Environmental Science and Pollution Research (2023) 30:29859–29873
https://doi.org/10.1007/s11356-022-24299-5

RESEARCH ARTICLE

Does location of the households' matters? Identifying the households' willingness to pay and preference heterogeneity in advancement of vulnerable ecosystem services: An approach of choice experiment

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Received: 12 April 2022 / Accepted: 15 November 2022 / Published online: 23 November 2022

Abstract

The present research underlines the need to expand far outside bundling or hierarchical providing strategy that often focuses on a specific habitat or ecosystem and creates a location-based strategy that considers how dependency in other parts of the region with ecosystem functions and processes leads to complements and resources' trade-offs. Thus, for assessment of spatial heterogeneity based on willingness to pay (WTP) for upgrading environmental attributes across Heihe River Basin (HRB), a choice experiment survey was carried out in the entire river basin. The HRB is one of the big inland river in the Northwestern region of China and is selected on basis of its geomorphological and geographical significance. A sum of 1679 individuals were interviewed through choice experiment technique from whole river basin consisting of five main cities and 33 adjoining rural areas. The Random Parameter logit model, Krinsky-Robb technique as well as delta method were applied for the evaluation of spatial heterogeneity and estimation of individual specific WTP, respectively. Spatial heterogeneity is verified among sampled individuals' preferences about upgradation of environmental attributes, such as, observed preferences of individuals' and their varying corresponding WTP amounts for per unit's upgradation in agriculture product quality, greenhouse gases reduction, farmland landscape, and biodiversity, which reflects heterogeneous tastes and preferences of the selected individuals. In addition, the assessed outcomes for identifying the impacts of distance decay through random parameter logit model depicted the vital role of distance influence on respondents' WTP for restoring the degraded environmental attributes, such that among 3 ad hoc distance bands, WTP of those sampled individuals who are in proximity of ≤ 10 km to HRB is more than the rest of the individuals, i.e., individuals living in the range of ≤ 20 km and > 20 km. For instance, WTP for agriculture product quality is 119.147 CNY/year in ≤ 10 km and is higher than the remainders.

Keywords Choice experiment · Random parameter logit model · Environmental attributes · Individual's perceptions · Influence of distances

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Introduction

The uneven distribution of population and their various socioeconomic features such as different income levels, public perception and willingness to pay for environmental attributes, and other demographic characteristics across an area is referred as spatial heterogeneity (Anselin 2010; Cockx and Canters 2020). The spatial preferences point to the hypothesis that river basin dwellers residing in different locations are valuing the ecological resources differently (Brouwer et al. 2010). Similarly, the choices that are made up among some particular alternatives on a particular location are referred as spatial choices (Fotheringham 1988). The economic valuation of ecological attributes can be considerably influenced by several spatial aspects such as the distance of resource from respondents and access to the available substitutes (Schaafsma et al. 2012). The respondents' preferences and their willingness to pay for a certain environmental attribute are spatially heterogeneous, and thus in cost–benefit analysis, spatial heterogeneity is becoming more prevalent. Usually, it is believed that willingness to pay decreases as a continuous function of distance, which gives rise to the traditional distance decay evaluation. For river restoration, for instance, a distance decay of willingness to pay may be used to calculate the logical connection between willingness to pay of individuals (for river restoration) and their distances from the deteriorated river's closest point (Hanley et al. 2003). The natural resources that are available in various parts of China deliver distinct ecosystem services and serve diverse purposes depending on the local environment. The level of ecosystem services that are supplied for human wellbeing varies greatly over the landscape of the earth, which eventually affects the public's willingness to pay for advancements to these services (Zhou et al. 2015; Liu and Huang 2017).

River basins are referred as the rich and abundant sources for the provision of ecosystems from which the people are getting better off (Knüppe and Knieper 2016). However, apart from these public welfares, these sources are continuously facing the serious threat of deterioration and their unsustainable utilization, resulting a decline in the provision of major ecological benefits, while many rivers had already undergone massive destruction due to human activities at global scale (Mauerhofer et al. 2018). Thus, it becomes one of the significant problems by attaining the attention (Hong et al. 2009), because the variation or degradation posed by humans can cause the loss of these ecological services and their associated welfares for the society (Jadhav et al. 2017; Destek et al. 2018).

The available estimates for cost–benefit analysis can be significantly influenced by the choices developed by researchers' while accumulating respondent benefits (Morrison 2000). Usually, the sample's average values of respondent's welfares are used to aggregate the ecological values. However, in the assessment process where respondents' location might be affective in terms of site proximities, it is essential to consider spatial heterogeneity while assessing accumulative benefits (Bateman et al. 2006). Biasness can be reduced by analysing how values vary spatially within the population as a whole, through identification of values conditioned on variables related to the place of hypothetical speculation for influencing respondent's preferences.

Numerous researches on stated preferences (SP) take into account spatial choices amongst environmental advancements at various locations in a particular geographic region. The spatial perspective factors that contribute to the underestimation of ecological services, such as service provider's site, accessibility of potential substitution locations, and the distance between the beneficiary inhabitants and service provider, are all probable to have an impact on the value assigned to the ecological service (Schaafsma et al. 2013). In places with numerous water resources, e.g., lakes, canals, and rivers, the willingness to pay of households for improving water quality may be significantly influenced by distance and alternatives (Johnston et al. 2002). The availability of alternatives grows with distance from the source for various ecological services, causing distance decay impacts. The substitutability of ecological attributes is influenced by the distance between the sites offering these attributes/services and the participants in a stated preferences survey. Hence, in spatial choice research, substitution and distance effects are interconnected. The distance decay effect suggests that respondent's willingness to pay for any good or service decreases with an increase in distance between these goods and services and respondents (Schaafsma et al. 2013).

Based on literature where persuasive indications are observed that spatial patterns are followed by some ecological preferences, due to the reasons of variations in spatial configuration of these ecological services, those preferences are adopted according to respondent's own choice (Nielsen et al. 2007), as well as their accessibility to substitutes (Munro and Hanley 1999). Similarly, another reason is related to individual's living place in which their preferences are correlated with their distance to the specific ecosystems or with the quality of ecosystems (Timmins and Schlenker 2009; Baerenklau et al. 2010). The impact of spatial variations on ecosystem services has also been indicated by ecological literature (Pickett and Cadenasso 2002; Turner 2005). Spatial heterogeneity can lead towards major impacts in the endowment and utilization of ecosystem services (Barbier 2009), as well as it can significantly affect the fulfillment or inadequacy of conservation polices.

Previously, researchers have analysed a household's distance from a site in terms of their spatially heterogeneous preferences and have gained a lot of attention (Czajkowski et al. 2017a; Khan et al. 2019). The dependency on the sample's mean willingness to pay can result in inappropriate estimates, as evidenced by the statistically significant distance decay in results (Hanley et al. 2003; Bateman et al. 2006). To estimate the distance decay, Concu (2007) was one of the first to use the technique of choice experiment method, and he discovered that omitting the distance results in undervaluation in the calculation of cumulative benefits and losses.

