Journal of Cleaner Production 274 (2020) 123176

Contents lists available at ScienceDirect

Journal of Cleaner Production

journal homepage: www.elsevier.com/locate/jclepro

Improvisation of indigenous environmental benefit transfer and valuation for cleaner environment: Choice experiment across northwest China

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ARTICLE INFO

Article history:
Received 4 March 2020
Received in revised form
7 May 2020
Accepted 1 July 2020
Available online 17 July 2020

Handling editor. Prof. Jiri Jaromir Klemeš

Keywords:
Ecosystem services
Benefit transfer
Choice experiment
Random parameter logit
Transfer error
Wei river basin northwest-China

ABSTRACT

Valuation of environmental goods and services offers valuable information for environmental management, where there exists heterogeneity in household's taste and preferences. The current study evaluated the willingness to pay for ecosystem services with regard to assess benefit transfer among sub-basins of Wei River. In order to achieve an improved environmental status in Wei River basin, a choice experiment survey was conducted with the perception regarding valuation of ecosystem services in the upper, middle and lower basin. A total of 900 households sampled respondents were interviewed in the entire river basin. Seven ecological attributes were selected in an arrangement with improvements in ecological conditions in choice a set. Welfare estimates were measured through conditional logit (CL) and random parameter logit (RPL) models. Outcomes of our study validated the diversity in the public preferences regarding valuation of selected ecological attributes in all three basins. Like, water quality level was relatively highly valued (i.e. 109.3 Yuan) by those who live in lower basin followed by inhabitants of middle basin (81.57 Yuan). With the addition of heterogeneity in tastes and preferences, relatively lower transfer errors were estimated in RPL model as compared to CL model. While transferring benefits from lower to upper basin, the estimated transfer errors were 35.37% and 7.06% of transfer errors were estimated from upper to middle basin and 19.30% were estimated from middle to lower basin in RPL model. While for the same conditions, the estimated transfer errors in CL model were 44.49%, 9.49% and 29.37% respectively. In the light of current outcomes, there are sufficient evidences to claim for transferability of benefits between upper, middle and lower basins. The conclusive empirical outcomes of the current study thus help in proper management of ecosystem services and allow for benefit transfer from one basin to the other basins of Wei River.

1. Introduction

Current progresses in population, heterogeneity in public tastes and preferences, growing scarcity of natural resources, diminishing environmental conditions, and various other pressures argue that worldwide policy making personnel are facing complex challenges of management of deteriorated natural resources (Richardson et al., 2015). The degradation of ecosystem services has been converted to a global issue with the current economic growth and extreme human commotion, and China is not the only country suffering of severe ecological and environmental disasters (Shi et al., 2016).

Wetland ecosystem services offer food provisions i.e. rice, fresh water, fish and fiber as well as regulating services effect climatic changes, hydrological managements, decrease environmental pollution and disasters. The biodiversity and economic value of wetland ecosystem services be more important than many terrestrial ecosystems. For instance, inland wetlands had a total economic value nearly five times greater than tropical forests; the most valuable terrestrial habitat (Gardner et al., 2015). Whereas, most of human developments (e.g. from raw goods to food production) are

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https://doi.org/10.1016/j.jclepro.2020.123176
0959-6526/

supported by terrestrial ecosystems. Thirty percent of the global surface is made up of forests, which mainly contribute in the provision of oxygen, provide roof for numerous land species and constitute significant carbon stock (Gigliotti, 2018). Aquatic ecosystems are the essential elements of global environment. As critical contributors to biodiversity and ecological productivity, they also offer habitation for economically important fisheries, drinking water, irrigation and recreational sites. However, aquatic ecosystems are directly or indirectly, threatened gradually by social activities. Aquatic ecosystems are predicted to rapidly start suffering with additional pressure of global climate change in addition to the challenges set by land-use change, environmental contamination and water diversion (Poff and Brinson, 2002).

Various environmental problems have been arisen in Wei River basin with the current economic development that comprise; growing scarcity in water resources, water contamination, local ecological environment degradation mainly affected by the sedimentation in middle and down streams, which ultimately restrained the socio-economic development of the area (Millington et al., 2006). Valuation of environmental amenities is always important for policy makers, which face time and financial constraints. When monetary assets are scarce to measure environmental valuation, benefit transfer could be an alternate method for approximation of required environmental values at minimum cost. It can be ruminate as the second best approximation of the values that have been measured from a primary study while, such values has to pre-test before using them in a policy making decisions. The payments for environmental goods and services measured through benefit transfer as of one or many sites are used in forecasting the values of a similarly related goods and services at other site (Colombo et al., 2005). Benefit transfer is the only way to deliver practical economic information, for instance benefit cost estimation in the absence of primary studies, which could be costly or infeasible. The monetary assessment of numerous environmental amenities in policymaking process would be unrecognized in the absence of benefit transfer. Apart of its various uses, benefit transfer is virtually essential and could be argued nearly universal element of extensive benefit-cost analysis (Johnston and Wainger, 2015).

The current study employed spatial choice experiment procedure to calculate the monetary values of the degraded ecosystem services by testing the willingness to pay of the sampled respondents for the restoration of ecosystem services (Follain and Jimenez, 1985; Khan et al., 2019b; Nicosia et al., 2014). For this study, two statistical models that are frequently applied in choice modeling, i.e. Random parameter logit (RPL) and Conditional logit (CL) model were used. RPL model is established on limited explanatory variables consistent with random utility theory with the assurance of projected probability of selecting any alternative is between 0 and 100%. While, CL model assesses merely a set of coefficients taking the mean values of preferences of the levels of attributes (Ziegel and Eric, 1991). Whereas, linear probability models may yield probabilities of choice which are larger than 1 or smaller than 0 for certain levels of attributes combinations (Hauber et al., 2016). The RPL model also avoids the key limitations of multinomial logit model. Significantly, it accommodates unobserved heterogeneity in taste and preferences as well as repetitive choices and is not limited to the independence of irrelevant alternatives (IIA) property. Moreover, these models are flexible and practically computational that may estimate any random utility model (Mcfadden and Train, 2000).

With the perception of local residents, the benefits from ecosystem management in the Wei River basin has not yet been explored (Shi et al., 2016), hence the assessment of welfare estimates gained from improvements in ecosystem services of Wei River basin is necessary (Carpenter et al., 2009; Kumar et al., 2019). If the current degraded condition of ecosystem services will not be assessed, it could let the fiscal system to cause the over-exploitation of ecosystem services (Organization, 2005; Shi et al., 2016). Estimation of benefits can be helpful in cost-benefit analysis and can be beneficial for the governance projects in Weihe river basin.

