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RESEARCH ARTICLE

Spatial heterogeneity of ecosystem services: a distance decay approach to quantify willingness to pay for improvements in Heihe River Basin ecosystems

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Abstract
The growing appreciation of distance decay as an important parameter necessary for estimating willingness to pay (WTP) is hugely recognized in the literature. In this paper, we estimated the extent to which distance decay and individual's socioeconomic characteristics influence the WTP for restoration of environmental quality attributes in the Heihe River Basin. A choice experiment technique was used to evaluate the household's WTP for the improvements in local environmental attributes. The results of mixed logit model significant impact of distance on the individual's WTP for the improvements in environmental attributes. Findings of the study revealed that people living within 25 km from the river are willing to pay more for an increase in the river water quality level, a reduction in sandstorm days, and an increase in the area of the east Juyan Lake than the people living within the range of 50 km and much more compared to 50 km away from the river. Based on the socioeconomic characteristics, it is concluded that the level of education, age, household's annual income, and household size have a significant effect on the WTP. Results of the implicit prices for each attribute showed the preferences of the inhabitants for every attribute, where the highest WTP in pooled data was recorded for river water quality level (i.e., RMB 124.81/year) and the lowest for leisure and entertainment (i.e., RMB 0.40/year). The highest WTP for water quality suggests that water quality level was the most favored attribute compared to others, subject to the given conditions of water quality and the river basin.

Keywords Discrete choice experiment · Mixed logit · Spatial heterogeneity · Distance decay · Socioeconomic characteristics · Willingness to pay (WTP)

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Introduction

Various spatial factors including the site substitutes and distance from the site to the households can significantly influence the monetary value of environmental goods and services (Schaafsma et al. 2012). Willingness to pay (WTP) for environmental goods and services is spatially heterogeneous, and the policy analysis for this heterogeneity is progressively recognized. In the analysis of stated preferences, the distance decay is a frequently evaluated form of spatial heterogeneity, where WTP is presumed to lessen as a monotonic function of distance from the pretentious resource. This distance is characteristically measured from each household to the closest degraded point of natural resource, using either travel or Euclidean distance. The analyses of distance decay mainly focus on the effects associated with a unidimensional measure of proximity to a naturally degraded resource and the distance between (typically nearest) degraded resource and respondent's locality. Generally, the spatial analysis of WTP for improvements in river attributes might evaluate systematic relationships between the respondent's WTP for attributes of river and the observed distance to the adjacent point on the environmentally degraded river (Hanley et al. 2003).

The estimates regarding cost-benefit analysis can be significantly influenced by the sets of choices made by a researcher while accumulating individual benefits (Mark and Jeff 2004). Generally, the individuals' values of sample mean leads to the accumulation of environmental values. However, the location of individuals from affected sites may significantly influence the value estimation, and hence, it is preliminary to account for spatial heterogeneity while evaluating the aggregate benefits (Bateman et al. 2006).

Based on the spatial heterogeneity of preferences, respondents' distance from a location was estimated and has attained substantial consideration as reported in previous studies. Highly substantial distance decay in values represents that dependence on the mean WTP of the sample can consequently lead to biased assessments (Bateman et al. 2006; Hanley et al. 2003). Concu (2010) was among the first authors who applied the choice experiment method for the estimation of distance decay and revealed that the omission of distance yields underestimation in the measurement of aggregate losses and benefits.

The term "location effect or distance decay effect" refers to the respondents' locations and their corresponding impacts on WTP. Both the distance and location effects share some mutual properties, but the location effect may not determine the precise assessable distance of the individuals' location from the investigated site. One way to investigate spatial heterogeneity is the impact of distance decay, which is also employed in the current study.

Despite the value of natural water reservoirs (including lakes, rivers, and streams), they have undergone increasing exploitation and degradation, which has reduced their capacity to provide key environmental services. Though some practices of pollution and resource exploitation might be top at societal priority, in many cases however, the resource is exhausted through practices with partial benefits for locality, while in some cases, it burdens high charges (Turner et al. 2004). River services are considered a quasi-public good based on the general benefits from its existence such as recreational and aesthetic uses; water is utilized for other purposes, such as for domestic consumption or irrigation; and the lack of market values for certain river services limits the incentives to maintain or invest in restoration actions (Hogue 2010).

Generally, the choice experiment techniques implemented in many research areas such as marketing and natural resource assessment mostly focus on spatial analysis techniques (Mazur and Bennett 2008). Researchers observed that spatial effects are significant and complex, as the effects could have an impact upon household's traveling choice, consumer's purchasing choice, the choice of visitors' destination, and the participation of the public in improving environmental projects (Bateman et al. 2006; Bateman and Langford 1997; Campbell et al. 2009). In fact, some researchers emphasize on space heterogeneity to be considered while assessing the ecological value. Similarly, Bateman et al. (2009) previously studied the use of the spatial choice experiment approach in the valuation of environmental goods and services and reflected two main aspects of spatial heterogeneity, that is the distance decay and the geo-political threshold effects. The distance decay effect revealed that WTP declines as a monotonic function (Brouwer et al. 2010; Jørgensen et al. 2013; Pate and Loomis 1997). For instance, the decline in individual's WTP for lake/river water quality improvement was because of the distance to the river or lake, while the geo-political threshold effect considering WTP demonstrates discrete thresholds over geo-political boundaries (Georgiou et al. 2000; Hanley et al. 2003; Mark and Jeff 2004).

Many forms of spatial patterns regarding the estimation and identification have been recognized in the literature. In order to estimate the spatial relationship of the non-market values, the most common and extensively applicable method is the Hedonic price method (Agee and Crocker 2010; Hatton MacDonald et al. 2010; Kong et al. 2007). Several studies have reported the distance decay effect on individual's WTP, but to our knowledge, no study is conducted so far to estimate effect of distance decay and socioeconomic characteristics on individual's WTP for ecological improvements in any inland river in China, particularly the Heihe River Basin. To fill this research gap, the current study aims to examine the spatial hypotheses for improvement in environmental attributes, i.e., river water quality level, guarantee rate of farmland irrigation, area of the east Juyan Lake, frequency of sandstorm days, leisure and entertainment, and household's WTP to improve these attributes. The study therefore scrutinizes the distance impact on individual's WTP for the improvement of environmental attributes in the Heihe River Basin. Further, this study examines the effect of individual's socioeconomic characteristics on their WTP.

Methodology

Background of the Heihe River Basin

In the arid zone of Northwestern China, the Heihe River Basin is considered to be the bigger inland river basin located in the middle section of the Hexi Corridor Region, Gansu Province, between 98° and 101° 30′ E and 38° and 42° N. It covers an area of about 130,000 km^2. It originates from the boundary district of Qinghai and Gansu provinces, and it ends to the desert in the western part of Inner Mongolia. The three main basins are upper, middle, and lower basins. The upper basin comprises of a county of Qinghai Province; the middle basin comprises of a city and counties of Gansu Province, namely Zhangye City, Sunnan County, Minle County, Shandan County, Linze County, and Gaotai County; whereas the lower basin consists of a county (within the Ejina Qi Oasis with the location in the lower reaches of the basin) in Inner Mongolia. The main source of the water provision in the basin is the precipitation and snow melting in the southern region of the Qilian Mountains (Luo et al. 2016).