According to study by Pate and Loomis (1997) in California, where different programs were developed for the reduction of ecological degradation, it was found that the impacts of distance are very significant in willingness to pay by individuals for large non-use values. Similarly, Hanley et al. (2003) endorsed that the effects on willingness to pay by distance-decay are more significant for use values and for specified local ecological good, as compared to the non-use values and for public ecological good. Many other researchers have applied choice experiment and concluded that respondents' willingness to pay is higher for the environmental goods and services while they are living near to the site (Czajkowski et al. 2017b; Badura et al. 2020). These assessment studies revealed that generally ecosystems' value is negatively dependent on the geographic distance between the site and the respondent, on income and ecological awareness.

Rapid industrialization has triggered massive changes in physical outlook of rivers (Khan et al. 2020b), as well as resulted in environmental problems (Ali and Yi 2022). The ecosystem services provided by rivers have been significantly impacted by human encroachment and urban development (Khan et al. 2020b). The Heihe River Basin, China's second-largest inland river, is plagued by serious resource utilization, environmental degradation, and water pollution issues in northwest of the country (Wang et al. 2019). The environmental condition of Heihe River has been constantly threatened by water pollution and scarcity problems since few decades, which has resulted in deteriorating the quality of ecosystem services (Chen et al. 2016). Grassland erosion, spread of hazardous weeds, and desertification pose serious concerns to the upper basin of river. Similarly, salinization, desertification, and aquatic pollution are the major concerns associated with middle basin of river. Whereas, the most delicate and vulnerable basin of the Heihe river is lower basin which is challenged by four major environmental problems, i.e., escalating desert and sand resource as well as depletion of east Juyan lake and oasis area. In addition to having a direct impact on the local environment and species, all of these ecological degradation severely threatens the ecological security of the entire basin and places substantial restrictions on the development of society (Chen et al. 2016).

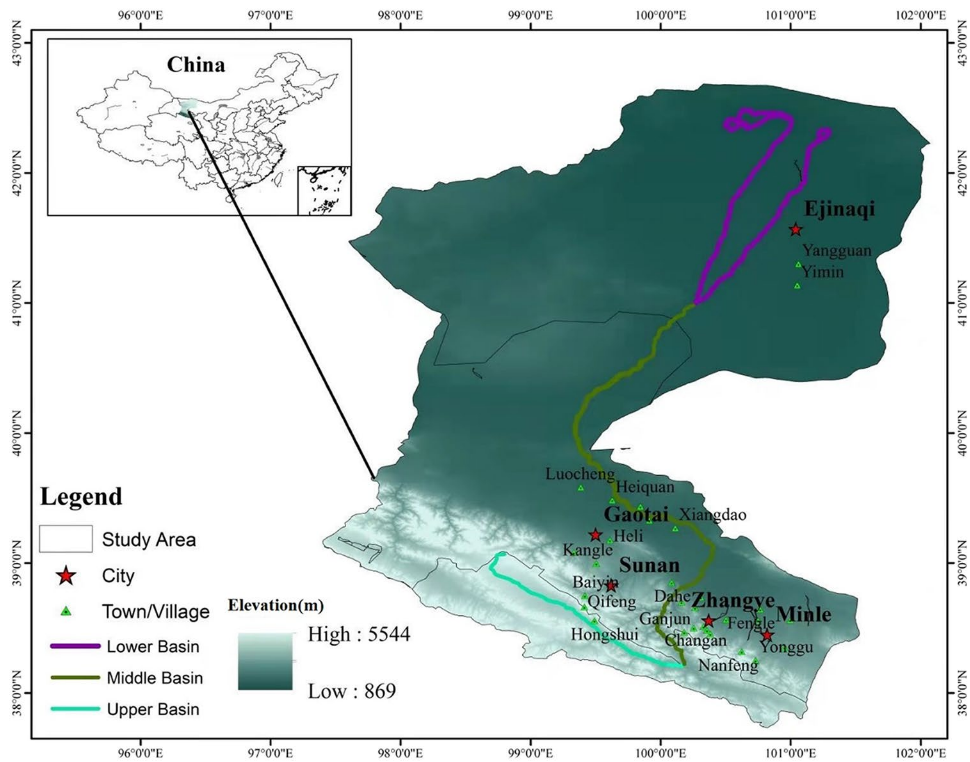
The present research underlines the need to expand far outside bundling or hierarchical providing strategy that often focuses on a specific habitat or ecosystem and creates a location-based strategy that considers how dependency in other parts of the region with ecosystem functions and processes leads to complements and resources' trade-offs. Therefore, depending on the attitudes and expressions to the prevailing economic and environmental situations, the focus of current research is to examine the welfare effects of upgrading the Heihe river basin's environmental attributes, as well as examining the effects of spatial heterogeneity and distance-decay over the sampled individuals' willingness to pay for the river ecosystem services improvements. However, river basins are delivering a variety of services and welfares to general public; we focused our research on 6 environmental attributes and their associated welfares, which are most influential in affecting individual's livelihood in Heihe River Basin. Thus, the aim of this specific research is to enlighten the literature by adding distinct spatial approach of "distance decay" in the assessment of willingness to pay for the upgradation of river environmental attributes. The selected environmental attributes are: (1) Yield of cultivated land (Production), (2) Quality of agriculture products (Quality), (3) Ejinaqi oasis size (Oasis), (4) Biodiversity, (5) Emission of greenhouse gases reduction (GHG), and (6) Farm-land landscape (Landscape).

Methodology

Study area description

The worldwide demand has been increased for the limited resources of water, and many rivers are unable to meet all of the public's requirements or enter to terminal lacks/sea due to a lack of water supplies (Liu and Xia 2004). In this study, Heihe river basin was selected on the basis of its geomorphological and geographical significance. It has attracted the widespread consideration as a result of the growing pressures on its water reserves and associated environmental deterioration. The Heihe river basin is one of the big inland river in the Northwestern region of China, covering 128,000 km^2 area (Fig. 1) (Qi and Luo 2007). There are 3 sub-basins of the Heihe river basin in which the upper-sub-basin is located in Qinghai, and the location of middle-sub-basin is Gansu region, i.e., Zhangye and other adjacent counties and towns, while the lower-sub-basin of this river is located in the Inner Mongolia, i.e., Ejina Qi oasis. Apart from evaporation differences which are ranging from 700 to more

