water attributes

Table 3 describes the estimated results of the mixed logit model for the 2nd set of ecological attributes i.e. river water related attributes. The results acknowledge that the payment (monetary attribute) and ASC i.e. alternative specific constant (status quo attribute) is statistically significant and has expected negative signs in all major cities and surrounding villages/counties. The negative and significant results of the monetary

attribute prove our prior expectations that as the price for the restoration of ecological attributes increases, the corresponding willingness to pay will decrease. Similarly, the negative and significant results of ASC suggest that people prefer the upgradation of the current status of ecological attributes and are willing to pay for their restoration. The results are in line with the studies of Czajkowski et al. (2017), Khan et al. (2019a)) and Khan et al. (2019b). The results also indicates that all the water related ecological attributes are statistically significant at 1 and 5% and contains expected signs in Ejinaqi region except farmland irrigation attribute. Similarly, in Gaotai region with the exception of sand storm attribute all other ecological attributes are statistically significant and of expected signs. While in Minle and Sunnan all the ecological attributes are statistically significant at 1, 5 and 10% level of significance except lake area. In case of Zhangye region the results implies the significance of the all ecological attributes with the exception of sand storm and leisure & entertainment. For pooled data the outcomes in the Table 3 denotes that the selected ecological attributes are statistically significant except leisure & entertainment, signifying the importance of the selected ecological attributes.

The main objective of valuating public goods and services is to measure the social welfare change related with the variation in the public goods and services. Consequently, estimated results in Table 4 indicates the MWTP for single unit change in the selected ecological

**Table 3** Estimated results of the mixed logit model for water attributes (spatial heterogeneity)

Choice	Ejinaqi		Gaotai		Minle		Sunnan		Zhangye		Pooled data	
	Coef.	SE	Coef.	SE	Coef.	SE	Coef.	SE	Coef.	SE	Coef.	SE
<b>Mean</b>												
Pay	-0.01***	0.00	-0.01***	0.00	-0.01***	0.00	-0.01***	0.00	-0.01***	0.00	-0.01***	0.00
ASC	-2.85***	0.63	-1.74***	0.31	-2.14***	0.29	-3.70***	1.13	-2.12***	0.53	-2.71***	0.31
Water quality	-2.85***	0.60	-1.77***	0.33	-1.63***	0.18	-1.72***	0.55	-1.06***	0.22	-1.60***	0.17
Irrigation	0.01	0.04	0.02*	0.01	0.03***	0.01	0.07**	0.04	0.04**	0.02	0.02**	0.01
Sand storm	-0.09**	0.04	-0.01	0.01	-0.13***	0.03	-0.13*	0.07	-0.04	0.03	-0.03**	0.01
Lake area	0.06**	0.03	0.02**	0.01	0.02	0.02	-0.03	0.03	0.03*	0.02	0.02**	0.01
Leisure & entertainment	0.02**	0.01	0.00*	0.00	0.01**	0.00	0.02**	0.01	0.00	0.00	0.00	0.00
<b>SD</b>												
Water quality	3.43***	0.83	2.65***	0.44	3.02***	0.30	2.27***	0.84	2.41***	0.38	3.04***	0.29
Irrigation	0.32***	0.07	0.22***	0.01	0.01	0.03	0.22***	0.04	0.19***	0.02	0.22***	0.01
Sand storm	-0.15**	0.06	0.03	0.04	0.13***	0.04	0.25***	0.05	0.23***	0.03	0.21***	0.02
Lake area	0.16***	0.04	0.06**	0.03	0.11***	0.03	0.19***	0.04	0.15***	0.02	0.19***	0.02
Leisure & entertainment	-0.05***	0.01	-0.02***	0.01	0.04***	0.01	0.04***	0.01	0.04***	0.01	0.05***	0.00
<b>Summary Statistics</b>												
No. of Obs	1791		2736		2520		1809		6264		15,120	
LR $\chi^2(6)$	137.5		108.3		131.5		138.5		434.6		1227.7	
Log likelihood	-448.1		-841.1		-809.4		-489.6		-1862.1		-4418.3	
Prob > $\chi^2$	0.000		0.000		0.000		0.000		0.000		0.000	