Sampling framework

To assess the current features and practices of environmental dilapidation of the Heihe River Basin, a detailed survey was conducted among a sample from all the prefecture level cities and a subsample from surrounding villages and counties. Primary data of 1680 respondents was collected from main cities, namely Zhangye, Sunnan, Minle, Gaotai, and Ejina Qi and its surrounding 33 villages. The rural areas were included in order to consider the economic and ecological characteristics of the surveyed respondents. Moreover, by employing stratified random sampling techniques, the villages and townships were selected based on equidistance principles from the preselected urban center.

The Heihe River Basin was chosen as a pilot research area for the current project as it is a typical inland river basin representative for many others of its kind. Knowledge acquired from the Heihe River Basin may therefore be applied to many other inland basins. The Heihe River Basin is also particularly suited for the current investigation as it has been subject to integrated watershed research over an extensive period of time. The selected counties/cities are the main reference and representative cities of the Heihe River Basin. The selected counties are chosen from upper, middle, and lower basins of the Heihe River Basin which faces extreme environmental degradation of ecological attributes. The reason for choosing these counties was based on a lack of research done on environmental valuation in the previously reported literature. The individual's preferences for the improvements in ecological attributes are discussed in the "Results and discussion" section.

Based on previous literatures (Khan et al. 2019a; Khan et al. 2019b) and thorough discussions with local authorities, the environmental attributes and corresponding levels were selected and then included in our choice experiment (Fig. 1).

Table 1 shows the frequencies of the sampled households in the selected study area. A total of 1680 respondents were interviewed during the survey. Out of which, 695 respondents were interviewed from the Zhangye region, 280 from the Minle region, 304 from the Gaotai region, 200 from the Sunnan region, and 201 from the Ejina Qi region.

Theoretical framework and choice experiment

For any improvements in environmental attributes at different locations in geographically limited areas using stated preferences, techniques comprise of spatial choices. The ecosystem services that need to be valued and their corresponding characteristics especially the spatial characteristics such as the available site substitutes, location providing the service, and socioeconomic characteristics are expected to influence the valuation of ecosystem service and functions (Khan et al. 2018).

The inclusion of status quo in the choice task is a common characteristic of the choice experiments (CEs), and within such studies, the status quo could be preferred by the households over any proposed change in the level of attributes. As the attributes and their levels differ according to the morphology of the river, geographical location of the river and season, etc., therefore describing status quo in water quality–related studies is annoying and at may also be overly restrictive in the summarization of current variable modules into a solitary fixed state. Additionally, the households are not homogenous and improperly educated and their insights of the *status quo* may allow little or no similarity to realism (Konishi and Coggins 2008). The accuracy of welfare estimation can be declined by this divergence (Poor et al. 2001).

This study used a choice experiment technique to evaluate the household's WTP for the improvements in local environmental attributes. The individual was provided with choice collections composed of numerous choices (as shown in Table 2), and each alternative consists of a group of environmental attributes with the reflection of policy consequences. Using Ngene 1.1.1 software and D-efficiency design, we have generated 60 choice sets divided into 20 blocks, in which the D error is 0.006939 and the A error is 1.420521. Thus, each respondent was asked to answer 3 choice sets (see Appendix 1).

Experimental design theory suggests that the combinations and the levels of attributes vary systematically across the alternatives. The respondent is inquired to select their most

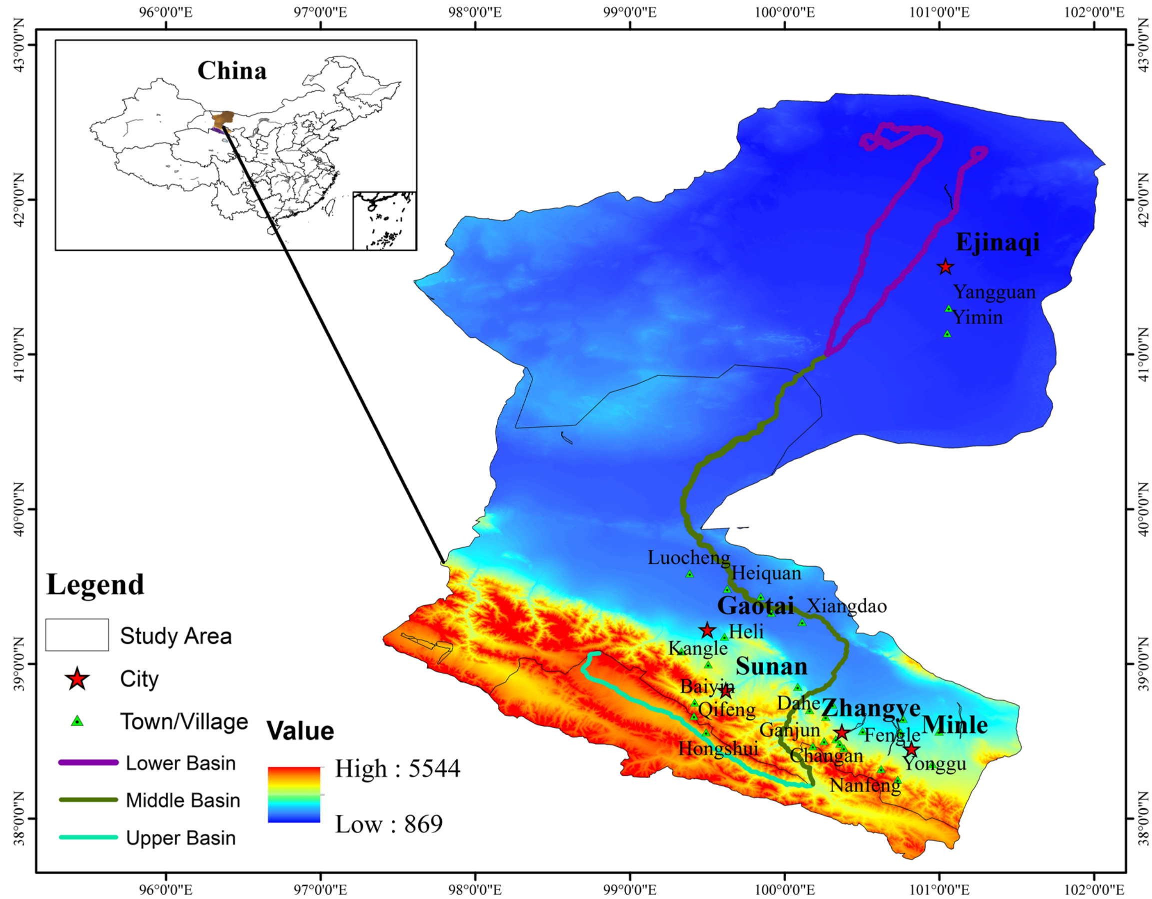

Fig. 1 Map of the study area (Heihe River Basin) (ArcGIS 10.3)