Specifically, in the current study, we intended to assess the relations between people's preferences and attitude towards valuation of ecosystem services for their restoration. Moreover, we are also testing for transferring of values from upper to middle and lower basin, from middle to upper and lower basin, and from lower to upper and middle basin, which specified that benefit transfer could be considered as a consistent substitute for valuation of improvements in river quality and quantity, particularly under geospatial modifications (Andreopoulos and Damigos, 2017). In recent era, benefit transfer has however been applied repeatedly for the valuation of ecosystem services, but to best of our knowledge, only few researchers have applied primary collected data using choice experiment technique for benefit transfer from a study site to policy site, and its use in benefit transfer estimation is still very scarce (Colombo et al., 2005).

Most of the researchers (Desvousges et al., 1992; Muthke and Holm-Mueller, 2004b; Ready et al., 2004; Rozan, 2004; Shrestha and Loomis, 2003) used contingent valuation technique for benefit transfer. However Morrison et al. (2002) described that relatively choice experiment approach is more suitable for benefit transfer. Choice experiment has advantage because while transferring value estimates, it permits for heterogeneity in developments in environmental quality and socio-economics characteristics. Local inhabitants are provided with a plenty of benefits from river basin (Aregay et al., 2016), but to limit our research for ecosystem benefits, we sensibly select seven most important attributes which are supposed to have significant impacts on ecological and socio-economic improvements in the selected sampled areas. These attributes are forest cover ratio, water quality level, water quantity per capita, the mount of controlled soil and water erosion area, water loss and soil erosion intensity, natural landscape and visiting eco-tourism & parks respectively.

The monetary valuation and benefit transfer of ecosystem services in Wei River basin could provide significant estimates regarding improvements in the current degraded ecosystems and could be applied on other regional inland river ecosystem services with the aim of providing ecosystems benefit transfer values for regional transfer purposes. In broader sense, this study can be served as a reference for transferring benefits of ecosystem services from single sub-basin to the other sub-basins of the same river and could contribute within the broader environmental valuation literature. One of the aim of current study is also to enable broader dissemination of information regarding value transfer to both researchers and practitioners worldwide. Because many researchers (Muthke and Holm-Mueller, 2004a) use the existing valuation studies (specifically mean willingness to pay of the available studies) for national and international benefit transfer.

In the past, Tait et al. (2012) objectified residents' willingness to pay for river and stream conservation programs in Canterbury, New Zealand. Similarly, Khan et al. (2019b) reported that in Heihe River basin, people were more inclined towards spending on water quality improvements than recreational purposes. Based on these studies, it is evident that to efficiently identify the households' willingness to pay for ecosystem services and benefit transfer across sub-basins of Wei River, the results of current study could be of value and helpful in indicating public actions. Additionally, findings of such survey can help to: (1) develop strategic planning by the local governing bodies to improve the water quality level of this region based on their willingness to pay and preferences for other ecosystem services (2) induce environmental awareness and (3) indicate the level of satisfaction with the current conditions of ecosystem services.

The remaining of the article is arranged as, the next portion discusses methods and materials used in this study particularly the methodological approaches used for the welfare estimation, choice experiment approach, data collection and study area description, followed by results and their discussion. At the end, the conclusion derived on the bases of results and their policy recommendations are presented.

2. Methodology

2.1. Study area description

Wei River is the main and largest stream of the yellow river basin (Fig. 1), which originates from the Peak of Niaoshu Mountain located in Weiyuan county of Gansu region of China. The Wei River flows from west to east passing through Gansu, Ningxia and Shaanxi regions and at Tongguan county in Shaanxi region it connect with Yellow river. Wei River covers 135,000 Km^2 of area, out of which, 67,100 Km^2 is in Shaanxi region i.e. 49.7%. The length of Wei River is 818 Km and out of total length 502 Km (61.4%) is in Shaanxi region. In Shaanxi region self-generated annual average volume of water resources ranges to 6.9 billion m^3. It is considered as maternal river in Shaanxi region, which flows from west to east through the cities of Baoji, Yangling, Xianyang, Xian and Weinan. The Population in the river basin is about 22.04 million i.e. 61% of the total population in Shaanxi region with a cultivated land of 1.6 million hectares that is 56% of the total area of Shaanxi region and cover of 0.95 million hectares (72%) of the irrigated area. The significant importance of the basin for scientific research, educational base, local industries as well as national defense basis for the gross domestic product aggregates to about 134.5 billion Yuan. In fact, the Shaanxi region particularly the basin area contribute a vital strategic role in the China Western Development Program (Aregay and Minjuan, 2012; Li et al., 2013).

The development in socio-economic conditions of the inhabitants of Wei River basin, the entire basin still facing the problems of severe shortage of water quantity, sedimentation in lower basin river course and severe water pollution due to industrialization. The water available per capita per annum is just 317 m^3 i.e. only 13% of the national level. Due to shortage in quantity of water, there is gradual decline in the irrigation area, which has ultimate diverse impact on ecosystems. Soil erosion is getting worse after the completion of Sanmenxia reservoir and its unsuitable exploitation. Due to key challenges to flood control, the local ecosystems are seriously getting worse with the passage of time. 78% of the water in central watercourse of Wei River is categorized as beating grade V, which indicates that the water in current condition is nearly out of use and a severe challenge for contaminated and wastewater management (Aregay and Minjuan, 2012; Millington et al., 2006; Zhao et al., 2016).

2.2. Choice experiment

Ecosystem services can be categorized into four different types, habitat service, regulating service, information service, and production service (Assessment, 2005; Costanza et al., 1997; de Groot et al., 2000; Mace, 2008). The results of two pilot surveys, meetings with hydrological and ecological experts and local authorities and available literature review of the current conditions of ecosystem services enable us to select an aggregate of seven most important ecological attributes. Keeping in view four type of ecosystem services (Assessment, 2005), a choice experiment in the study area was sensibly planned by including appropriate ecological attributes. Amongst all, percentage of forest cover ratio falls under the category of habitat service, water quality level[1] and water quantity per capita were selected from the category of production services. While, soil and water erosion area and water & soil erosion intensity were selected from regulating services. Similarly, Natural landscape and percentage of visiting eco-tourism and parks were selected from the information services.

These particular attributes are presented in the first column of the choice set while the rows categorize their corresponding levels (see Table 1). The existing conditions of ecosystem services i.e. status quo is presented in the second column of the choice set with zero willingness to pay while the alternative policy programs illustrating the improvements in the ecosystem services with voluntary willingness to pay are presented in third and fourth column of the choice set. Alternative policy programs consist of different levels of ecological attributes that help in the assessment of utility parameters (Poder et al., 2016). The choice task allow every individual to select the most favored alternative that provides maximum utility.