**Table 4** MWTP for water attributes

	Ejinaqi	Gaotai	Minle	Sunnan	Zhangye	Pooled data
River water quality	393.61	163.63	140.63	148.00	90.05	122.89
Farmland irrigation	0.95	2.01	2.59	6.04	3.50	1.89
Sand storm	12.62	0.91	11.64	11.29	3.32	2.02
Area of east Juyan lake	8.24	2.04	1.98	2.95	2.38	1.49
Leisure & entertainment	2.23	0.43	0.82	1.34	0.17	0.30

attributes. Marginal willingness to pay is the per year maximum amount of money an individual is willing to pay for a single unit incremental change (improvements) in the ecological attributes. The estimated results in Table 4 suggests that the inhabitants of Ejinaqi pay highest willingness to pay (i.e. RMB 393.61/year) for water quality attribute followed by Gaotai, Sunnan, Minle and Zhangye respectively. While the estimates for pooled data suggest that comparatively improvements in the river water quality is the most favored attribute. The lowest willingness to pay is for leisure & entertainment in all selected sampled areas as well as in pooled data i.e. RMB 0.30/year.

**Significance of interaction of distances and MWTP for land and water attributes**

Table 5 indicates the outcomes of the mixed logit model resulted from the interactions between the distances from the origin and all selected land & river water related ecological attributes. The results identifies the impact of the distance from the origin on the willingness to pay for the upgradation of selected ecological attributes. The statistically significant results of the interactions between distances from the origin and ecological attributes prove that the distance from the origin has substantial influence on household’s preferences for ecological attributes and thus effect the household’s willingness to pay for the restoration and improvements in these attributes. The standard deviation parameters are also highly significant which recommend the existence of significant taste heterogeneity for the selected ecological attributes (Kosenius and Markku 2015; Khan et al. 2019a). The estimated results in Table 6 states that an average respondent is willing to pay RMB 2.84, 132.64, 37.45, 95.89 and 35.71 for a single unit incremental change in cultivated land yield, quality of agricultural products, biodiversity, greenhouse effect and landscape respectively. Likewise, willingness to pay of an average respondent for a single unit improvement in water quality, farmland irrigation and area of east Juyan Lake is RMB 95.64, 1.81 and 1.96 respectively.

**Table 5** Interactions between distances and ecological attributes (Pooled data)

Land attributes	Coefficient	SE	Water attributes	Coefficient	SE
Choice			Choice		
Mean			Mean		
Distance*Payment	-0.01***	0.00	Distance*Payment	-0.02***	0.01
Distance*Cultivated land yield	0.02***	0.00	Distance*Water quality	-1.95***	0.39
Distance* Quality of agricultural product	1.37***	0.15	Distance*Farmland irrigation	0.03**	0.02
Distance*Oasis	0.00***	0.00	Distance*Sand storm	-0.12***	0.03
Distance*Biodiversity	0.39***	0.09	Distance* Lake area	0.04***	0.01
Distance*Greenhouse effect	0.99***	0.14	Distance* Leisure & entertainment	0.01*	0.01
Distance*Landscape	0.37***	0.14			
SD			SD		
Distance*Cultivated land yield	0.09***	0.01	Distance*Water quality	2.28***	0.51
Distance*Quality of agricultural product	1.98***	0.22	Distance*Farmland irrigation	0.09***	0.02
Distance*Oasis	0.00***	0.00	Distance*Sand storm	0.17***	0.04
Distance*Biodiversity	1.26***	0.12	Distance* Lake area	0.18***	0.02
Distance*Greenhouse effect	-2.25***	0.20	Distance* Leisure & entertainment	-0.03***	0.01
Landscape*Distance	2.07***	0.20			
<b>Summary statistics</b>			<b>Summary statistics</b>		
No. of Observations	14,589		No. of Observations	15,120	
LR chi <sup>2</sup> (6)	1555.41		LR chi <sup>2</sup> (5)	1227.70	
Log likelihood	-4073.7		Log likelihood	-4418.2	
Prob > chi <sup>2</sup>	0.000		Prob > chi <sup>2</sup>	0.000	