preferable alternative from a given set of alternatives in the choice task. The subsequent data is analyzed using logistic models that narrate the probability of an alternative being chosen to the levels of the attributes. The choice experiment is a procedure that investigates the public preferences regarding non-market goods and services by providing an imaginary market to value goods and services. Respondents ought to select the most preferred set of attributes among the available choice sets. On the basis of Lancaster's consumer theory, the choice experiment implements the characteristic theory of value that describes the characteristics of goods are more valuable in terms of utility rather than goods itself (Lancaster 1966). Each set of questionnaire comprises of two choice sets and status quo alternative while each choice set consist of three alternatives (Appendix 2). In order to collect the respondents elicit choice among three alternatives (one status quo and two policy alternatives), a choice experiment was designed in a multinomial choice question. The alternatives were equivalent across the choice sets while the level of attributes was analytically varied in a way that information related to preference parameters of an indirect utility function can be inferred (Carson et al. 2010). Table 2 shows the sample of choice set used in our data collection.

Table 1 Surveyed areas and their frequencies

City/ district	Frequency
Zhangye	695
Minle	280
Gaotai	304
Sunan	200
Ejina Qi	201
Total	1680

Source: field survey

Description of the river attributes, environment changes in the attributes, and selection in Heihe watershed

River water quality

The average water quality of the watershed provides a clean water source for the living and survival of the animals and plants. Water quality ranges from 1 (lowest) to 5 (highest): level 2 water is cleaner, which can become potable water by conventional purification treatment, and level 3 water is

Table 2 Attributes and their levels in the choice set

Evaluation indicators	Program 1 (keep the status quo)	Program 2 (improved 1)	Program 3 (improved 2)
River water quality level[a]	Level 2.5	Level 3	Level 2
Guarantee rate of farmland irrigation (%)	60	70	60
Sandstorm frequency (days)	44	35	30
Area of the east Juyan Lake (km^2)	40	50	60
Leisure and entertainment conditions (km^2)	55	130	105
Your family is willing to pay for this (every year)	0	RMB 150	RMB 100
Please select 1 of these	□	□	□

[a] Water quality levels are as follows: 2, clean and with conventional purification that can be used for drinking; 2.5, not suitable for drinking without advanced purification but appropriate for fishing and swimming; and 3, only suitable for industrial and agricultural uses

suitable for general fish reserves and swimming area. The status level is 2.5.

Guarantee rate of farmland irrigation

The actual irrigation water is the percentage of the irrigation amount, and the current situation is 60% to guarantee the agricultural production in the Heihe River Basin.

Sandstorm frequency

In Ejina Qi (dust source), the annual number of days of ascension is closely related to the air quality and the health of residents, and the current situation is 44 days.

Area of the east Juyan Lake

In the east Juyan Lake stable water area, for the downstream provision of animal and plant habitats, regulating the basin climate, the status quo is 40 km^2.

Leisure and entertainment conditions

The area of the Heihe Middle Swimming Wetland Park provides ecotourism, beautiful scenery, and other functions, i.e., protection of biodiversity in the watershed, and has been built in a 55-km^2 area.

In order to evaluate the non-market values for improvements in river attributes, the choice experiment approach was employed in our study (Hole and Kolstad 2012; Khan et al. 2019a), which focuses on the technological relationship between the public's WTP and their corresponding distances from the catchments under considerations. It was challenging to determine the exact distance of the households from the river due to the large area of the basin.

On the basis of explicit utility theory, the choice experiment was used for the valuation of non-market goods (Asioli et al. 2016; Louviere 2001). The choice experiment is based on the random utility maximization and states that the utility obtained by a respondent (i) from choosing an alternative (j) comprises two components, i.e., deterministic component and stochastic component.

Hence, the utility is as follows:

$$Uij = \left(Z_{ij}, Xi\right) + \varepsilon_{ij} \quad (1)$$

where Z_{ij} denotes the attributes of an individual (i) for the alternative (j) and Xi denotes the demographic characteristics of individuals. Different individuals considered the attribute Z_{ij} in different ways and vary over alternatives with change in the attribute levels, while for an individual, the X_i remains unchanged over alternatives. A respondent (i) prefers an alternative (j) over k if the utility obtained from alternative j is higher than the utility obtained from alternative k, i.e., $U_{ij} > U_{ik}$.

$$(j/J) = \{Vij + \varepsilon ij > Vik + \varepsilon ik, \textbf{\textit{for}} \text{ all } j \in J\} \quad (2)$$

where J denotes the numbers of alternatives in the choice task. The current study consists of 3 alternatives, i.e., $J = 3$ (status quo, alternative A and alternative B). The distribution of error terms was presumed for the estimation of Eq. (2).

Random parameter logit model

In the econometric literature, conditional logit models are often employed and their desirable properties are discussed in the standard textbooks (Greene 2003). Therefore, directly turn to the problems and shortcomings resulting from the restrictive assumption that the error terms are IID with a homogenous variance. Train (2009) names three main limitations of conditional logit: those being repeated choices over time, taste variation, and the most prominent, substitution patterns.

In recent years, several more general discrete choice models have been developed that relax the IID assumption and circumvent the limitations of conditional logit. A mixed logit model or random parameter logit model is a logit model for which the parameters are assumed to vary from one individual to another. It is therefore a model that takes the heterogeneity of the population into account. The mixed logit model has the advantage over the conditional logit (CL) model in relaxing the three basic assumptions of the CL model (heterogeneity preferences, substitution, and correlation in unobserved factors) and therefore allows for heterogeneity among respondents, unrestricted pattern of substitution, and correlation in latent (stochastic) variables with the passage of time (Train 2009). Across alternatives, the autocorrelation and heterogeneity will be considered by including the extra stochastic element (ηij) in the mixed logit model (Hensher 2007). Utility can be determined in mixed logit models given as follows:

$$U_{ij} = \left(Z_{ij}, X_i, \beta_i\right) + \eta_{ij} \quad (3)$$

The probability of selecting alternative j is as follows:

$$P_{ij} = \int L_{\eta i}(\beta) f(\beta) d\beta \quad (4)$$

where L_{ni} (β) is the logit probability evaluated at parameter β

$$L_{ni}(\beta) = \frac{e^{V_{ni}(\beta)}}{\sum_{j=1}^{J} e^{V_{nj}(\beta)}} \quad (5)$$

where (β) is a density function.

$V_{ni}(\beta)$ is the observed portion of the utility, which depends on the parameter β.

Simulated log-likelihood can be maximized by the value of휄θ, i.e., the maximum simulated log-likelihood estimator. The estimator θ helps in maintaining independence of the decision makers regarding the simulated probabilities of the log-likelihood. The logit probability for an alternative is never exactly zero. If the research believes that an alternative has actually no chance of being chosen by a decision maker, the researcher can exclude that alternative from the choice set. A probability of exactly 1 is obtained only if the choice set consists of a single alternative (Train 2009). For the estimation of stable log-likelihood results, a number of 500 draws are found to be appropriate.