Fig. 1 Heihe river basin

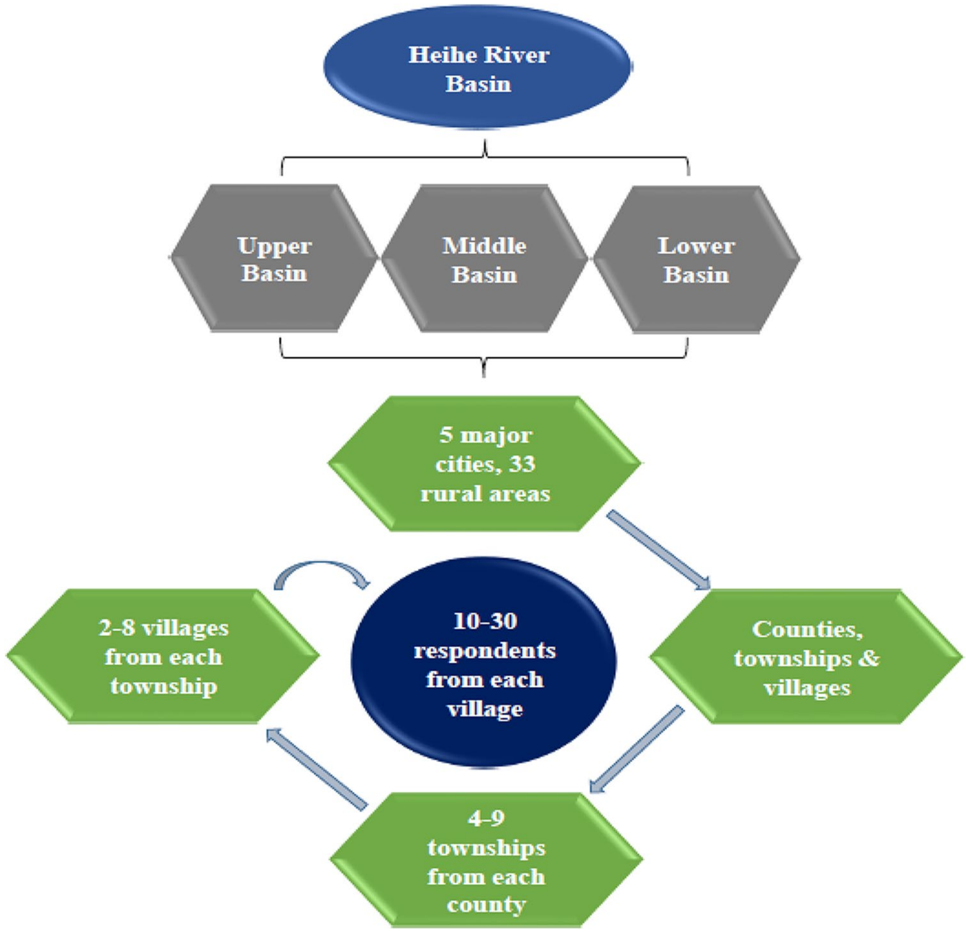


than 3000 mm throughout the basin, Heihe river basin's characteristics differ significantly, i.e., upper-sub-basin, middle-sub-basin, and lower-sub-basin receive 200 to 500 mm, less than 200 mm and less than 5-mm average rainfall, respectively. Similarly, Cheng et al. (2006) concluded that this basin is composed of deserts, mountains, and oasis having 57.15%, 33.16%, and 8.19% proportion respectively. Climatic variation and land cover have severely deteriorated the different functions and services provided by the river basin, especially in middle-sub-basin where nearly 65% irrigation water has been lost from the runoff, significantly impacting the hydrological pattern of the river (Wu et al. 2015).

Sample size and sampling procedure

With the identification of significant environmental attributes and the associated levels, a pre-test investigation was developed in study region with 70 regional respondents. A systematic and thorough investigation was undertaken among the randomized samples from the selected big cities (5) and neighbouring rural areas (33) in the whole basin in order to evaluate the prevailing environmental quality of the deteriorated natural ecosystems and their functions, and to determine the developments in the specified natural ecosystems of HRB. The selection of the surrounding rural territories was based on to reflect the economic and ecological features of the reference cities. Moreover, nomination of the 5 big cities was based on the equidistance principle such as proximal regions of Heihe river basin which was the main focus of this research, whereas stratified random sampling procedure was applied to select county, town, and village in the study region. Following that, a random selection of 5–9 and 6–8 towns and villages out of each county was done, respectively. At the end, applying the procedure of proportional allocation, 10–30 respondents were selected out of each village (Fig. 2). Because of the less educated and rural community involvement, and to avoid the complexities associated with the questionnaire, face-to-face interview was conducted, in which the interviewers might aid the selected sampled households by adding additional guidance and reducing the associated complications with questionnaire comprehension. Thus, a sum of 1679 finalized questionnaires/households was obtained for the final investigation, in which 304 and 199 households were from Gaotai and Ejinaqi regions, respectively, while 695, 201, and 280 households were interviewed from the Zhangye, Sunnan, and Minle regions, respectively. Prior to evaluating the model, the collected data was filtered, in which incomplete questionnaires, protest replies, and the non attendance analysis were eliminated from the final data, and hence 1621 questionnaires were finalized. Based on the former research works of Ali et al. (2020) and Kosenius and Markku (2015), and through the procedure of proportion allocation, the existing sample size is claimed to be enough for highlighting study area.

Fig. 2 Sampling flowchart in Heihe river basin



Theoretical framework and specification of econometric model

Choice experiment is an approach of stated preference and widely utilized in the arena of environmental and ecological economics. This approach enables the surveyed individuals on their preferred management options for the sustainability and management of environment from a variety of available choices. The research scholars can compute the non-marketed values and their associated benefits of various social goods through estimation of mean WTP of the individuals. It is based on the behavioural principles like other stated preference approach on random utility and Lancaster consumer theories (Thurstone 1927; Lancaster 1966). According to the Lancaster theory, the utilities of consumer could be split into qualities of consumers and consumers' products attributes, while the theory of random utility, on the other hand, is the foundation of the consumers' evaluation and policymaking in social sciences and psychology (Thurstone 1927; McFadden 1974). A random element of utility function could be proposed to describe the differences in the consumers' preferences.

The basic assertion is that under financial restrictions, customers adopt decisions to optimize their satisfaction based on the intrinsic characteristics of commodities (McFadden and Train 2000). Regardless of inherent complexity of the issue owing to sociodemographic attributes such as lower levels of education and income, environmental economists adapted paid close attention to the application of choice experiments in emerging economies (Birol and Das 2010; Rai and Scarborough 2015). These empirical works proposed a number of solutions for the developing economies to deal with the behavioural and communicative difficulties that come with acquiring stated preferences (Rai and Scarborough 2013). The method of choice experiment was utilized for the evaluation of individuals' preferences to restore the river ecosystem services, as well as to improve the basin's environmental quality. The individuals were asked to choose a preferred option from a list of options provided. Lancaster theory is the base of the choice experiment, such that commodities (goods/services) could be characterized as set of attributes (Lancaster 1966). Furthermore, this technique exemplifies the features of typical value theory. In the hypothetical choice tasks, individuals typically compare the payments for improving qualities with the alternative states of attributes.