**Table 6** MWTP for land and water attributes

Land attributes		River water attributes	
Variable	MWTP	Variable	MWTP
Cultivated land yield	2.84	Water quality	95.64
Quality of agricultural products	132.64	Farmland irrigation	1.81
Oasis	0.41	Sandstorms	0.60
Biodiversity	37.45	Area of east Juyan Lake	1.96
Greenhouse effect landscape	95.89 35.71	Leisure & entertainment	0.49

### Distance decay effect

In previous studies the distances are taken within the calculated areas for welfare estimation which also include hedonic price analysis that considers the effect of nearby attributes for house pricing (Johnston et al. 2001; Bateman et al. 2002; Paterson and Boyle 2002). However, respondents' willingness to pay to justify the spatial heterogeneity of preferences have infrequently been employed, although only by applying the pre-selected, ad hoc distance ranges (Yao et al. 2014).

To account for directional differences in distance decay, we distributed the data into four ad hoc band regions i.e.  $\leq 100$  km,  $\leq 200$  km,  $\leq 300$  km and  $> 300$  Km. The reason for distribution on ad hoc bands is as Heihe is an inland river and as it flows towards lower reaches, the considered ecological attributes get degraded. In this scenario Tables 7 and 8 explains the estimates of mixed logit model for land and water related attributes on ad hoc basis distributed sample respondents respectively. The results in Table 7 are statistically significant at 1,5 and 10% level of significance, contains expected signs and are according to the economics theory with the exception of oasis in  $\leq 100$  km,  $\leq 300$  km and  $> 300$  km while biodiversity and landscape are non-significant in  $\leq 200$  km area and in  $> 300$  km respectively. Similarly, the results in Table 8 agrees that all the water related ecological attributes are statistically significant except leisure & entertainment in  $\leq 200$  km,  $\leq 300$  km and  $> 300$  km.

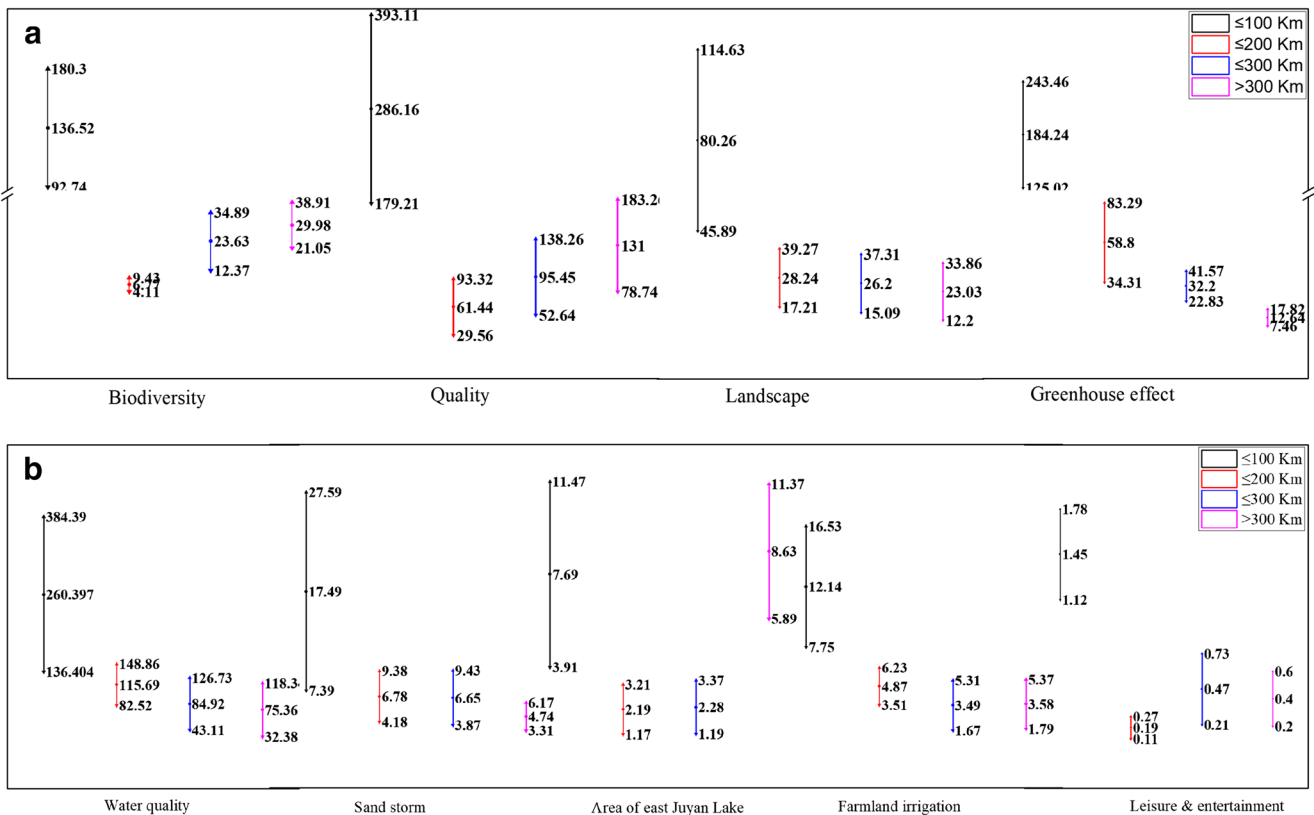
To demonstrate the effect of distance from river origin on willingness to pay, the mean willingness to pay estimates are calculated through Krinsky Robb method. Figure 2 (A,B) identifies the mean willingness to pay and upper and lower bounds of 95% confidence intervals for land and water attributes respectively in all four ad hoc basis distributes areas. The estimated results of mean willingness to pay in Fig. 2