Location/distance effect

Generally, the studies do not use respondent's valuations of the route distance. They might 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, respondent's WTP to confirm the spatial heterogeneity of preferences has infrequently been employed, although only applying preselected, ad hoc distance ranges. For example, to investigate the quantity of woodland, Yao et al. (2014) applied ad hoc distance bands of 10 km, 10–50 km, 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 ≤ 5 km, ≤ 10 km, ≤ 20 km, ≤ 30 km, and > 30 km. The mentioned ad hoc band zones were considered as explanatory variables to describe the heterogeneity in WTP for improvements in river ecosystem.

To account for directional differences in distance decay, we distributed the data into three ad hoc band regions, i.e., ≤ 25 km, ≤ 50 km, and > 50 km.

These interaction terms are included in the utility function

$$U_{ij} = \text{ASC} + \beta_1 D^* x_1 + \beta_2 D^* x_2 + \beta_3 D^* x_3 + \beta_4 D^* x_4 + \beta_5 D^* x_5 + \varepsilon \quad (6)$$

where ASC is the alternative-specific constant, B_i is the parameter to be estimated, X_1 is the river water quality (RWQ) level (2, 2.5, 3), X_2 is the guarantee rate of farmland irrigation (60%, 70%, 60%), X_3 is the sandstorm frequency per year (no. of days per year) (44, 35, 30), X_4 is the area of the east Juyan Lake (44 km^2, 50 km^2, 60 km^2), X_5 is the leisure and entertainment (55 km^2, 130 km^2, 105 km^2), and D is the distance in kilometers.

WTP for environmental attributes can also be influenced by the population's socioeconomic factors. For the purpose, the socioeconomic characteristics were also included in the model to examine their effect on individual's WTP for improvements in environmental attributes. However, it is possible and frequently necessary to capture preference heterogeneity in the model by interacting respondents' socioeconomic characteristics with the ASCs. This involves multiplying them by ASC, which makes them alternative-specific.

$$U_{ij} = \text{ASC} + \beta_1 \text{ASC}^* \text{G} + \beta_2 \text{ASC}^* E + \beta_3 \text{ASC}^* A + \beta_4 \text{ASC}^* \text{YOR} + \beta_5 \text{ASC}^* \boldsymbol{IN} + \beta_{\boldsymbol{6}} \text{ASC}^* \text{HHS} + \varepsilon \quad (7)$$

where G is the gender of the respondents, E is the years of education, A is the age, YOR is the years of residency, IN is the annual income, and HHS is the household size.

Marginal willingness to pay/implicit prices

The main objective of the implementation of discrete choice model is to determine individual's WTP for being benefitted from recognizing some specific tasks or actions (Hensher 2007). Usually, marginal WTP (MWTP) quantities are computed as the proportion of two parameter values (i.e., coefficients of monetary and ecological attributes). Mostly, in environmental and resource economics research, the application of implicit prices/MWTP is of great importance for the estimation of valuation of public goods such as water quality (Tait et al. 2011). Such that one of the attribute should be calculated in financial units, the proportion of the two parameters will allow us to calculate the monetary indicator of the WTP.

Therefore, by employing the mixed logit model on the monetary attribute, the estimated coefficient can be inferred as the marginal utility (MU) of the income. The division of coefficient of any additional attribute by the coefficient of this monetary attribute will therefore result in an *MWTP/implicit price*, which revealed a WTP requirement for improving the current degraded status of environmental attributes. Hence, the MWTP for any specific attribute (k) may be measured as the ratio of negative of k's coefficient to the payment attributes' coefficient, i.e., β_{pay}, which can be stated as follows:

$$\boldsymbol{MWTP}_{k,\text{CL}} = -B_k/\beta_p \tag{8}$$

Results and discussion

This section discusses the results that were obtained by the analysis of different econometric models through the econometric software Stata. The first section is about the descriptive statistics that quantify the total number of households that was interviewed from different cities and villages during the collection of data.

Descriptive statistics

Table 3 shows the descriptive statistics of household social and demographic characteristics.

The results show that a total of 160 female and 1591 male respondents were interviewed during the data collection. The mean age of the individuals in the studied area was 41 years with the minimum age of 18 years and the maximum age of 78 years, whereas the average age of Chinese people was 49.9 (in 2009). It changes over years, but the average age of Chinese goes up recently, that is because of the policy of born limitation by the government. So, according to the result, the average age of Chinese people increased to about 51.2 in 2017, and according to that, China should loosen the law of the born limitation in order to slow down the hyper-age problem (Library 2017). According to the results analyzed, 389 respondents were of primary educational level, while 469 respondents had a junior level of education; similarly, 344 respondents had an educational level of high school, and 242 respondents were having an educational level of college, while 245 respondents were educated as bachelor and above. Out of 1679 respondents, a total of 577 were farmers, 382 were unit worker, 265 were self-employed, 155 were workers, 56 were unemployed, and 240 were engaged in other different types of activities for earning income (Table 3). The results also indicate the household size of the respondents with a minimum household size of one and a maximum size of eight. The average number of people living in one household in China dropped from 3.5 in 1990 to 2.87 in 2011. A partial ease in the one-child policy was introduced in 2013, due to which couples, where at least one parent was an only child, were allowed to have a second child. The law was changed into a two-child policy in October 2015 and became effective starting January 2016. In2017, the household size is slightly increased to 3.17 people per household (Library 2017). Figures 2, 3, and 4 express the detailed socioeconomic characteristics of the households in the corresponding ad hoc basis zones.

Welfare estimation

The random utility model for the choice experiment was estimated using the mixed logit model with 500 Halton draws. A random normal distribution was assigned to all the ecological attributes. The normal distribution is one of the popular and commonly used distributions in the RPL model. The assumption of this distribution makes the coefficient estimate without a strict sign. The normal distribution is unbounded, and so, every real number has a positive probability of being produced as a draw; specifying a given coefficient to follow a normal distribution is thus equivalent to making a priori assumption that both positive and negative values for the coefficient exist in the population (Ghosh et al. 2013), while the price attribute was assigned non-random distributions. To minimize the instability of the mixed logit model, the price coefficient was kept fixed. When distributions of all coefficients are allowed to vary, the mixed logit model will experience instability (Ruud 1996).

In Table 4, the results predicted that payment has a negative and statistically significant effect on WTP at 1% level. It approves our prior expectations that as the price increases, people will pay less because of the decrease in their utility level. In other words, the probability of an affirmative response declines as the suggested price rises. The status quo variable was involved in the utility function as an ASC, i.e., alternative-specific constant for the fact of *no new improvements*. ASC is negative and significant, which concludes that usually inhabitants develop utility from improvements in environmental quality; hence, all the designated attributes can affect respondent choices. The results are in line with the studies of Czajkowski et al. (2017) and Khan et al. (2019a).