In the current study, the respondents were specified to choose the options between two policy and a status quo program. The ecological attributes along with their diverse parallel levels are presented in Table 1. The existence of status quo (existing conditions) is essential due to the fact to retrieve from unbiased and unreliable welfare estimates in accordance to the demand theory (Khan et al., 2019c). The addition of status quo to the choice set approves the appropriate investigation of welfare estimates; however, the consistent selection of status quo will still allow for relative desirability of the ecological attributes. Which permits the respondents to choose the alternative restoration plans with improvements in current ecosystem services rather to choose status quo condition with an inspiration to do trade-offs and don't let the respondents to proceed with an casual choice (Brazell et al., 2006). The experimental designs were created by using Bayesian D-efficient approach with earlier indications concerning parameters (Yao et al., 2015). A total of 512 choice sets were designed which consists of a status quo and two alternative policy programs. After clearance for unpredictable choice sets, finally 450 choice sets were clustered into booklets, each having three choice tasks. Different questionnaire versions consist rotational order of ecological attributes. The ecological attributes and their corresponding levels were arranged as; the alternative policy programs were placed side to side in the choice set.

2.3. Sample description

The current segment determines the sampling procedure of the household's data collection concerning improvements of the ecosystem services of the Wei River basin. The selection of respondents was carried out in three phases. Initially, the whole Wei River basin was divided into three sub-basins i.e. upper, middle and lower basin, where ecological conditions are different from each other. In the next phase, 5 counties were selected randomly,

[1] The "Ministry of Water Resources of the People's Republic of China" with professional measuring tools measures the water quality levels. According to different test results, water quality is divided into different levels/grades as: grade-2, grade-3, grade-4 and grade-5. Where grade-2 indicates that the water is clean and could be used for drinking purposes after conventional purification treatment. Grade-3 represents that water quality applicable to centralized drinking water, general fish reserves and swimming areas. Grade-4 refers to industrial water and agricultural water, which is not suitable for drinking, swimming and fishing. Grade-5 water denotes that the water quality is seriously polluted and is not suitable for irrigation. http://www.mwr.gov.cn/.

Table 1
An example of choice set.

Attributes	Status quo	Policy 1	Policy 2
Forest cover ratio	30%	33%	35%
Water quality level	4.5	3.5	3
Water quantity per capita (proportions of the national average)	15%	17%	19%
The mount of controlled soil and water erosion area	80%	90%	88%
Water loss and soil erosion intensity	Moderate (=3)	Mild (=2)	Lighter (=1)
Natural landscape	20%	30%	25%
visiting eco-tourism & park	25%	25%	35%
WTP of household per year (Yuan)	0	100	150
Select most preferred choice	☐	☐	☐

representing each basin individually. In the third phase, respondents were categorized into urban and rural households. Baoji city and adjacent rural areas are located in the upper basin, Xianyang city, Xian city, adjacent rural areas in middle basin while Huayin city, Weinan city, and adjacent rural areas are located in lower basin of Wei River. The corresponding rural areas were selected to mirror the existing demographic characteristics of the selected cities. Additionally, for the selection of adjacent rural areas, an application of stratified random sampling technique was carried out. Subsequently, from each county 4–9 townships were selected randomly and 3 villages were selected from each randomly selected township. Following this procedure, 12–14 households were randomly selected by application of proportional allocation procedure from each village or community.

2.4. Data screening

With the conduction of follow up queries, the uncertain responses data with no willingness to pay were removed before evaluating the welfare estimation. Subsequently, 89 disputed samples (9.8%) were omitted from a total of 900 sample size and considering 811 samples accurate for the welfare estimation. The disputed responses, choice task simplifications and attribute non-attendance responses were omitted from the data. For recognizing the protest and choice-task simplification responses, the households were queried for ranking the environmental problems presented at the preliminary section of the survey design. The responses were reflected as protest responses if the respondent ranked the environmental issues with highest importance but still choosing the status-quo alternative in all three choice tasks. Whereas, attribute non-attendance is the condition when information on one or more than one attributes were ignored in the process of taking a choice decision (Lagarde, 2013).

Data screening is essential for many reasons; the foremost is that ignoring attribute leads that respondents have a non-compensatory attitude, if any of the attributes is ignored, improvement in that particular attribute will be unsuccessful to compensate respondents for a decrease in utility through another attribute level. Subsequently, there is a defilement of the continuity maxim, which indicates that preferences would not be signified by conventional utility functions (Lancsar and Louviere, 2006). The other reason for data screening is that the omitted respondents were not the representative of broader population that could result in over-estimation or biased coefficients and could lead to biased welfare estimates and policy outcomes (Lagarde, 2013).

A comparatively low share of genuine zero willingness to pay responses were confronted in upper, middle and lower basin (Khan et al., 2019b). Out of which 230 were interviewed from upper basin, 220 from middle basin, 361 from lower basin were interviewed. A CL and RPL models were then estimated with the help of Econometric software Stata 20.0. Ecological attributes were allocated with random normal distribution whereas; payment and status quo attributes were assigned a non-random distribution (Khan et al., 2019a).

2.5. Model specification

For the measurement of public attitude and preferences towards progresses in ecosystem services, a choice experiment technique is used. In this technique, respondents are presented with an imaginary choice task and let them match and choose among the relative payments for the improvements in ecological conditions (Greene and Hensher, 2007; Scarpa et al., 2007). Usually, the respondents select providing maximum utility alternatives in every choice set which can be describe in a function as;

$$MaxU\ (x_1,\ x_2,\ \ldots\ldots x_k) subject\ to\ P(x_1,\ x_2,\ \ldots\ldots x_k) + d = y \qquad (1)$$

The x_1, $i = 1 \ldots \ldots \ldots \ldots, k$ denotes the alternatives designated by the attributes that are chosen by the respondents based on their preferences. $P(x_1,\ x_2,\ \ldots\ldots x_k)$ indicates the payment incurred by the respondents for the betterments in ecosystem services with normal goods d that should not beyond the purchasing power of respondents (Ledoux and Turner, 2002). Utility maximization concept is associated with econometric model in the framework of random utility model (RUM). In RUM the utility obtained by respondent n from j alternative is given as;

$$U_{nj} = V_{nj} + \varepsilon_{nj} = \alpha_j ASC_j + \sum_k \beta_{nk}\, X_{njk} + \sum_k \gamma_{nk}\, X_{njk}\, C_n + \mu_{nj}\, ASC_{nj}\, C_n\, \varepsilon_{nj} \qquad (2)$$

where V_{nj} indicates the deterministic element of the utility and ε_{nj} denotes the latent elements. The coefficients of ASC_j i.e. α_j denotes the utility that capture the average effect of the components that are not taken into account (unobserved variables) in relation to the respondent's preferences for the selected ecosystem services improvements.

An assessment of the models with choice data observe the influence of selected ecosystem services X_{njk} on the specific alternative. β_{nk} are the coefficients that are understood contrarily in different econometric models, as in RPL model it demonstrates the aggregate taste of individual β_k and deviance from mean taste $stde_{nk}$, while in CL model it demonstrates taste of average respondent for X_{njk} ecosystem services.