**Table 7** Estimated results of the mixed logit model for land attributes (ad hoc distance bands)

Choice	$\leq 100$ Km		$\leq 200$ Km		$\leq 300$ Km		$> 300$ Km	
	Coef.	SE	Coef.	SE	Coef.	SE	Coef.	SE
<b>Mean</b>								
Pay	0.04***	0.02	-0.01***	0.00	-0.01***	0.00	-0.02***	0.00
ASC	-1.67***	0.25	-1.59***	0.43	-1.58***	0.33	-3.43***	1.16
Cultivated land yield	0.02**	0.01	0.03***	0.01	0.02***	0.01	-0.02***	0.01
Quality of agricultural products	0.43***	0.45	0.91***	0.21	1.13***	0.21	2.71***	0.89
Oasis	0.00	0.00	0.00*	0.00	0.00	0.00	0.00	0.00
Biodiversity	0.65**	0.26	0.10	0.13	0.27***	0.12	0.61**	0.32
Greenhouse effect landscape	0.88**	0.37	0.87***	0.21	0.38**	0.18	0.26***	0.12
landscape	0.38***	0.16	0.41***	0.19	0.31**	0.16	-0.48	0.58
<b>SD</b>								
Cultivated land yield	0.09***	0.02	0.11***	0.01	0.10***	0.01	0.07***	0.02
Quality of agricultural products	2.27**	0.83	-1.69***	0.36	2.34***	0.29	4.77***	1.26
Oasis	0.00	0.00	0.00***	0.00	0.00***	0.00	0.01***	0.00
Biodiversity	-1.48**	0.59	1.21***	0.22	-1.68***	0.20	-1.40**	0.72
Greenhouse effect landscape	-1.96**	1.01	2.24***	0.35	2.76***	0.28	-3.66***	0.96
Landscape	2.04***	0.69	1.89***	0.33	-1.66***	0.27	2.95	2.08
<b>Summary Statistics</b>								
No. of Obs	1269		4959		6723		1638	
LR $\chi^2(6)$	119.4		541.2		826.1		241.6	
Log likelihood	-354.4		-1328.2		1867.5		-422.1	
Prob > $\chi^2$	0.000		0.000		0.000		0.000	