Improvements in the level of river water quality in the entire river basin are highly valued by respondents. A possible explanation may be the prior use of water of either directly or indirectly by the respondents living in the area. The attribute has negative and significant results, indicating that the people of the study area care more about the level of water quality and they have more WTP for the improvements, i.e., respondents are more likely to choose alternatives with good water quality

Table 3 Socioeconomic characteristics of the surveyed respondents

Variable	Description	No. of observations	Min	Max	Mean	SD
Gender	Gender of the respondents	1680	0	1	0.904	0.293
Female		161			2.606	1.264
Male		1591			2.702	1.366
Age	Age of the respondents (in years)	1680	18	78	41.234	12.868
Education	Educational level of the respondents	1680	1	5	2.693	1.356
Primary		389			1.971	1.732
Junior		469			2.452	1.657
High school		334			3.305	1.703
College		243			2.884	1.447
Bachelor and above		245			3.155	1.715
Profession	Primary profession of	1680	1	6	2.675	1.735
	the respondents	578			1.651	0.746
Farmer Unit worker		382			4.065	0.971
Self-employed		265			2.743	1.084
Work		159			2.515	1.011
Unemployed		56			2.464	0.990
Others		240			3.129	1.421
HHS	Household size	1680	1	8	4.430	4.033
Distance	Distance categories in km	1680				
0–25 km						
Gender (male = 1)			0	1	0.441	0.496
Age			18	78	42.87	13.26
Income			1000	486,000	47,731.23	33,711.83
Years of residency			1	78	41.330	14.688
HHS			1	11	3.963	1.359
25–50 km						
Gender (male = 1)			0	1	0.441	0.496
Age			18	68	42.87	13.26
Income			2500	223,000	47,731.23	33,711.83
Years of residency			1	63	41.330	14.688
HHS			1	12	3.963	1.359
> 50 km						
Gender (male = 1)			0	1	0.441	0.496
Age			18	70	42.87	13.26
Income			2160	230,001	47,731.23	33,711.83
Years of residency			6	70	41.330	14.688
HHS			1	10	3.963	1.359

(Khan and Zhao 2019). Many previous studies (Bateman et al. 2011; Jørgensen et al. 2013) mentioned that people's WTP is high to get better water quality since it guarantees their survival; besides, it is an important basic need. Similarly, the guarantee rate of farm land irrigation is positive and significant which expresses that people are willing to pay for the increase in the percentage of the irrigation water amount allocated to the agricultural land in the study area.

The results also evaluate that the respondents pay much intention to the decrease in the frequency of sandstorm days per year in the entire basin, as sandstorm are a big problem in the whole basin. Concluding from the results, the coefficient is negative and significant. The negative sign shows the decrease in the number of days of sandstorm, whereas inhabitants of the study area are willing to pay for the decrease in the number of days of

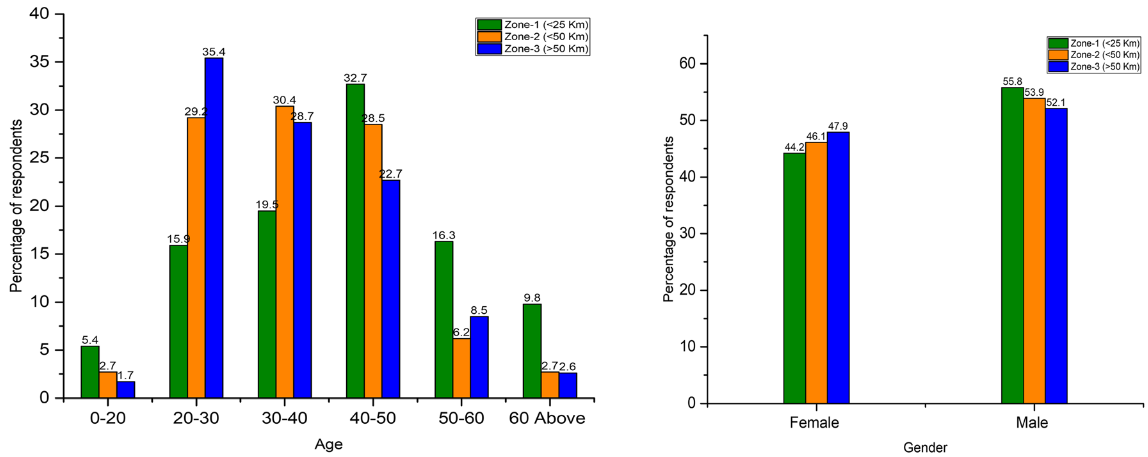

Fig. 2 Age and gender

sandstorm. The number of days of sandstorm is closely related to the air quality and health of residents.

It was expected that the area of the east Juyan Lake needs to be increased. The data collected from the respondents predicted that they are willing to pay for the increase in the area of the east Juyan Lake. Statistical analysis outcomes also provide the same evidence of positive and significant results suggesting that the people have WTP for this important attribute.

Results for leisure and entertainment are positive and significant, showing that people are willing to pay for the improvement in the area of the wetland park (Khan et al. 2019a). The area of the Heihe Middle Swimming Wetland Park provides ecotourism, beautiful scenery, and other functions. Inhabitants of the study area are willing to pay for improvements in ecotourism, and it could also be one of the sources for generating income for the natives of the studied region. Signs and magnitudes of statistically significant parameters match prior intuitions and findings; these results indicate a preference for stricter development restrictions and larger environmental improvements.

Willingness-to-pay estimation

Results in Table 5 indicate that the water quality level attribute is highly valued by respondents. The average WTP for river water quality improvements was RMB 124.244 per year. Similarly, the people in the study area are willing to pay RMB 1.79 per year for every increase in the percentage of guarantee rate of farmland irrigation. For sandstorm frequency, people are willing to pay RMB 1.85 per year for every decrease in the days of sandstorm. The negative WTP sign for water quality and sandstorm shows the descending order of water quality level which indicates the better river water quality and the decrease in the number of days of sandstorm, respectively.