Former modeling techniques treated parameters as fixed across observations (i.e. impact of individual independent variable remains constant for every observation), but unobserved variables may put forward that the estimated parameters may differ from one observation to the other. Therefore, the random parameters models account for the impacts of such unobserved heterogeneity. CL model perceives equal proportional substitutions between alternatives and suppose that the tastes and preferences of individual are dependent on visible features, whereas RPL model assume that unobserved variables may also effect the utility. Thus RPL models has an advantage over CL models in permission for substitution, heterogeneity in preferences, correlation among unobserved variables (Train, 2009). The RPL model also avoids the key limitations of multinomial logit model. Significantly, it accommodates unobserved heterogeneity in taste and preferences as well as repetitive choices and is not limited to the independence of irrelevant alternatives (IIA) property. Moreover, these models are flexible and practically computational that may estimate any random utility model (Mcfadden and Train, 2000).

2.5.1. Estimation of marginal willingness to pay in CL and RPL model

In addition to the random approach, heterogeneity could be consider systematically as the interactions of individual-explicit features C_n with ecological attributes X_{njk} or with alternative specific constant ASC_{nj}, γ_{nk} as well as μ_{nj} being related constants (Martin-Ortega et al., 2012).

The calculated β_s are applied to estimate marginal willingness to pay for each attribute. For CL model linear in utility the marginal willingness to pay can be estimated as;

$$MWTP_{k,CL} = -\beta_k/\beta_p \tag{3}$$

which describes the negative ratio of k i.e. coefficient of ecological attribute and p i.e. coefficient of monetary parameter with other factors keeping constant. For RPL model, marginal willingness to pay can be estimated as:

$$MWTP_{k,RPL} = -(\beta_k stde_k * rna_k)/\beta_p \tag{4}$$

where $stde_k$ demonstrates the estimated standard deviation of coefficient β_k whereas rna_k demonstrates draw from a random distribution (Da Costa and Hernandez, 2019; Hensher et al., 2005). While in estimation of benefit transfer for ecosystem services through sites and population by applying various data set either the equivalence of parameters in the utility function (β_k) or the related welfare measures ($MWTP_{k,model}$) can be tested.

2.5.2. Transfer error

The parameter equality test is linked with value function transfer but it does not comply with our study. However, different techniques can be used to investigate benefit transfer in a certain policy site, like meta-regression technique, benefit function transfer technique, transfers of unit value and many more (Jiang, 2017).

We estimated the equality of willingness to pay for different ecological attributes and scenarios (i) between different basins and their residents with the comparison of 95% confidence interval (CI) overlapping and measure the precision of value transfer (Brouwer and Bateman, 2005) by assessing the marginal willingness to pay for policy and study sites and by calculating the transfer error:

$$Transfer\ error_i(TE_i) = \frac{|WTP_s - WTP_p|}{WTP_p} * 100 \tag{5}$$

Study site is represented by S and P represents the policy site, the benefits are supposed to be transfer from S to P. The values of transfer errors can be influenced by the individual's random preference heterogeneity, accuracy, theoretical and non-theoretical (Brouwer et al., 2015; Khan et al., 2019b). Moreover, S may also describe the pooled model if they are used to be in transferability test.

3. Results and discussion

3.1. Socio-economic characteristics

Fig. 2 depicts the various socio-demographic properties of all sampled respondents in the upper, middle and lower basin of Wei River. Out of the total sampled respondents in the upper basin, 36.29% and 63.71% were female and male respectively, whereas, in middle and in lower basin, they were 53.18% and 46.82% and 36.95% and 62.04% respectively. While for education, the lowest level was considered junior school education and lowest number of sampled respondents in all three sub-basins had junior school education, i.e. 6.2% in upper basin, 10% in middle and 11.36% in lower basin. On the other hand, highest number of sampled respondents had primary-class education. For instance, 34.03% of the total respondents in upper, 33.64% in middle and 38.23% in lower basin had primary education. Finally, bachelor and above level was defined as highest level of education in the sampled respondents. The results from the socio-economic analysis described that relatively less number of sampled respondents in all three sub-basins of Wei River had bachelor and above level of education i.e. 14.71%, 14.55 and 16.07% in upper, middle and lower basin respectively.

Fig. 3 describes the age and living age of sampled respondents in the study area. The research experienced that the data collected through choice experiment from the sampled respondents had an average age between 21 and 60 years in all three sub-basins. While comparatively low number of sampled respondents had an average age 18–20 years and 60–80 years. Maximum of the sampled respondents had number of living or residency years between 21 and 40 years; for instance, 37.39% in upper, 39.09% in middle and 49.03% in lower basin had 21-40 living years. While lowest number of respondents had an average living years i.e. 61-80 years. The upper basin contributed 10.08% of the total sampled respondents in 61–80 years of living, which was 8.18% in middle and 7.48% in lower basin.

Fig. 4 portrays that household size of the respondents and their average annual income (in million Yuan). Due to one child policy in China, relatively large number of the sampled respondents had an average 3–4 household size. In upper basin 54.2% of the respondents, 54.55% in middle basin and 54.85% in lower basin had an average 3–4 household size followed by 5–6 number of households in a family. While lowest number of respondents had nine and above numbers of family members in all three sub-basins. The figures of average annual income of the sampled respondents declared that the range of the majority of sampled respondents lies under the average annual income 0–0.05 million Yuan, i.e. 63.87% in upper basin, 57.27% in middle basin and 63.99% in lower basin. While lowest number of sampled individuals had an average yearly income above 0.15 million Yuan for instance, 5.88% in upper basin, 6.38% in middle basin and 3.05% of the respondents in lower basin had an average annual income greater than 0.15 million Yuan.

3.2. Welfare estimation

Respondent choices were analyzed with the application of CL and RPL models. Both models were estimated individually for respective basin with the expectation of variations in the estimates of marginal willingness to pay because parameters and variances of both models vary between upper, middle and lower basin. The estimated models (i.e. CL and RPL) are described in Tables 2 and 3 respectively, and account for the panel structure of the collected data (each respondent were asked to choose among two alternative and a status-quo program), and latent and perceived preference heterogeneity. Latent heterogeneity is selected through the insertion of random factors in choice attributes and estimated models