**Table 8** Estimated results of the mixed logit model for water attributes (ad hoc distance bands)

Choice	≤100 Km		≤200 Km		≤300 Km		>300 Km	
	Coef.	SE	Coef.	SE	Coef.	SE	Coef.	SE
<b>Mean</b>								
Pay	-0.01**	0.00	-0.01***	0.00	-0.01***	0.00	-0.01*	0.00
ASC	-2.77**	1.46	-2.44***	0.68	-2.41***	0.50	-3.57**	1.55
Water quality	-2.94***	0.80	-1.71***	0.31	-1.02***	0.21	-0.63***	0.19
Irrigation	0.13***	0.06	0.07**	0.03	0.04***	0.02	-0.03***	0.01
Sand storm	-0.20**	0.10	-0.09***	0.04	0.07***	0.03	-0.03**	0.02
Lake area	-0.08***	0.04	0.03**	0.02	0.03**	0.01	0.07*	0.04
Leisure & entertainment	0.02*	0.01	0.00	0.00	0.01	0.00	0.00	0.01
<b>SD</b>								
Water quality	4.10***	1.42	-2.66***	0.45	2.28***	0.33	-2.14***	0.31
Irrigation	0.30***	0.06	0.22***	0.02	0.17***	0.02	0.36***	0.11
Sand storm	0.47***	0.10	0.29***	0.04	0.19***	0.03	0.35***	0.10
Lake area	0.08**	0.04	0.16***	0.03	0.16***	0.02	0.21***	0.06
Leisure & entertainment	0.02**	0.01	-0.05***	0.01	0.03***	0.00	0.07***	0.02
<b>Summary Statistics</b>								
No. of Observations	1278		4968		6723		1809	
LR chi <sup>2</sup> (6)	111.3		474.9		487.8		133.6	
Log likelihood	-346.3		-1384.6		-2043.7		-453.7	
Prob > chi <sup>2</sup>	0.000		0.000		0.000		0.000	



**Fig. 2** A. Mean willingness to pay and upper & lower limit of 95% CI (Land attributes). B. Mean willingness to pay and upper & lower limit of 95% CI (Water attributes)

(A,B) clarify that the inhabitants living near to the origin of the Heihe River are willing to pay higher amount for upgradation of degraded ecological attributes. As we move away from the inland river origin the corresponding willingness to pay for ecological attributes decreases. For instance, the people living within the range of 100 km from the origin of the Heihe River are willing to pay RMB 136.52, 286.16, 80.26 and 184.24 annually for a single unit improvement in biodiversity, quality of agricultural products, landscape and greenhouse effect respectively (Fig. 2a). Which confirms the argument that the people in this region are willing to pay more than the rest of the selected respondents that are away from the origin of the Heihe River.

Similarly, Fig. 2 (B) also confirms that the households living close to the origin of river are willing to pay higher amounts for the restoration of degraded water related ecological attributes. Likewise, the mean willingness to pay of the sampled respondents living within the range of 100 km from the origin for river water quality, sandstorm days, farmland irrigation, increase in the area of east Juyan Lake and conditions for leisure & entertainment is RMB 260.397, 17.49, 7.69, 12.14 and 1.45 respectively. Which confirms the statement that the people living in  $\leq 100$  km are willing to pay more than the people living in  $\leq 200$  km,  $\leq 300$  km and  $> 300$  km away from the origin of the Heihe River.

In the literature, the studies have confirmed that the distance between the inhabitant living place and the environmental goods/services providing ecosystem services inclines the corresponding willingness to pay declines with the reason of less awareness (Bateman et al. 2006). However in some cases individuals living adjacent to an environmental creature may worth the good less than the individuals live far away (Imber et al. 1991; Espey and Owusu-Edusei 2001). Clawson and Knetsch (2013)) also argue that if good is iconic or scarce, the willingness to pay may be the same across different distances from that good.

The public preferences and the availability of information can be influenced by the distance (Bach and Beckmann 1999) The finding of (Sutherland and Walsh 1985) and (Hanley et al. 2003) revealed the negative relationship between distance and willingness to pay, while no impact was found in some studies (Pate and Loomis 1997) and (Loomis 1996).