In the area of the east Juyan Lake which needs to be increased, the people in the study area are willing to pay RMB 1.75 per year for the 1 km^2 increase in the east Juyan Lake area. Similarly, for leisure and entertainment, the people of the study are willing to pay RMB 0.40 per year which is the lowest WTP of inhabitants among all attributes. The possible

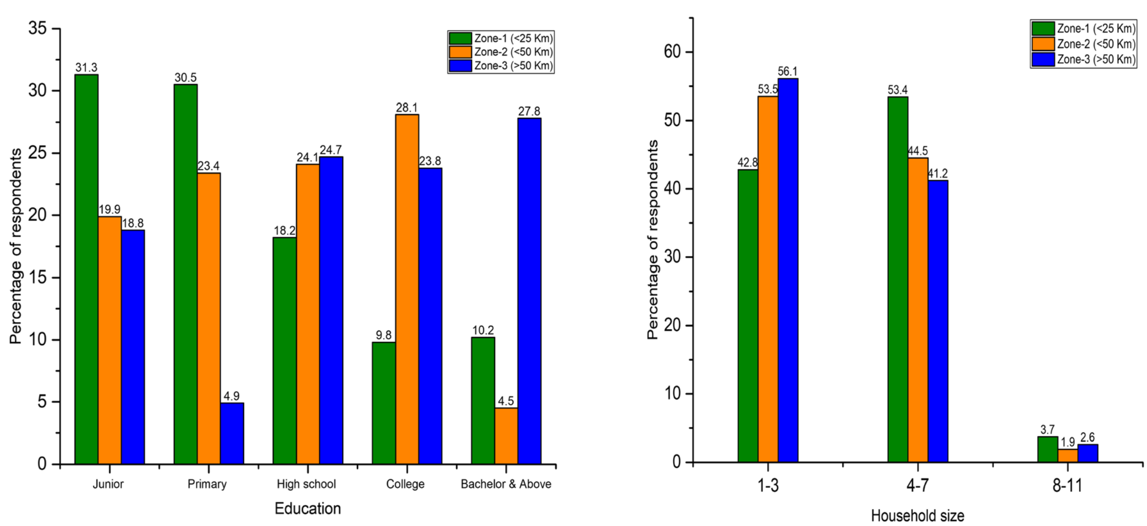

Fig. 3 Level of education and household size

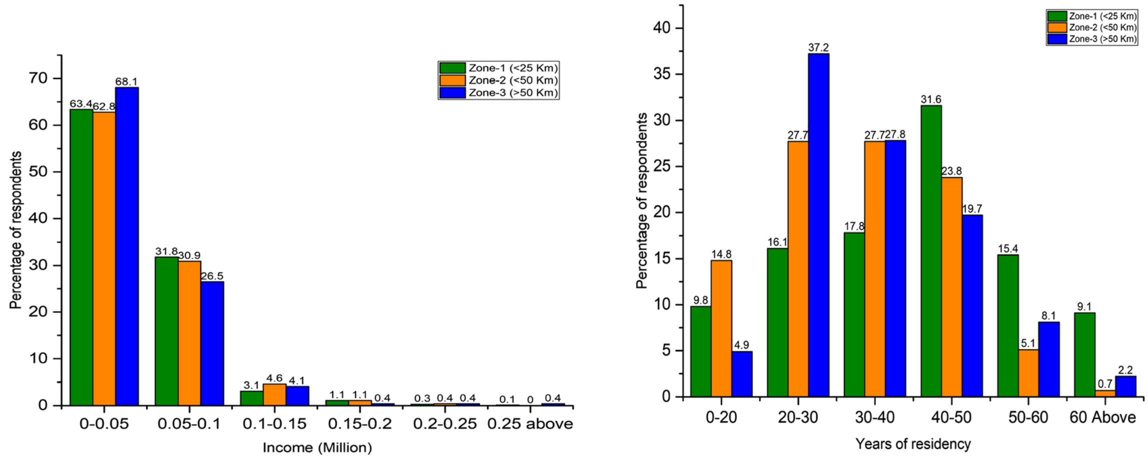

Fig. 4 Household annual income and years of residency

reason might be the ample availability of refreshment places in the study area due to which people's WTP is lowest among all attributes.

Distance decay effect

Table 6 represents the estimated results of the mixed logit model and the effect of distance and location on the WTP of the respondents for the environmental attributes. The interaction results are statistically significant and have the expected signs which suggest that the distance has a significant influence on the WTP for the improvements of the degraded environmental attributes. The results of standard deviation of mean also recommend the existence of taste heterogeneity for the attributes. The results are in line with Concu (2010) and Khan et al. (2018).

The estimated results in Table 7 show the marginal willingness to pay/implicit prices of the environmental attributes calculated through the delta method. The results confirmed that an average respondent is willing to pay RMB 97.45, RMB 2.16, RMB 4.95, RMB 1.79, and RMB 0.41 annually for the upgradation of river water quality, farmland irrigation, a decrease in sandstorm frequency, an increase in the area of lake, and leisure and entertainment, respectively.

Table 8 illustrates the estimated results of the mixed logit model on ad hoc–based distribution of the selected area–sampled respondents. The outcomes of the mixed logit model suggest that the selected environmental attributes have predicted signs and are highly significant as well as consistent with the economic theory.

Sig. significance

The results in Fig. 5 predict that the people living near to the river pay more than the people living far from the river which confirms the impact of distance/location on the respondent's WTP for improvements in the environmental attributes.

Table 4 Estimated results of the mixed logit model for ecological attributes (pooled data)

Choice	Coefficient	Standard error	*Z*	Sig.
Mean				
Payment	− 0.013	0.001	− 11.41	***
ASC	− 2.711	0.323	− 8.38	***
Water quality	− 1.628	0.181	− 8.97	***
Farmland irrigation	0.023	0.013	1.70	*
Sandstorm	− 0.024	0.014	− 1.65	*
Area of lake	0.023	0.010	2.19	**
Leisure and entertainment	0.005	0.002	1.98	**
SD				
Water quality	3.017	0.306	9.85	***
Farmland irrigation	0.218	0.015	14.08	***
Sandstorm	0.228	0.027	8.30	***
Area of lake	0.173	0.016	10.30	***
Leisure and entertainment	0.052	0.004	12.24	***
No. of observations	15,120			
LR χ^2 (5)	1248.47			
Log-likelihood	− 4406.45			
Prob. > χ^2	0.0000			

***, ** and * represent significance levels of 1%, 5% and 10%, respectively

Table 5 The implicit prices of attributes/MWTP (pooled data)

Attributes	Coefficient	Sig.	Marginal WTP (IP)
Water quality	− 1.628	***	− 124.244
Farmland irrigation	0.023	***	1.799
Sandstorm	− 0.024	***	− 1.853
Area of lake	0.023	***	1.759
Leisure and entertainment	0.005	***	0.400

***, ** and * represent significance levels of 1%, 5% and 10%, respectively

Table 6 Interaction between distances and attributes (pooled data)

Variable	Coefficient	SE	Sig.	95% confidence interval	
Mean					
Distance × payment	−0.024	0.012	***	−0.092	0.004
Distance × water quality	−1.949	0.386	***	−2.705	−1.193
Distance × farmland irrigation	0.052	0.017	***	0.019	0.085
Distance × sandstorm	−0.119	0.030	***	−0.177	−0.060
Distance × area of lake	0.043	0.013	***	0.017	0.069
Distance × leisure and entertainment	0.010	0.005	*	−0.001	0.020
SD					
Distance × water quality	2.284	0.508	0.000	1.289	3.280
Distance × farmland irrigation	0.098	0.021	0.000	0.058	0.139
Distance × sandstorm	0.171	0.040	0.000	0.092	0.249
Distance × area of lake	0.181	0.016	0.000	0.150	0.212
Distance × leisure	−0.034	0.008	0.000	−0.050	−0.019
No. of observations	15,120				
LR χ^2 (5)	1227.70				
Log-likelihood	−4418.2				
Prob. > χ^2	0.0000				