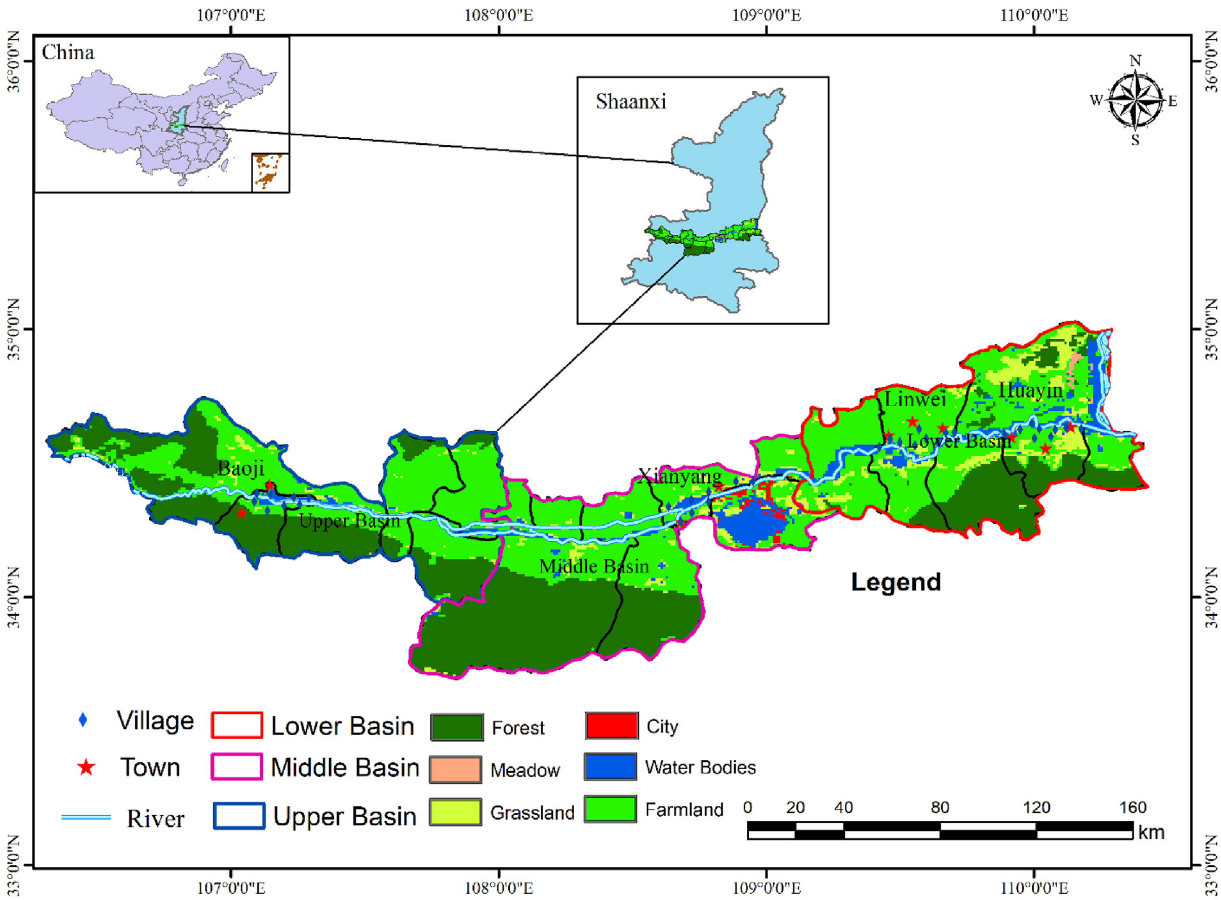

Fig. 1. Map of study area (Wei River basin) Arc GIS 10.3.

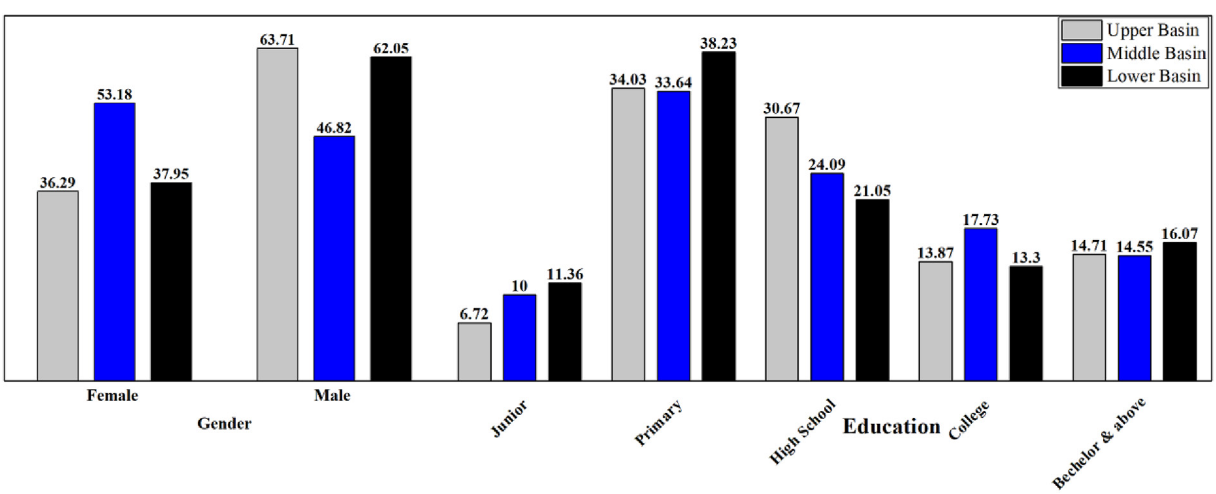

Fig. 2. Percentages share of Gender and education of the households in upper, middle and lower basin.

were assessed with a classification of 1000 Halton replications (Bhat, 2001).

The results presented in Table 2 demonstrate that all particular ecological attributes in upper, middle and lower basin have expected signs and statistically significant at different levels of significance (1%, 5% and 10%), as well as with a comparatively higher pseudo R^2 values for such type of cross-sectional data. The amount of water per capita in upper and lower basin while, water and soil erosion intensity in middle basin are however, non-significant. The ASC is related to the opt-out alternative in the estimated models and negative and significant coefficients in all three basins, though reveal strong preferences other than status quo for the restoration of ecosystem services (Brouwer et al., 2016). As expected, the highly significant and negative coefficients of payment (monetary attributes), denotes that respondents averse to increase in price and will be willing to pay comparatively lesser, agreed by King et al. (2016).

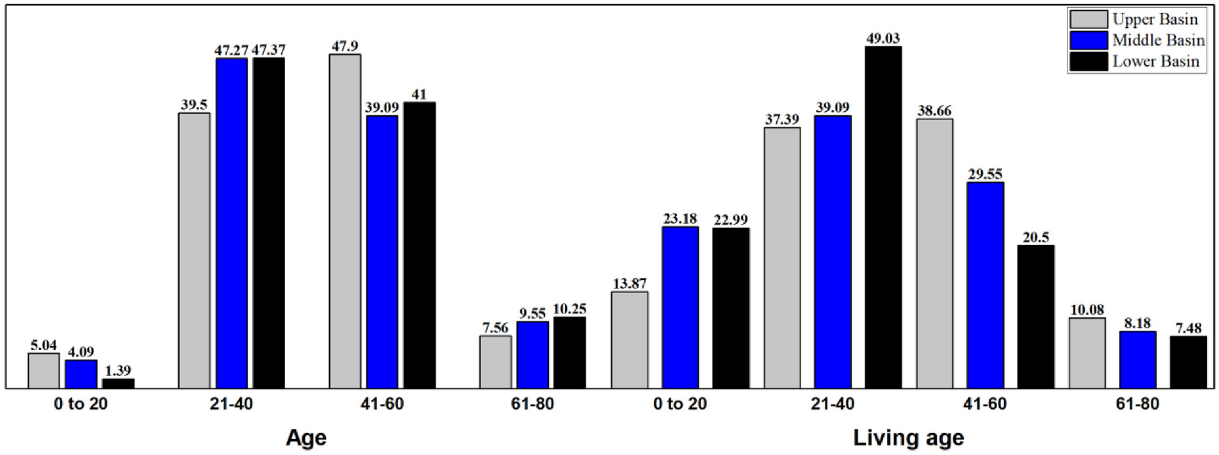

Fig. 3. Percentages share of Age and living age of the households in upper, middle and lower basin.