The individuals, or generally homogenous societies, are assumed to have market behaviour based on the preference optimization in modern economic choice theory. Because of differences in behaviours, expectations, and other unquantified components, preferences might involve random elements (McFadden 1986). The use of choice experiment demonstrates the characteristics of the clear and unambiguous utility theory based on random utility maximization (Louviere 2001). As a result, within every choice task, an individual will go for the selection of that alternate option that will provide the most benefit and satisfaction. The random element of the utility function of individuals could be used to handle discrepancies in option, which can be computed as follows:

$$U_i = V_i + \varepsilon_i \tag{1}$$

In Eq. (1) is shown a demonstration of true and non-observable utility (i^{th} option) = U_i. Observed utility element = V_i, while unknown and random error element = ε_i.

The likelihood of selecting (i^{th}) option among the offered and available choice set of (j^{th}) alternates by a rational individual, mathematically:

$$P(i) = Pr[U_i > U_j] = Pr[(V_i + \varepsilon_i) > (V_j + \varepsilon_j)] \tag{2}$$

and

$$V_i = C + \beta' X_i \tag{3}$$

In the above mentioned equation, alternative specific constant's binary selections are represented by C. This C takes two values, i.e., 0 or 1, when an individual goes for an alternate policy option such as policy A or policy B, then it takes the value of 0, while in case of choosing status-quo, this value is 1. Similarly, β' and X, both are representing the coefficients and a vector for the explanatory variables, respectively.

The random parameter logit model, which is broadly applied method, is considered to relax the IIA (independence from irrelevant alternatives) property of multinomial-logit model. At the same time, it allows the random variation of parameters among individuals (Revelt and Train 1998; Brownstone et al. 2000). Furthermore, it also assumes the impact of unobservable factors on utility. Furthermore, it also assumes the impact of unobservable factors on utility and provides greater flexibility as compared to multinomial logit model and conditional logit model, allowing for the replacement of heterogeneous preferences and association in the unobservable components. We employed a random parameter logit model, which we adapted from our prior investigation (Ali et al. 2020). In the random parameter logit model, η_{ij} is an extra stochastic component, which will consider for heterogeneity and auto-correlation throughout options, in which the distribution of ε_{ij} is identical and independent along with an extreme value of type 1. In random parameter logit model, the mathematical representation of utility's function is

$$U_{ij} = V(Z_{ij}, X_i, \beta_i) + \eta_{ij} + \varepsilon_{ij} \tag{4}$$

As the choice experiment identifies the trade-off between individual willingness to pay and environmental features, thus the projected conclusions from choice experiment ought to be instructive. The marginal willingness to pay of an individual for the improvement of any environmental attribute can be evaluated through the estimated coefficients, such as the estimation of marginal willingness to pay for Z_k (an environmental attribute) can be evaluated as

$$MWTP_k = \partial P / \partial Z_k = -\beta_k / \beta_p \tag{5}$$

The willingness to pay dispersal must be identified in order to calculate the marginal willingness to pay's confidence interval. The marginal willingness to pay's confidence intervals could be accessed using delta and Krinsky–Robb techniques. In delta technique, values of the willingness to pay are uniformly dispersed, and variation is calculated using the first-order Taylor expansion of mean values of variables. For estimating the confidence interval, following equation cab be utilized:

$$WTP_k = Z_{\alpha/2}\sqrt{var(WTP_k)} \tag{6}$$

In the above equation, inverse of cumulative normal distribution is demonstrated by $Z_{\alpha/2}$ whereas 100 $(1-\alpha)$% is confidence interval. The appropriateness of delta approach might not be suitable when the distribution of willingness to pay is not normal. However, the non-parametric approach of Krinsky–Robb, irrespective of the confidence interval distribution, is the best option.

Estimation of distance decay effect

In general, researchers do not employ individuals' route distance evaluations, which may be less precise, but this may accurately depict choice perspectives. Several researches have validated dummy variables across zones (kilometres' ranges surrounding administration zones) to define if the respondent is a native of the region/county in which the goods/services are situated, notably for those kind of goods/services having regional significance (Schaafsma et al. 2013). The individuals' willingness to pay for validation of spatially heterogeneous choices, on the other hand, has been barely used, just with pre-selected ad hoc distance ranges being used, such that the ad hoc distance bands utilized by Yao et al. (2014) for the investigation of woodland quantity were 10, (10 to 50), and (50 to 100) km from every respondent. In addition, the study of Khan et al. (2018) also utilized ad hoc distance bands by dividing the sampled households in 5 categories, i.e., less than or equal to 5, less than or equal to 10, less than or equal to 20, less than or equal to 30 km, and more than 30 km. The ad hoc bands stated above were used as exogenous factors to characterize the variation/heterogeneity in willingness to pay for river ecosystem services improvements.

The respective data is distributed in three ad hoc distance bands based in order to measure the impact of distance decay (distances of sampled respondents from the specified river). The first category/zone contains those sampled individuals who are living in less than or equal to 10-km range, second category/zone contains those sampled individuals who are living in less than or equal to 20-km range, while third category/zone contains those sampled individuals who are living in more than 20-km range from Heihe river, whereas, the number of sampled individuals in every category/zone are 963, 206, and 452, respectively. Utilizing the econometric program Stata, random parameter logit model was applied to perform empirical analysis.

Selection of choice attribute levels

The determination of environmental ecosystem services along with their levels for the assessment is the initial phase of designing choice experiment (Birol et al. 2006). There are four primary roles of ecosystems based on Millennium Ecosystem Assessment, including regulation, supply, culture, and support. Preliminary interactions with study participants and environment officials (policymakers) were held to acquire an accurate and efficient characterization of basic valuation concerns. The goal of a prelim data collection from 70 local individuals in study region was to determine the relevant environmental attributes along with their varying levels. The determination of river environmental ecosystem services was based on the prelim investigation, interactions with regional research scholars (agriculture and resource economists, and ecological experts) and officials (Heihe Municipal People’s Government http://hrb.yrcc.gov.cn/), and pertinent review (Ali et al. 2020). Table 1 illustrates the most significant Heihe River Basin’s environmental ecosystem services along with their varying levels that should be assessed.

The selection of multiple choice options was given to the respondents (Table 1), with each alternative containing a set

Table 1 Selected environmental attributes and their levels in the choice set

Evaluation indicators	Program 1 (status quo)	Program 2 (Improved 1)	Program 3 (Improved 2)
Yield of cultivated land (reference wheat)	450 (kg)	470 (kg)	460 (kg)
Quality of agriculture products (level of safety)	Good	Excellent	Good
Ejinaqi Oasis Size	3200 (km^2)	4000 (km^2)	3600 (km^2)
Biodiversity	☆	☆☆☆	☆☆
Emission of green-house gases reduction (whether to pay attention to)	No	No	Yes
Farmland landscape (whether or not beautiful)	No	Yes	No
Your home is willing to pay for it. (per year)	RMB 0	RMB 150	RMB 200
Please select one of these			

Description of the selected environmental attributes

1. Yield of cultivated land: Enhance the quality (fertility) of soil, reduce soil salinity and desertification, and boost crop production. (Crop production in this case is predicted on wheat production (in acres)).