## Conclusion

The current study is an attempt to estimate the effect of distance from origin of Heihe River on the sampled respondents' willingness to pay for restoration, upgradation and improvements in the selected land and river water related ecological attributes. The estimated results suggested that respondents

living in different cities and neighboring villages of the Heihe River basin worth the selected ecological attributes contrarily. For instance, the inhabitants of Zhangye region get more utility from improvements in quality of agricultural products, biodiversity, greenhouse effect and landscape and are willing to pay annually RMB 96.36, 19.58, 95.66 and 57.38 respectively for every single unit improvement in land attributes. While inhabitants living in Ejinaqi region preferred to bring more improvements in landscape, greenhouse effect, quality of agricultural products and biodiversity and were willing to pay annually RMB 74.86, 70.55, 40.98 and 34.43 respectively. Similarly, in case of river water related ecological attributes the inhabitants of Gaotai region were willing to pay RMB 163.63 for progresses in the current level of river water quality, while people of Minle region were willing to pay RMB 148 per year for upgradation of river water quality level. The highest willingness to pay in pooled data was recorded for quality of agricultural products and improvement in river water quality and the estimated willingness to pay was RMB 91.09 and 122.89 respectively. To account for distance decay effect on willingness to pay, the data was distributed into four sub groups (ad hoc distance bands) according to the distance from Heihe River's origin. The results achieved from interactions of the distances with ecological attributes proved that the spatial preference heterogeneity exists among the sampled respondents. An average respondent is willing to pay RMB 132.64 and 95.64 for upgradation of the current level of quality and water quality. To determine the effect of distance from origin on respondents' willingness to pay the data was redistributed among four ad hoc basis distance from origin zones. The estimated results of mixed logit model and the results of mean willingness to pay through Krinsky Robb method approved the existence of consistent distance decay effect. The results also confirmed that the people living near to origin of Heihe River were willing to pay more than the remainders. As such this study determines that the non-market benefits which may accumulate from diverse kinds of improvements in water quality are nuanced in terms of their environmental impacts, their potential beneficiaries and, by inference, their overall value and policy implications. Findings of the current study suggest some policy implications and recommendations to the government of China and local bodies. Explicitly the governmental bodies and elite class should focus on the improvements in ecosystem services. Moreover, to enhance the scope and foreseeing of current research further revisions are mandatory to consider the heir of this specific zone.

**Acknowledgements** The survey was sponsored by a major project supported by the National Social Science major Foundation of China (no. 15ZDA052) and Integrated Soil and Water Conservation Technology Research and Demonstration on Loess Plateau, National key R&D Program of China (no. 2016YFC0501707).