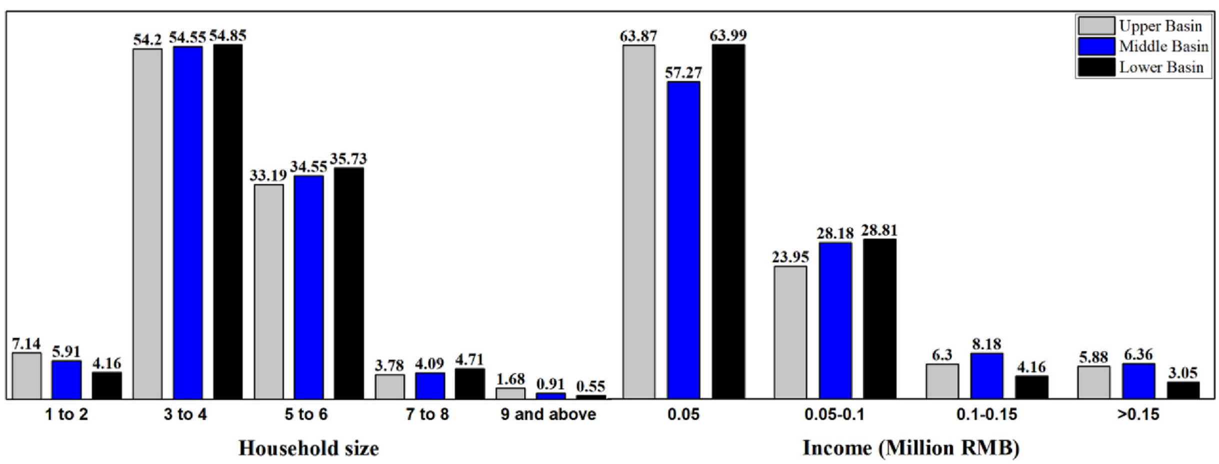

Fig. 4. Percentages share of household size and income (million RMB/Yuan) of the households in upper, middle and lower basin.

Table 2
Estimated results of ecological indicators (CL model).

Choice	Pooled data		Upper basin		Middle basin		Lower basin	
	Coef.	SE	Coef.	SE	Coef.	SE	Coef.	SE
Pay	−0.007***	0.001	−0.007***	0.002	−0.011***	0.002	−0.005***	0.001
ASC	−0.846***	0.208	−1.005**	0.418	−0.764**	0.399	−0.964***	0.305
Forest cover ratio	0.069***	0.016	0.069**	0.032	0.141***	0.033	0.052***	0.024
Water quality level	0.714***	0.097	0.619***	0.192	0.938***	0.186	0.669***	0.141
Water quantity per capita	0.064***	0.019	0.049	0.037	0.145***	0.039	0.037	0.028
Soil & water erosion area	0.027***	0.007	0.031**	0.014	0.044***	0.014	0.020**	0.010
Water loss & soil erosion intensity	0.155***	0.033	0.181***	0.065	0.080	0.065	0.184***	0.047
Natural landscape	0.021***	0.004	0.021***	0.009	0.032***	0.009	0.021***	0.007
Eco-tourism & parks	0.027***	0.006	0.030***	0.013	0.040***	0.013	0.027***	0.009
Summary statistics								
Number of Obs	7299		2070		1980		3249	
LR chi2(8)	110.58		54.36		64.67		56.93	
Prob > chi2	0.0000		0.0000		0.0000		0.0000	
Pseudo R2	0.0207		0.0359		0.0446		0.0239	
Log likelihood	−2617.6		−730.9		−692.7		−1161.3	

***, ** and * shows significance level at 1%, 5% and 10%.

The results in Table 3 demonstrate the outcomes obtained with the application of RPL model. The ecological attributes with expected signs and statistically significant coefficients argue that the respondents of the upper, middle and lower basin are willing to pay for the renovation of the river ecosystem services which corroborates to the findings of Bhat (2001). While coefficients of water and soil erosion intensity are however non-significant in middle basin. The coefficients of ASC in all basins are bound by significant preference heterogeneity as could be understood from the statistically significant standard deviations agreeing to previous

Table 3
Estimated results of ecological indicators (RPL model).

Choice	Pooled data		Upper basin		Middle basin		Lower basin	
	Coef.	SE	Coef.	SE	Coef.	SE	Coef.	SE
Mean								
Pay	−0.025***	0.002	−0.038***	0.010	−0.040***	0.008	−0.018***	0.003
ASC	−5.028***	0.644	−11.797***	3.433	−4.593***	1.592	−4.831***	1.033
Forest cover ratio	0.244***	0.046	0.478***	0.163	0.559***	0.143	0.136***	0.063
Water quality level	2.156***	0.291	2.684***	0.969	3.299***	0.789	2.003***	0.415
Water quantity per capita	0.317***	0.057	0.506**	0.218	0.550***	0.144	0.218**	0.076
Soil & water erosion area	0.115***	0.020	0.136***	0.052	0.165***	0.053	0.069***	0.028
Water loss & soil erosion intensity	0.595***	0.090	0.816**	0.333	0.334	0.211	0.659***	0.135
Natural landscape	0.088***	0.012	0.102**	0.051	0.149***	0.037	0.076***	0.017
Eco-tourism & parks	0.077***	0.019	0.138**	0.068	0.136***	0.046	0.085***	0.027
SD								
Forest cover ratio	0.550***	0.083	−0.675*	0.365	−0.528***	0.162	−0.533***	0.112
Water quality level	−3.258***	0.291	4.639***	1.053	−2.838***	0.559	3.020***	0.382
Water quantity per capita	0.557***	0.080	0.987***	0.219	0.929***	0.201	0.564***	0.101
Soil & water erosion area	0.208***	0.037	0.475***	0.169	0.426***	0.122	0.218***	0.049
Water loss & soil erosion intensity	−1.004***	0.179	1.581***	0.569	−1.448***	0.384	−0.838**	0.329
Natural landscape	0.100***	0.030	0.221***	0.068	0.035	0.047	0.095***	0.027
Eco-tourism & parks	0.232***	0.030	0.183**	0.089	0.196***	0.088	0.177***	0.049
Summary statistics								
Number of obs	7299		2070		1980		3249	
LR chi2(7)	826.51		293.98		232.02		309.83	
Log likelihood	−2204.3797		−583.876		−576.73		−1006.4	
Prob > chi2	0.0000		0.0000		0.0000		0.0000	

***, ** and * shows significance level at 1%, 5% and 10%.

reports (Khan et al., 2019b, 2019c; Martin-Ortega et al., 2012). Significant standard deviation values of mean also approves the presence of preference heterogeneity for all ecological random parameters in three basins. The negative and significant coefficient for payment (monetary attribute) in all three basin approve our expectations, i.e. as the price increases, the corresponding willingness to pay of the respondents will decrease. Similar findings were also reported by King et al. (2016). Payment has the predicted negative sign according to the economic theory, representing that higher prices reduces the utility as well as the possibility of alternative policy program selection (Guofang and Suzuki, 2008; Perni and Martínez-Paz, 2017).