2. Quality of agriculture products: Enhancing the calibre and standard of agriculture outputs by reducing the contamination of herbicides, insecticides, mulching, and the water used for irrigation purpose.

3. Ejinaqi Oasis Size: Construction of irrigation techniques that use less water, protection of channels, and certain scale development of oasis in lower basin region. The regional climate is regulated by the Ejinaqi Oasis, which also successfully prevents sand and wind from encroaching on farmlands.

4. Biodiversity: Agricultural lands and environmental ecology benefit from abundant biodiversity because agricultural lands give an ideal habitat for micro-organisms and animals.

5. Emission of green-house gases reduction: The effects of climate change, harsh weather (variations in temperature), and agriculture (water and soil) pollution can all be lessened by decreasing the emission of greenhouse gases.

6. Farmland landscape: Adequate management of the farmlands, including the development of a grassy zone, tree plantations, and a forest belt. Residents have access to pleasant, lovely fields where they may stroll, rest, and have fun.

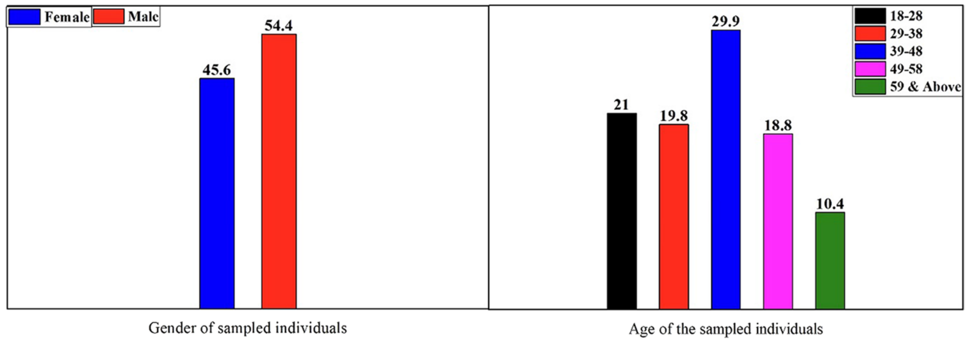


Fig. 3 Gender and age of the sampled individuals

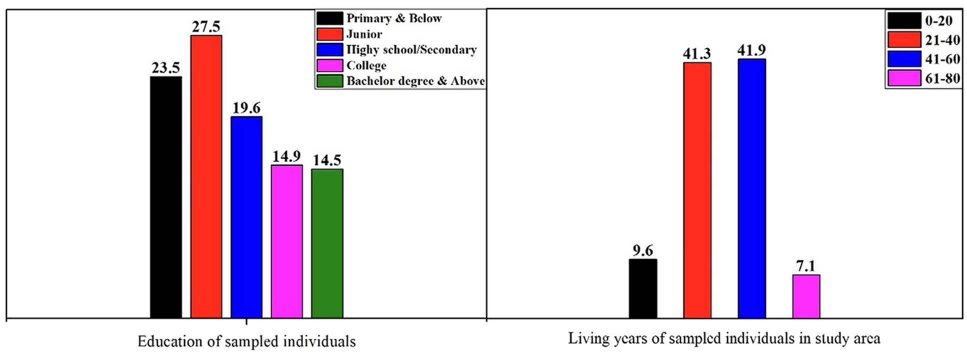


Fig. 4 Education and living years of the sampled individuals

of ecological attributes, and their associated levels reflecting the outcome of the policy, along with status quo that represent the current conditions with zero payment. Moreover, coding and allocation of random normal, and non-random distribution to the attributes are presented in Supplementary Table S1. A sum of 60 choice sets was developed through the implementation of D efficiency design and Ngene software 1.1.1 (Bliemer and Rose 2010; ChoiceMetrics 2012), which were separated in twenty blocks, whereas error D is 0.006939, while error A is 1.420521. Hence, a set of three questions (choice sets) was enquired from every respondent to answer. In order to enhance the choice set's appropriateness, status quo option is added among alternatives (Louviere et al. 2000). Similarly, Hanley et al. (2001) concluded that the absence of status quo and just focus on improved and varying policy schemes in choice tasks may lead to vague and incompatible welfare estimations with economic theory.

Results and discussion

Socioeconomic status of the sampled individuals

The socioeconomic status of the sampled individuals in the study area is represented in supplementary Table S2 and the following Figs. 3, 4, and 5. Furthermore, minimum, maximum, mean, and standard deviation are also represented in the mentioned Table S2. In 1621 sampled individuals, 739 (45.6%) are females, while 882 (54.4%) are males in the sampled individuals (Fig. 3). Similarly, the sampled individuals are divided in 4 different age groups, i.e., 18–28, 29–38, 39–48, 49–58, and 59 and above, in which each group contains 342 (21%), 321 (19.8%), 485 (29.9%), 304 (18.8%), and 169 (10.4%) sampled individuals, respectively (Fig. 3).

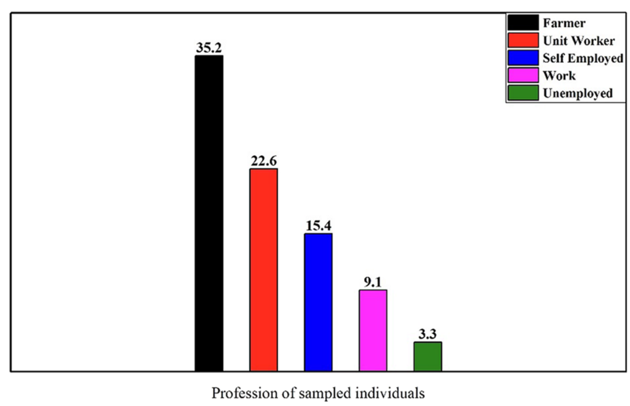


Fig. 5 Profession of the sampled individuals

Whereas, education scenario (Fig. 4) demonstrated that maximum sampled individuals 447 (27.5%) have junior level education, 381 (23.5%) individuals have primary and below level of education, and 317 (19.6%) individuals have high school/secondary level education, while the sampled individuals having college, and bachelor and above level of education are 241 (14.9%), and 235 (14.5%), respectively. Moreover, the living years (Fig. 4) of the sampled individuals living in the study area are divided in 4 different categories, i.e., 0–20, 21–40, 41–60, and 61–80. In which maximum number of the sampled individuals 680 (41.9%) are in 41–60 category of living years in the study area. A total of 670 (41.3%) sampled individuals are in 21–40 category, 156 (9.6%), and 115 (7.1%) sampled individuals are in 0–20 and 61–80 living years' groups, respectively.