***, ** and * represent significance levels of 1%, 5% and 10%, respectively

The mean WTP of the respondents living in zone 1, i.e., within the range of 25 km from the Heihe River, is RMB 142.16, RMB 14.08, RMB 5.16, RMB 16.41, and RMB 0.16 for a single-unit improvement in the ecological attributes, namely river water quality, farmland irrigation, sandstorm days, area of the east Juyan Lake, and leisure and entertainment, respectively. It is higher than that of the respondents living within the range of 50 km and more than 50 km away from the river. The mean WTP of the respondents living in zone 2, i.e., ≤ 50 km, is RMB 112.89, RMB 12.22, RMB 9.77, RMB 3, and RMB 0.33 for improvements in ecological attributes. Similarly, the mean WTP of the respondents living in zone 3, i.e., > 50 km away from the river, is RMB 79.27, RMB 5.18, RMB 6.54, RMB 2.91, and RMB 1.45, respectively, for upgradation of ecological attributes. The results suggests that river water quality level was the most preferred attribute across all the zones, while conditions for leisure and entertainment were the least preferred attribute having the minimum marginal willingness to pay across all the zones. Additionally, the respondents living in zone 2 also preferred the reduction in sandstorm days compared to the other two zones. The results therefore conclude that distance has a significant effect on the WTP of households. As the households' distance from the environmental site increases, the respective WTP of the respondents decreases (Khan et al. 2018; Schaafsma et al. 2013). Similarly, Bach and Beckmann (1999) described that as the space between particular site and target population increases, the knowledge and awareness of the public regarding the site decrease, which directly influence the individuals' preferences and their WTP for the attributes. The public preferences and the availability of information can be influenced by the distance (Bach and Beckmann 1999). The findings of Southerland Sutherland and Walsh (1985) and Hanley et al. (2003) revealed the negative effect of distance on WTP, while some studies have suggested a positive impact of distance on WTP (Espey and Owusu-Edusei 2001; Imber et al. 1991; Do and Bennett 2007) and some reports suggest no impact on WTP (Loomis 1996; Ozdemiroglua et al. 2004; Pate and Loomis 1997).

Table 7 Estimated marginal willingness to pay/implicit price for the pooled data (delta method)

Variables	Coefficient	MWTP	Sig.
Distance × water quality	−1.949	97.45	***
Distance × farmland irrigation	0.052	2.16	***
Distance × sandstorm	−0.119	4.95	***
Distance × area of lake	0.043	1.79	***
Distance × leisure and entertainment	0.010	0.41	*

***, ** and * represent significance levels of 1%, 5% and 10%, respectively

Effect of socioeconomic characteristics

The effect of distance on WTP to improve ecological attributes can also be influenced by the socioeconomic factors of the respondents. For this purpose, the socioeconomic characteristics were included into the model to examine their effect on individual's WTP for improvements in environmental attributes.

Table 8 Results of the mixed logit model for ad hoc distance bands (spatial effects)

Choice	Zone 1 (≤ 25 km)		Zone 2 (≤ 50 km)		Zone 3 (> 50 km)	
	Coefficient (SE)	Sig.	Coefficient (SE)	Sig.	Coefficient (SE)	Sig.
Mean						
Payment	− 0.012 (0.001)	***	− 0.009 (0.003)	***	− 0.011 (0.003)	***
ASC	− 2.384 (0.440)	***	− 2.118 (0.527)	***	− 2.043 (0.815)	***
Water quality	− 1.706 (0.309)	***	− 1.016 (0.211)	***	− 0.872 (0.210)	***
Farmland irrigation	0.169 (0.084)	***	0.110 (0.039)	***	0.057 (0.063)	
Sandstorm	− 0.062 (0.021)	***	− 0.088 (0.043)	**	− 0.072 (0.043)	*
Area of lake	0.197 (0.099)	**	0.027 (0.014)	**	0.032 (0.013)	***
Leisure and entertainment	0.002 (0.004)		0.003 (0.010)		0.016 (0.009)	***
SD						
Water quality	− 2.66 (0.446)	***	2.28 (0.329)	***	2.18 (0.345)	***
Farmland irrigation	0.350 (0.103)	***	0.211 (0.044)	***	0.304 (0.063)	***
Sandstorm	0.081 (0.051)		0.245 (0.070)	***	0.214 (0.059)	***
Area of lake	0.467 (0.101)	***	0.161 (0.021)	***	0.176 (0.022)	***
Leisure and entertainment	− 0.048 (0.007)	***	0.067 (0.015)	***	0.022 (0.011)	**
No. of observations	6264		4959		3897	
LR χ^2 (5)	434.7		541.1		372.6	
Log-likelihood	− 1862		− 1328		− 1011	
Prob. > χ^2	0.000		0.000		0.000	