## References

- Bach MF, Beckmann MJ (1999) Lectures on location theory. Springer Science & Business Media
- Bakhtiari F, Jacobsen JB, Thorsen BJ, Lundhede TH, Strange N, Boman M (2018) Disentangling distance and country effects on the value of conservation across National Borders. *Ecol Econ* 147:11–20
- Bateman IJ, Jones AP, Lovett AA, Lake IR, Day B (2002) Applying geographical information systems (GIS) to environmental and resource economics. *Environ Resour Econ* 22:219–269
- Bateman IJ, Cooper P, Georgiou S, Navrud S, Poe GL, Ready RC, Riera P, Ryan M, Vossler CA (2005) Economic valuation of policies for managing acidity in remote mountain lakes: examining validity through scope sensitivity testing. *Aquat Sci* 67:274–291
- Bateman IJ, Day BH, Georgiou S, Lake I (2006) The aggregation of environmental benefit values: welfare measures, distance decay and total WTP. *Ecol Econ* 60:450–460
- Bateman I, Brouwer R, Ferrini S, Schaafsma M, Barton DN, Dubgaard A, Hasler B, Hime S, Liekens I, Navrud S (2011) Making benefit transfers work: deriving and testing principles for value transfers for similar and dissimilar sites using a case study of the non-market benefits of water quality improvements across Europe. *Environ Resour Econ* 50:365–387
- Ben-Akiva ME, Lerman SR, Lerman SR (1985) Discrete choice analysis: theory and application to travel demand. MIT press
- Bockstael NE, Hanemann WM, Kling CL (1987) Estimating the value of water quality improvements in a recreational demand framework. *Water Resour Res* 23:951–960
- Brouwer R, Spaninks FA (1999) The validity of environmental benefits transfer: further empirical testing. *Environ Resour Econ* 14:95–117
- Brouwer R, Martin-Ortega J, Berbel J (2010) Spatial preference heterogeneity: a choice experiment. *Land Econ* 86:552–568
- Chen WY, Hua J, Liekens I, Broeckx S (2018) Preference heterogeneity and scale heterogeneity in urban river restoration: a comparative study between Brussels and Guangzhou using discrete choice experiments. *Landsc Urban Plan* 173:9–22
- Cheng G-d, Xiao H, Xu Z, Li J, Lu M (2006) Water issue and its countermeasure in the Inland River basins of Northwest China: a case study in Heihe River Basin. *J Glaciol Geocryol* 3:016
- Clawson M, Knetsch JL (2013) Economics of outdoor recreation. RFF Press
- Czajkowski M, Budziński W, Campbell D, Giergiczny M, Hanley N (2017) Spatial heterogeneity of willingness to pay for Forest management. Working Papers 68:1–23
- Dallimer M, Jacobsen JB, Lundhede TH, Takkis K, Giergiczny M, Thorsen BJ (2014) Patriotic values for public goods: transnational trade-offs for biodiversity and ecosystem services? *Bioscience* 65:33–42
- Espey M, Owusu-Edusei K (2001) Neighborhood parks and residential property values in Greenville, South Carolina. *J Agric Appl Econ* 33:487–492
- Gao Q-z, Li F-x (1991) Case study of rational development and utilization of water resources in the Heihe River basin. Gansu Science and Technology Press, Lanzhou, pp 1–228
- Glenk K, Johnston RJ, Meyerhoff J, Sagebiel J (2019) Spatial dimensions of stated preference valuation in environmental and resource economics: methods, trends and challenges. *Environ Resour Econ*:1–28
- Greene WH, Hensher DA (2007) Heteroscedastic control for random coefficients and error components in mixed logit. *Transp Res E* 43:610–623
- Hanley N, Wright RE, Koop G (2002) Modelling recreation demand using choice experiments: climbing in Scotland. *Environ Resour Econ* 22:449–466
- Hanley N, Schläpfer F, Spurgeon J (2003) Aggregating the benefits of environmental improvements: distance-decay functions for use and non-use values. *J Environ Manag* 68:297–304
- Hensher DA, Greene WH (2003) The mixed logit model: the state of practice. *Transportation* 30:133–176
- Imber D, Stevenson G, Wilks LC (1991) A contingent valuation survey of the Kakadu conservation zone. Volume one. Australian Government Publishing Service for Resource Assessment Commission
- Interis MG, Petrolia DR (2016) Location, location, habitat: how the value of ecosystem services varies across location and by habitat. *Land Econ* 92:292–307
- Jacobsen JB, Thorsen BJ (2010) Preferences for site and environmental functions when selecting forthcoming national parks. *Ecol Econ* 69:1532–1544
- Johnston RJ, Duke JM (2009) Willingness to pay for land preservation across states and jurisdictional scale: implications for benefit transfer. *Land Econ* 85:217–237
- Johnston RJ, Opaluch JJ, Grigalunas TA, Mazzotta MJ (2001) Estimating amenity benefits of coastal farmland. *Growth Chang* 32:305–325
- Khan I, Zhao M, Khan SU (2018) Ecological degradation of an inland river basin and an evaluation of the spatial and distance effect on willingness to pay for its improvement. *Environ Sci Pollut Res* 25:31474–31485
- Khan I, Khan SU, Zhao M, Khan AA (2019a) Exploring the spatial heterogeneity of individual preferences for integrated river basin management: an example of Heihe river basin. *Environ Sci Pollut Res*:1–11
- Khan SU, Khan I, Zhao M, Khan AA, Ali MAS (2019b) Valuation of ecosystem services using choice experiment with preference heterogeneity: a benefit transfer analysis across inland river basin. *Sci Total Environ*
- Khan SU, Khan I, Zhao M, Khan AA, Ali MAS (2019c) Valuation of ecosystem services using choice experiment with preference heterogeneity: a benefit transfer analysis across inland river basin. *Sci Total Environ* 679:126–135
- Kosenius A-K, Markku O (2015) Ecosystem benefits from coastal habitats—a three-country choice experiment. *Mar Policy* 58:15–27
- Krinsky I, Robb AL (1986) On approximating the statistical properties of elasticities. *Rev Econ Stat* 68:715–719
- Li F, Zhu G, Guo C (2013) Shiyang River ecosystem problems and countermeasures. *Agric Sci* 4:72–78
- Loomis JB (1996) How large is the extent of the market for public goods: evidence from a nationwide contingent valuation survey. *Appl Econ* 28:779–782
- Martin-Ortega J, Brouwer R, Ojea E, Berbel J (2012) Benefit transfer and spatial heterogeneity of preferences for water quality improvements. *J Environ Manag* 106:22–29
- McFadden D, Train K (2000) Mixed MNL models for discrete response. *J Appl Econ* 15:447–470
- Morrison M, Bennett J (2004) Valuing New South Wales rivers for use in benefit transfer. *Aust J Agric Resour Econ* 48:591–611
- Morrison M, Bennett J, Blamey R, Louviere J (2002) Choice modeling and tests of benefit transfer. *Am J Agric Econ* 84:161–170
- Pate J, Loomis J (1997) The effect of distance on willingness to pay values: a case study of wetlands and salmon in California. *Ecol Econ* 20:199–207
- Paterson RW, Boyle KJ (2002) Out of sight, out of mind? Using GIS to incorporate visibility in hedonic property value models. *Land Econ* 78:417–425
- Qi S, Luo F (2007) Environmental degradation problems in the Heihe River basin, Northwest China. *Water Environ J* 21:142–148
- Revelt D, Train K (1998) Mixed logit with repeated choices: households' choices of appliance efficiency level. *Rev Econ Stat* 80:647–657
- Rolfé J, Bennett J, Louviere J (2000) Choice modelling and its potential application to tropical rainforest preservation. *Ecol Econ* 35:289–302