At the same time, profession of the sampled individuals (Fig. 5) is also divided in different groups, in which maximum individuals were farmers 571 (35.2%), followed by unit worker 367 (22.6%), the number of self-employed sampled individuals were 249 (15.4%), work category has 147 (9.1) individuals, unemployed 53 (3.3%), and other were 234 (14.4%) sampled individuals.

Welfare estimation

Table 2 reflects the assessed outcomes of the sampled individuals regarding HRB's environmental status through random parameter logit model, in which, other than ASC (alternative specific constant) and payment attributes that were fixed (non-normal distribution), rest of the enlisted environmental attributes were random distribution. The reason for keeping the payment attribute constant was that the coefficient distribution of the environmental indicator is identical to the distribution of that indicator's marginal willingness to pay. Furthermore, normal distribution was presumed for all the models and utilized 500 Halton draws. There was no imposition of required restraint over random variables' signs (environmental attributes) by following Hole (2007) and Train (2009). The assessed coefficients of the current environmental attributes indicated that sampled individuals have put preference on the improved levels of the attributes over existing condition (status-quo). All the coefficients for random parameters have demonstrated the statistical significance at 1% level of significance, except oasis attribute which is significant at 5% level. At the same time, ASC, which has both negative and significant outcome, signified that sampled individuals were moving towards alternative options from the existing condition, i.e., status quo (Brouwer et al. 2016), while on the other hand, negative and significant outcome for payment indicated that individuals' utility and satisfaction will be declined with increasing level of price, and thus their willingness to pay will decrease, which is consistent with economic theory (Perni and Martínez-Paz 2017). The current empirical outcomes are in accordance with research conclusions of Dupras et al. (2018) and Kunwar et al. (2020). The preference heterogeneity and its occurrence among sampled individuals are endorsed through the standard deviations of means for the existing environmental attributes which are statistically significant (Bernués et al. 2019).

Table 2 Estimated outcomes of random parameter logit model

Choice	Coefficient	Standard error	Sig
Mean			
Payment	−0.013	0.001	***
ASC	−1.674	0.245	***
Production	0.020	0.004	***
Quality	1.175	0.138	***
Oasis	0.000	0.000	**
Biodiversity	0.175	0.076	***
GHG	0.612	0.125	***
Landscape	0.215	0.115	**
SD			
Product	0.100	0.006	***
Quality	2.426	0.225	***
Oasis	0.004	0.000	***
Biodiversity	−1.271	0.145	***
GHG	2.378	0.199	***
Landscape	−2.178	0.212	***
Summary statistics			
Number of obs:	14,589		
LR chi2 (6)	1629.84		
Log likelihood	−4043.5167		
Prob > chi^2	0.0000		

Production=Yield of cultivated land; Quality=Quality of agriculture products; Oasis=Ejinaqi oasis size; Biodiversity; GHG=Emission of greenhouse gases reduction; Landscape=Farmland landscape

1% = (***), (5%) = **, (10%) = *

Individuals' prioritization of attributes based on willingness to pay

Following Mayer and Woltering (2018), that willingness to pay can be utilized to derive conclusions about ecosystems valuation, which might have different values, i.e., differences in individuals' willingness to pay (Higgins et al. 2020). As shown in Fig. 6, the sampled individuals have different perceptions and heterogeneity in their preferences. Quality of agriculture product is the most preferred attribute and has the highest amount of 103.495 CNY/year for its improvement, followed by greenhouse gases reduction, farmland landscape, biodiversity, and yield of cultivated land having willingness to pay of 47.476 CNY/year, 16.676 CNY/year, 13.531 CNY/year, and 1.535 CNY/year, respectively. In contrast, the sampled individuals showed less attention towards the improvement of Oasis; however, they are willing to pay 0.017 CNY/year for its improvement. The significance of environmental attributes is obvious from individuals' willingness to pay (Li et al. 2013; Dogan and Muhammad 2019), whereas taste and preferences of the individuals have important contributions regarding their improvements, which led to different level of payment (Li et al. 2020).

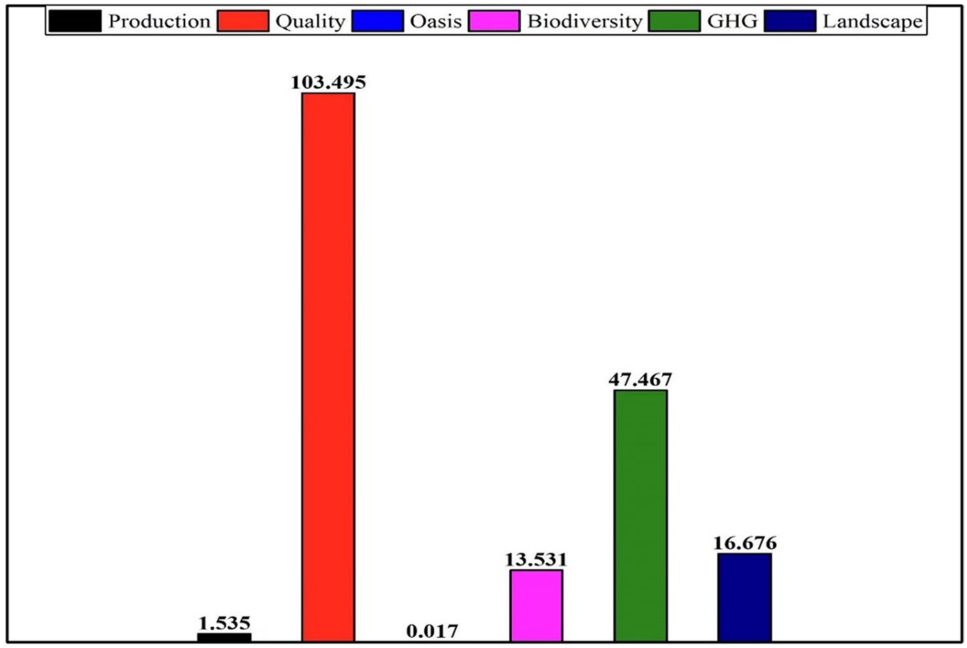


Fig. 6 Estimated outcomes of mean willingness to pay for selected environmental attributes

Table 3 Interaction outcomes from random parameter logit model between distances and selected attributes

Choice	Coefficient	Standard Error	Sig
Mean			
Dist. × Payment	−0.001	0.000	***
Dist. × Product	0.024	0.003	***
Dist. × Quality	0.113	0.010	***
Dist. × Oasis	0.000	0.000	***
Dist. × Biodiversity	0.038	0.006	***
Dist. × GHG	0.039	0.010	***
Dist. × Landscape	0.023	0.008	***
SD			
Dist. × Product	0.073	0.005	***
Dist. × Quality	0.259	0.018	***
Dist. × Oasis	0.000	0.000	***
Dist. × Biodiversity	0.142	0.010	***
Dist. × GHG	−0.300	0.022	***
Dist. × Landscape	0.177	0.012	***
Summary statistics			
Number of obs:	14,589		
LR chi2 (6)	1529.17		
Log likelihood	−4588.9634		
Prob > chi^2	0.0000		