***, ** and * represent significance levels of 1%, 5% and 10%, respectively

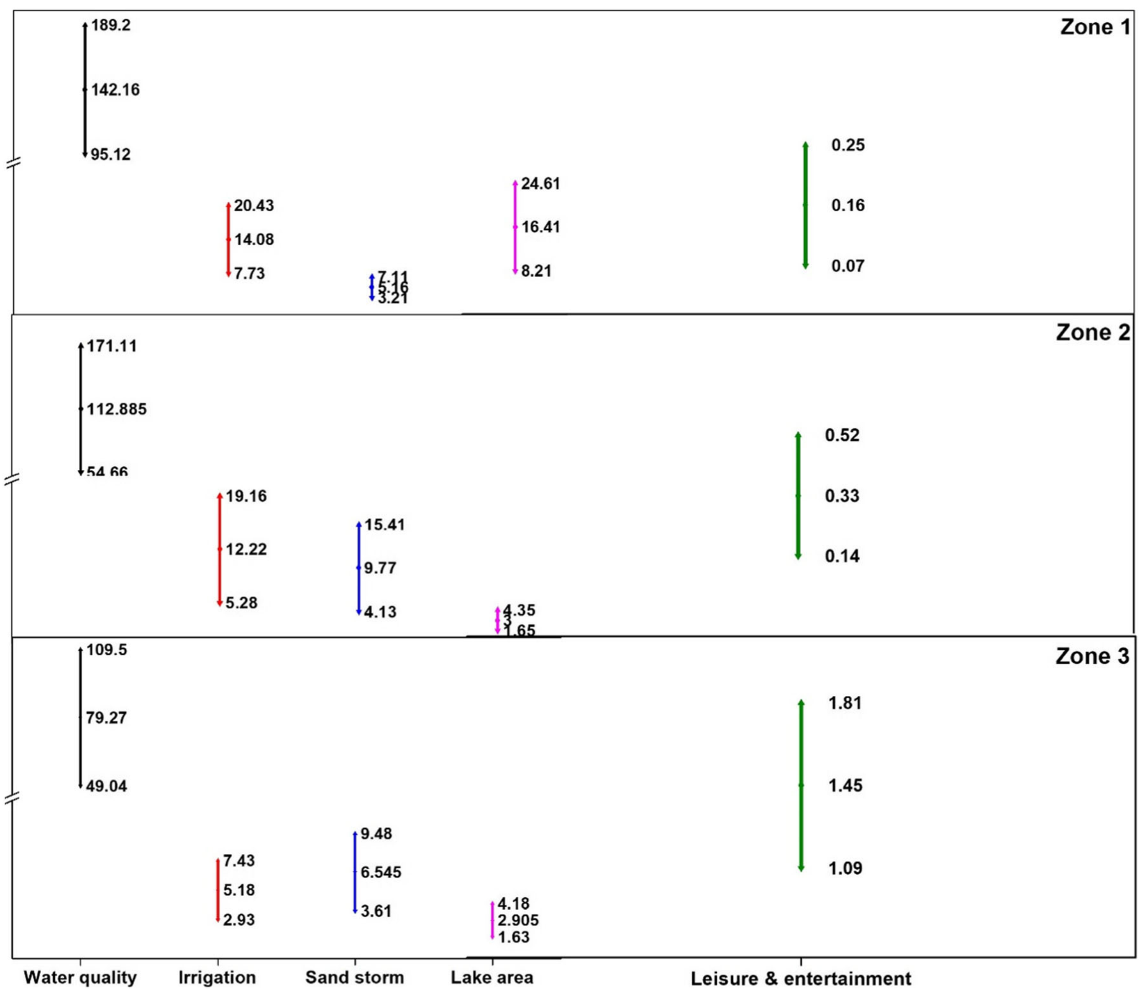

Fig. 5 Mean WTP and 95% confidence intervals (upper and lower bounds)

The results in Table 9 indicate the effect of demographic characteristics on the WTP of respondents. Although the demographic characteristics have great impact on individual's WTP, our finding reveals that the level of education, age of the respondents, individual's annual income, and household size have a significant impact on individual's WTP for ecological improvements. The signs of our estimated coefficients are according to the expected results and the economics theory.

The results in Table 9 show that education, age, income, and household size significantly affect individual's WTP, whereas the gender of the respondent and the number of years of residency were found to be non-significant. The significant and positive coefficient of education attribute suggests that an individual having a higher level of education is more willing to pay for a better environmental quality than the remainder of the sample. It might be due to their awareness about the value of clean environment and its benefits to the society (Dare 2014).

Age has a negative and significant relationship to WTP for the improvements in the environmental quality. This suggests that young people are more concerned about the environment and are willing to pay more than the aged people. The energetic nature and preferences for the outdoor activities among the young respondents may be the possible reason behind the obtained results. Older respondents, on the other hand, are less active and therefore show lesser WTP. In other words, the younger the respondents, the higher their WTP because most of the older respondents pay no attention towards environmental quality and are unaware of the importance of cleaner environment for health and productivity. Alberini et al. (1997) and Tanrıvermiş (1998) also found a negative correlation between age and WTP.

Table 9 Estimated results of the mixed logit model with interactions

Choice	Coefficient	SE	*Z*	Sig.
Mean				
Pay	− 0.012	0.001	− 11.36	***
ASC	3.299	0.602	− 5.48	***
ASC × gender	0.074	0.168	0.44	
ASC × education	0.130	0.060	2.16	**
ASC × age	− 0.031	0.013	− 2.30	**
ASC × year of residency	0.009	0.011	0.85	
ASC × income	6.061	2.50	2.42	**
ASC × household size	− 0.097	0.046	− 2.10	**
Water quality	− 1.619	0.179	− 9.00	***
Farmland irrigation	0.024	0.013	1.79	*
Sandstorm	− 0.027	0.014	− 1.85	*
Area of lake	0.022	0.010	2.18	**
Leisure and entertainment	0.005	0.002	1.94	**
SD				
Water quality	2.981	0.302	9.86	***
Farmland irrigation	0.216	0.015	14.13	***
Sandstorm	0.226	0.027	8.31	***
Area of lake	0.172	0.016	10.32	***
Leisure and entertainment	0.051			
No. of observations	15,120			
LR χ^2 (5)	1237.06	.004	12.19	***
Log-likelihood	− 4399.60			
Prob. > χ^2	0.0000			

***, ** and * represent significance levels of 1%, 5% and 10%, respectively

Similarly, the number of years of residency of the household in the study area has a positive but non-significant effect on the individual's WTP. Though non-significant, the prolonged period of residency of a respondent results in a higher WTP compared to a short period of residency, which are in line with the results of Jørgensen et al. (2013).

A positive and significant relationship was found between household income and WTP for the improvements in environmental quality, indicating that respondents with a higher level of income have higher probability of WTP for environmental improvements (Jørgensen et al. 2013). This makes sense because with increased income, individual can afford to pay for improved living conditions. There is a general concept in the environmental and resource economics literature that states a direct relationship between households' income and their demand for improvements in the quality of environmental goods and services. Therefore, the results suggest that income has a significant and positive effect on WTP for improvements in ecosystem services.

A negative and significant relationship was found between the household size and WTP for improvements in environmental quality (Kaffashi et al. 2015). This suggests that as the household size increases, the probability of WTP decreases. As consumption increases, the real income of household decreases, thereby leaving little or none for other expenses.

Concluding remarks

The study attempted to inspect the effect of distance and individual's demographic characteristics on the respondent's WTP for the improvements in different environmental attributes in the Heihe River Basin. Concluding from the results, inhabitants of the river basin have a general concern about the current degradation of the environmental attributes and show their WTP for the renovation of degraded environmental attributes, while implicit prices for each attribute declared their preferences for bringing improvements in the degraded environmental attributes. It is evident from the implicit prices that the inhabitants of the area pay more attention to the ecological restoration of river water quality and are willing to pay higher price compared to the other attributes. Although the residents of the whole river basin conveyed statistically significant WTP for the improvement in the river water quality level, increase in the guarantee rate of farmland irrigation, decrease in the sandstorm days, increase in the area of the east Juyan Lake, and improving the conditions for leisure and entertainment, the spatial heterogeneity analysis declared that the people living near to the river are willing to pay more than the remainders, i.e., the people living within the range of 25 km from the river are willing to pay more than the people living within the range of 50 km or more. The differences in the distances from the river and individual's demographic characteristics confirmed the significant effect on individual's WTP for improvements in environmental restoration. In the case of household income and household size, it has been illustrated that the higher the income, the higher the WTP, and that the bigger the household size, the lesser the WTP. This research has a broader implication by providing a precise policy instruction to local water executives, although significant distance decay in household's WTP away from the proposed site was discovered. 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. The selected attributes need more attention from the government as well as from the inhabitants of the Heihe River Basin. Additionally, in order to examine and develop the scope of the current research study, further investigation is required to consider the beneficiaries of this specific zone.

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