3.3. *Willingness to pay estimation*

The assessment of ecosystem services is the foundation for policy makers in making decisions regarding environmental management. The consistency and validity of choice experiment approach for the evaluation of public goods and services by obtaining household's willingness to pay will be core issue for researchers (Deng et al., 2016). Since last few decades, the water sources and their services faced severe damage due to growing rate of urbanization and speedy economic development in China (Li et al., 2014).

The estimates of willingness to pay for ecosystem services are measured by the application of Krinsky-Robb (Krinsky and Robb, 1990) method with 1000 Halton replications. Figs. 5 and 6 display the mean willingness to pay while Figs. 7 and 8 display the upper and lower limits of 95% confidence interval (CI). Figs. 7 and 8 also display the overlapping of indicators at 95% CI, which indicates the heterogeneous willingness to pay for the restoration of ecosystem services. The willingness to pay for ecosystem services calculated from CL model demonstrates that the highest willingness to pay was detected for Water quality level in all basins as well as in pooled data. As the water flows from upper basin towards middle basin and then towards lower basin the corresponding willingness to pay increases for its better quality. For instance, in upper basin the estimated willingness to pay for Water quality level is 83.25 Yuan followed by 86.22 Yuan in middle basin and 140.6 Yuan in lower basin. The Water quality level at high altitude and piedmont areas observed to be good enough, however due to recent industrialization in China and rapid population growth caused the Water quality level to be declined (Ma et al., 2009; Mu et al., 2019). The study of Shang et al. (2012) and Zhang (2012) also argued that most attractive willingness to pay was noted for Water quality level in different river ecosystem valuation studies across China. After Water quality level, the most favored ecological attribute that was highly valued by the households of the study area was Water and Soil Erosion intensity. Willingness to pay for Water and Soil Erosion intensity in the lower basin was relatively higher followed by upper basin and then middle basin, and the corresponding willingness to pay amount was 38.75 Yuan, 24.41 Yuan and 7.33 Yuan respectively. Where Water quality level and Water and Soil Erosion intensity was highly valued by the inhabitants of the study area, similarly Natural landscape was the attribute that was poorly valued and the corresponding willingness to pay in all three basins was the lowest i.e. 2.80 Yuan in upper basin, 2.96 Yuan in middle basin and 4.31 Yuan in lower basin. Although the willingness to pay for Natural landscape was the lowest, but the significant coefficients for Natural landscape proves that as long as the other ecological attributes needs to be improved and restored, similarly Natural landscape is also be worthy to improve but households of the study area relatively pay lower amount for its restoration (Park and Song, 2018).

The estimated willingness to pay values from RPL model are displayed in Fig. 6. The estimates of willingness to pay calculated from RPL model are somehow different from that of calculated from CL model. The reason for this disparity in willingness to pay estimates is because of inclusion of preference heterogeneity into the RPL model (Logar and Brouwer, 2018). Likewise, the highest willingness to pay was estimated for Water quality level in all three basins, i.e. 71.43 Yuan in upper basin, 81.57 Yuan in middle basin and 109.3 Yuan in lower basin respectively. Similarly, 12.73 Yuan in upper basin, 13.82 Yuan in middle basin and 7.42 Yuan amount of willingness to pay in lower basin was estimated for forest cover ratio and these results are in line with the findings of Cao et al. (2020), Escobedo et al. (2011) and Nielsen et al. (2007). The

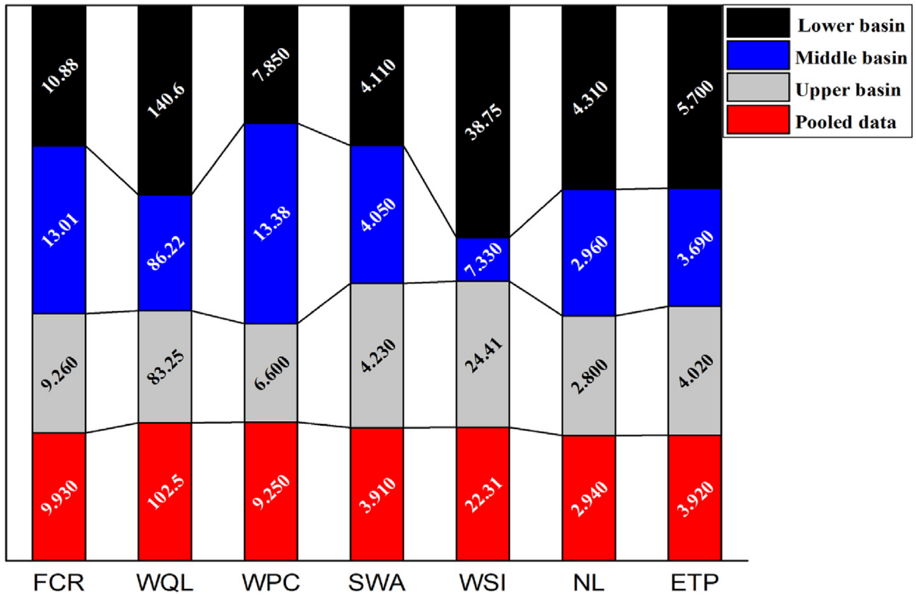

Fig. 5. Mean willingness to pay (CL model).