Production=Yield of cultivated land; Quality=Quality of agriculture products; Oasis=Ejinaqi oasis size; Biodiversity; GHG=Emission of green−house gases reduction; Landscape=Farm−land landscape. Dist. = Distance

1% = (***), (5%) = **, (10%) = *

Estimated results of distance interactions with environmental attributes and their willingness to pay

The estimated outcomes of random parameter logit model for interactions between environmental attributes and the distances (location of sampled individuals) from river basin are illustrated in Table 3. It is evident from the estimated statistically highly significant outcomes (1% significance level) that the distance from river basin (location of sampled individuals) has significant influence on the individuals' willingness to pay to improve the under study environmental attributes. At the same time, the estimated significant outcomes of standard deviation at the lower end of the table signified the heterogeneous preferences among sampled individuals regarding current environmental attributes (Concu 2007; Bernués et al. 2019; Ali et al. 2022).

Any evaluation method's primary goal is to assess the variation in society's welfare with respect to any difference in environmental parameters. Consequently, the estimated willingness to pay outcomes of the sampled individuals regarding upgradation the current conditions of the focused environmental attributes are demonstrated in Fig. 7. Based on the taste and preferences, sampled individuals are willing to improve the current degraded condition of the attributes, i.e., maximum willingness to pay for improving quality of agriculture product 184 CNY/year, followed by greenhouse gases reduction 62.766 CNY/year, biodiversity 62.202 CNY/year, yield of cultivated land (production) 38.663 CNY/year, landscape (farmland landscape) 38.028 CNY/year, and Oasis 0.067 CNY/year.

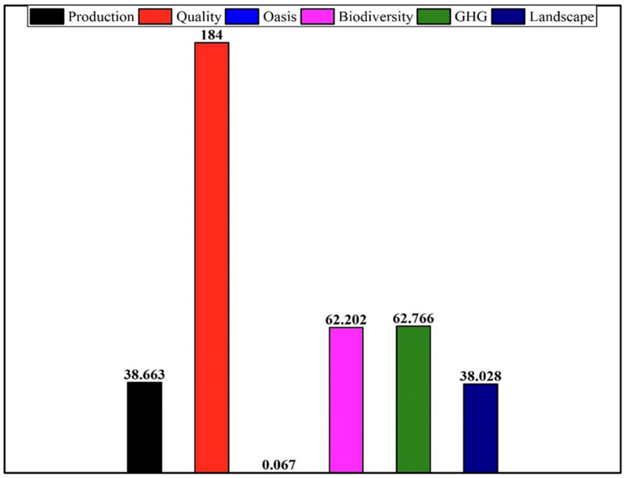


Fig. 7 Estimated outcomes of mean willingness to pay for selected environmental attributes (distance interactions)

Influence of distance decay

Based on the former research work, utilization of the estimated regions inside distances is frequent in numerous types of the welfare research, particularly in the hedonic pricing assessment, which clearly identifies the influence of adjacent features on property costs (Johnston et al. 2001; Paterson and Boyle 2002). Conversely, in order to comprehend the spatially heterogeneous preferences, individuals' willingness to pay has been utilized rarely, and only when utilizing preselected, ad hoc distance bands, such that in order to quantify the woodlands in New Zealand, Yao et al. (2014) utilized three different ad hoc distance ranges inside 10 km, 10 to 50 km, and 50 to 100 km from the location of every sampled individual, and for improving the woodlands and identifying the variations in individuals' willingness to pay, these ad hoc ranges were utilized as explanatory parameters. Similarly, in China, where Khan et al. (2018) make 5 ad hoc distance bands (i.e., ≤ 5 km, ≤ 10 km, ≤ 20 km, ≤ 30 km, and > 30 km) to identify the spatial heterogeneity and influence of distance on surveyed respondent's willingness to pay for improving the ecological attributes in Shiyang river basin through choice experiment technique.

Following this technique and to evaluate the impacts of distance decay, we make 3 different categories/zones (ad hoc bands) and redistributed the corresponding data accordingly, such that the first category/zone is less than or equal to 10-km range, second category/zone is less than or equal to

Table 4 Estimated outcomes from random parameter logit models for selected attributes (ad hoc bands)

	≤ 10 km		≤ 20 km		> 20 km	
Choice	Coef	SE	Coef	SE	Coef	SE
Mean						
Payment	− 0.013***	0.001	− 0.018***	0.003	− 0.011***	0.002
ASC	− 1.765***	0.293	− 1.881***	0.739	− 1.319***	0.470
Product	0.020***	0.004	0.034***	0.012	0.021***	0.010
Quality	1.491***	0.267	1.968***	0.451	1.103***	0.263
Oasis	0.000**	0.000	0.002***	0.001	0.001	0.001
Biodiversity	0.463***	0.105	0.087***	0.030	0.278***	0.126
GHG	0.705***	0.145	0.250***	0.087	0.459***	0.213
Landscape	0.382***	0.133	0.217***	0.076	0.116***	0.031
SD						
Product	0.100***	0.009	0.104***	0.018	0.104***	0.015
Quality	2.330***	0.289	3.223***	0.674	2.211***	0.438
Oasis	0.003***	0.000	0.003***	0.001	0.003***	0.001
Biodiversity	− 1.130***	0.157	1.595***	0.356	1.314***	0.395
GHG	2.331***	0.231	2.164***	0.438	2.334***	0.402
Landscape	− 1.508***	0.244	1.519***	0.562	2.404***	0.417
Summary statistics						
Number of obs	8,667		1,854		4,068	
LR chi2 (6)	876.82		226.12		510.37	
Log likelihood	− 2409.461		− 482.6139		− 1114.2386	
Prob > chi^2	0.0000		0.0000		0.0000	

Production=Yield of cultivated land; Quality=Quality of agriculture products; Oasis=Ejinaqi oasis size; Biodiversity; GHG=Emission of green−house gases reduction; Landscape=Farmland landscape

1% = (***), (5%) = **, (10%) = *

20-km range, while third category/zone is more than 20-km range. The evaluated outcomes obtained through the application of random parameter logit model are demonstrated in Table 4, regarding the mentioned ad hoc distance bands (categories/zones) sampled individuals. The statistically highly significant (1% and 5% significance level) obtained outcomes depicts that all environmental attributes have predicted signs and having consistency with economic theory (Perni and Martínez-Paz 2017), except oasis in the third category/zone (> 20 km). The fact that sampled individuals are concerned and resistant to the rise in the costs that they are willing to pay for improving environmental attributes is indicated by negative indicators for payment attribute in all three mentioned ad hoc distance bands (King et al. 2016). The ASC's negative but significant coefficient supported the substantial attitudes and preferences for improving environmental attributes over keeping status quo (Brouwer et al. 2016). The socioeconomic characteristics of sampled individuals vary from one another, and as a result, their attitudes and preferences for environmental attributes also differ. Similarly, it is also evident from standard deviation of mean for existing environmental attributes which are statistically significant, ensuring the predominance of heterogeneous preferences amongst selected individuals for all environmental attributes (Khan et al. 2022).