- Scarpa R, Ferrini S, Willis K (2005) Performance of error component models for status-quo effects in choice experiments. In: Applications of simulation methods in environmental and resource economics. Springer, pp 247–273
- Scarpa R, Willis KG, Acutt M (2007) Valuing externalities from water supply: status quo, choice complexity and individual random effects in panel kernel logit analysis of choice experiments. *J Environ Plan Manag* 50:449–466
- Scarpa R, Thiene M, Marangon F (2008) Using flexible taste distributions to value collective reputation for environmentally friendly production methods. *Can J Agric Econ* 56:145–162
- Schaafsma M, Brouwer R, Gilbert A, van den Bergh J, Wagtendonk A (2013) Estimation of distance-decay functions to account for substitution and spatial heterogeneity in stated preference research. *Land Econ* 89:514–537
- Shi H, Zhao M, Aregay FA, Zhao K, Jiang Z (2016) Residential environment induced preference heterogeneity for river ecosystem service improvements: a comparison between urban and rural households in the Wei River basin, China. *Discret Dyn Nat Soc* 2016:1–9
- Sutherland RJ, Walsh RG (1985) Effect of distance on the preservation value of water quality. *Land Econ* 61:281–291
- Train Kenneth E (2003) *Discrete choice methods with simulation*. Cambridge University Press, Cambridge
- Von Haefen RH, Phaneuf DJ (2008) Identifying demand parameters in the presence of unobservables: a combined revealed and stated preference approach. *J Environ Econ Manag* 56:19–32
- Whitehead JC, Pattanayak SK, Van Houtven GL, Gelso BR (2008) Combining revealed and stated preference data to estimate the non-market value of ecological services: an assessment of the state of the science. *J Econ Surv* 22:872–908
- Yao RT, Scarpa R, Turner JA, Barnard TD, Rose JM, Palma JH, Harrison DR (2014) Valuing biodiversity enhancement in New Zealand's planted forests: socioeconomic and spatial determinants of willingness-to-pay. *Ecol Econ* 98:90–101

**Publisher's note** Springer Nature remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.