The sustainability and restoration of natural river ecosystems have become crucial because of rising concerns regarding water quality and negative impacts on river ecosystems. According to ecological objectives, the implementation of such restoration initiatives is anticipated to offer significant ecological benefits (Brouwer 2008). The conditions of fragile rivers are being improved through development projects in Europe, China, USA, and many other nations across the globe (Clarke and Dalrymple 2003; Khan et al. 2020a). Regardless of the fact that significant initiatives are being executed and restoration programs for the rivers have been carefully thought out, there are still inequalities in the way rivers are being restored from a scientific and social perspective (Eden and Tunstall 2006). The importance of sustainable management and restoration of the rivers is widely acknowledged, from enhancing basic water quality to restoring ecosystems and making them functional. Human activities have been a major source of anxiety because it is affecting or nearly eradicating several rivers in the natural environment across the globe (Khan et al. 2022). It is crucial to protect the existing environment of the rivers as there are increasing concerns regarding the river's health and negative effects on river environmental conditions. Lowering anthropogenic effect on the river's natural landscape through the restoration of river-level ecological parameters will support a healthy habitat (Song et al. 2010).

Furthermore, the impact of distance decay on the willingness to pay of the sampled individuals regarding the improvement of environmental attributes is presented in Table 5. The estimated outcomes of willingness to pay endorsed that the amount of willingness to pay for restoring and upgrading the ecological attributes is higher for those individuals who are residing in the proximate areas (low distance between river and sampled individuals). On the other hand, this amount, i.e., willingness to pay of the sampled individuals becomes decline as this distance is increasing. And the findings are in line with Czajkowski et al. (2017a) and Schaafsma et al. (2013), such that the estimated willingness to pay of the sampled individuals who are living near to the Heihe river, i.e., in less than or equal to 10-km range, has placed highest willingness to pay amount 119.147 CNY/year, 56.354 CNY/year, 35.615 CNY/year, and 30.534 CNY/year for bringing upgradation in quality of agriculture products, reduction in the emission of greenhouse gases, biodiversity, and farmland landscape, respectively, which proves the claim regarding more willingness to pay of nearby residents as compared to those who are residing in far flung areas from river (Cheng et al. 2021). It is also evident from the previous literature that distance has significant influence on the individuals' willingness to pay; as the distance between ecosystems' site and individuals increases, their willingness to pay mostly decreases (Schaafsma et al. 2013). Similarly, the general public knowledge and awareness about specific location decline due to increasing distance, and thus it ultimately contributes in heterogeneous preferences and willingness to pay of the individuals (Bateman et al. 2006; Yao et al. 2014). Usually, individuals' willingness to pay for a certain good/service is assumed to be low with growing distance between the individuals and that specific source which provides that good/service (Hanley et al. 2003). However, Espey and Owusu-Edusei (2001) and Imber et al. (1991) reported that individuals' willingness to pay in close proximity to an environmental amenity, in some cases, might have low willingness to pay than rest of the individuals (far away individuals).

Table 5 Estimated mean willingness to pay (WTP) (CNY/year) in different ad hoc-based distance bands

	≤ 10 km	≤ 20 km	> 20 km
Variables	WTP (CNY/year)	WTP (CNY/year)	WTP (CNY/year)
Product	1.579	1.840	1.902
Quality	119.147	107.906	98.565
Oasis	0.036	0.088	0.540
Biodiversity	35.615	4.786	25.273
GHG	56.354	13.714	41.048
Landscape	30.534	12.056	10.329

Based on outcomes, some substantial policy recommendations developed regarding payment for the improvement of river ecological attributes. Payment for ecological attributes would specifically be acknowledged as a function of the area development strategy. It is essential to improve interaction and cooperation between the households of Heihe River basin and the regulatory bodies in order to narrow the gap between public preferences and plans for improvements of river environmental attributes. The assessed results of environmental attributes related to willingness to pay may serve as a crucial criterion and reference, when establishing policies about the restoration and management of ecological programs. The findings also suggest that substantial funding and investment in restoration and development initiatives be made in light of the household's positive willingness to pay for ecological attributes. Besides this, further attention and analysis are needed to take into account the beneficiaries of this certain territory to evaluate and widen the scope of the current investigation.

Conclusion

An effort was made in this study to examine the influence of distances on the sampled individuals' willingness to pay regarding restoration of degraded environmental attributes. For data collection, choice experiment approach was utilized in the study area (major cities and in the neighbourhood rural regions) to test the spatial heterogeneous preferences among the individuals of Heihe river. The significance of the selected environmental attributes is validated from the calculated outcomes, as the outcomes demonstrated that upgradations provide considerable benefit to the general population on average. In addition, based on the assessed outcomes, the sampled individuals from different localities of the Heihe river placed varying values on the restoration of environmental attributes, such that in order to get high utility, the preferences of the sampled individuals and their ranking for the selected attributes are quality of agriculture products, emission of greenhouse gases reduction, farmland landscape, and biodiversity, respectively. Moreover, with the distance of the sampled individuals from Heihe river and to assess the influence of these distances on their willingness to pay, three ad hoc distance bands were made from the corresponding data, whereas, random parameter logit model's outcomes indicated the significant influence of distances on willingness to pay of sampled individuals to upgrade the environmental attributes, such that the willingness to pay of those sampled individuals who are in proximity (≤ 10 km) to the Heihe river is more than rest of the individuals, i.e., individuals living in the range of ≤ 20 km and > 20 km.

Supplementary Information The online version contains supplementary material available at https://doi.org/10.1007/s11356-022-24299-5.

Author contribution **MASA:** conceptualization, data curation, investigation, modeling, formal analysis, writing original draft. **ZZ:** funding acquisition, project administration, and supervision. **SUK:** data curation, investigation, formal analysis, review, and editing. **AAK:** software and methodology, data curation, investigation. **MM:** data curation, investigation. **PR:** methodology, investigation. **YH:** data curation and methodology.

Funding This paper is supported by Key Research Project of the Ministry of Education's Philosophy and Social Sciences "Research on improving the market-oriented mechanism of technological innovation" (14JZD010), Major Project of Shandong Province's Key R & D Program in 2019 (Soft Science): "Research on the strategy of deepening scientific and technological cooperation and creating a new highland for opening-up" (2019RZB02013).

Data availability The datasets used and/or analysed during the current study are available from the corresponding author on reasonable request.

Declarations

Ethical approval This is an observational study, and we confirmed that no ethical approval is required.

Consent to participate Not applicable.

Consent for publication Not applicable.

Competing interests The authors declare no competing interests.

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