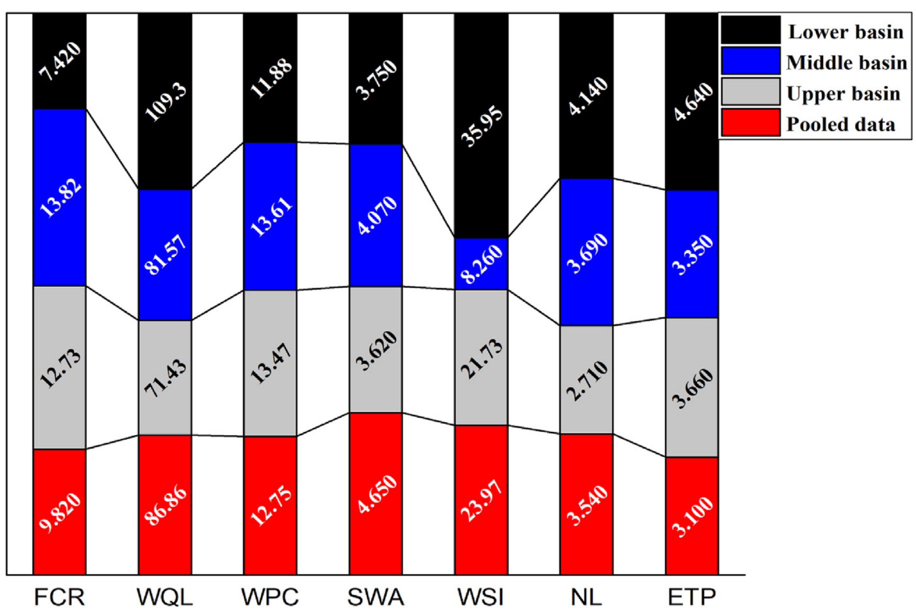

Fig. 6. Mean willingness to pay (RPL model).

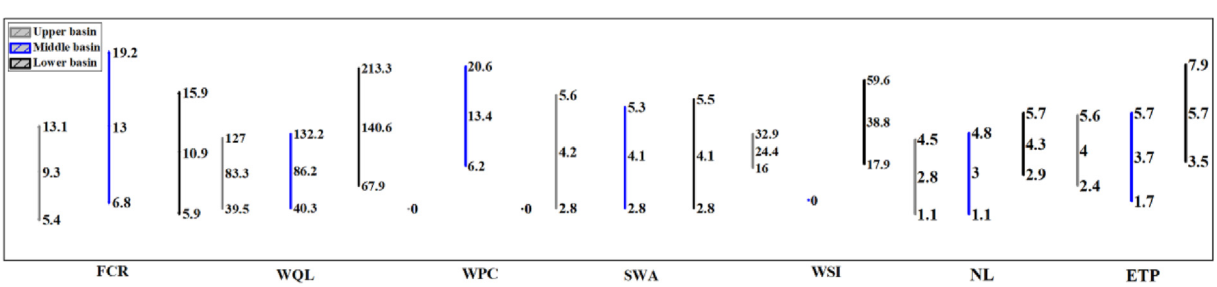

Fig. 7. Mean willingness to pay, upper and lower limit of 95% confidence interval (CL model).

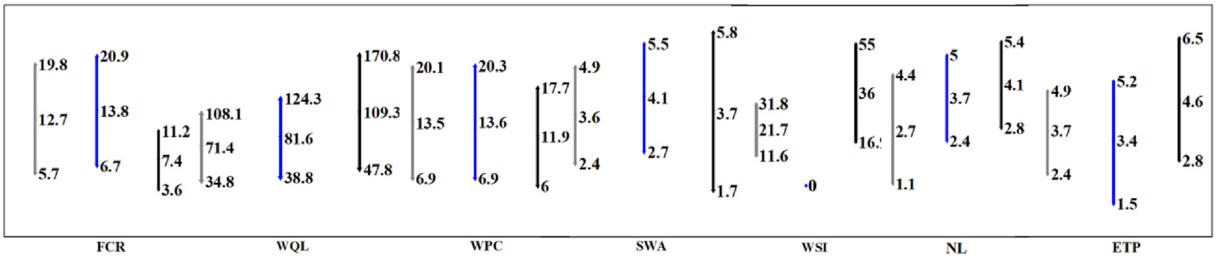

Fig. 8. Mean willingness to pay, upper and lower limit of 95% confidence interval (RPL model).
Note: The acronyms used in Figs. 5–8 are defined as: FCR indicates Forest cover ratio, WQL indicates Water quality level, WPC indicates Water quantity per capita, SWA indicates Soil & water erosion area, WSI indicates Water loss & soil erosion intensity, NL indicates Natural landscape and ETP indicates Eco-tourism & parks.

willingness to pay for amount of water per capita was estimated as 13.47 Yuan, 13.61 Yuan and 11.88 Yuan in upper, middle and lower basin respectively. Likewise, estimates of willingness to pay for Conditions for eco-tourism and parks was 3.66 Yuan, 3.35 Yuan and 4.64 Yuan in upper, middle and lower basin respectively. There was diversity in the household's taste and preferences in each basin, which caused heterogeneity in the willingness to pay for respective ecosystem services (Li et al., 2020). The approach and preference of households towards these specific attributes play a dynamic role in the validation of heterogeneity and fluctuation in their respective willingness to pay values (Doran et al., 2015). Our estimated results of willingness to pay are also justified by Wang et al. (2016), Colombo et al. (2007) and Zhou et al. (2015) in their studies.

3.4. Feasibility of transfer errors for benefit transfer across basins

The ultimate code for benefit transfer from one site to the other site (s) is the resemblance among the locations in the perspective of social characteristics, populations and policies (Newbold et al., 2018). For the purpose of resemblance in the localities, the scholars usually consider demographic characteristics of the residents, at the same time for transferring benefits the characteristics of bio-physical site are also necessary (MEa, 2005; Reid et al., 2005). Tables 4 and 5 display the resulting transfer errors. In the split-sample of three basins value transfer technique, the mean transfer error ranges from 9.49% to 44.49% in CL model (see Table 4), while in RPL model mean transfer error ranges from 7.06% to 35.37% (see Table 5). Usually benefit transfer are considered to be the transfers of mean values estimated through CL and RPL models. For instance, the outcomes in Table 4 demonstrates that mean transfer error estimated through CL model from middle to upper basin were 11.50% and 44.49% from lower to upper basin. Similarly, transfer errors from upper to middle basin were 9.49% and 34.81% from lower to middle basin. Estimated transfer errors from upper to lower basin were 29.16% and from middle to lower basin were 29.37%. The highest mean transfer error values (44.49%) were estimated from lower to upper basin and 34.81% of transfer errors were estimated from lower to middle basin. Whereas, the lowest mean transfer errors values i.e. 9.49% were assessed from upper to middle basin followed by 11.50% from middle to upper basin.

The results in Table 5 demonstrates the transfer errors calculated through RPL model. The results suggested that the mean transfer errors from middle to upper basin were 8.11% and from lower to upper basin were 35.37%. Similarly, from upper to middle basin the mean transfer errors were 7.06% and from lower to middle basin mean transfer errors were 17.58%. The estimated mean transfer errors from upper to lower basin and from middle to lower basin were 28.58% and 19.30% respectively. The highest value of mean transfer error were estimated from lower to upper basin i.e. 35.37% followed by 28.58% of transfer errors from upper to lower basin. While lowest values (7.06%) for transfer errors were assessed from upper to middle basin followed by 8.11% from middle to upper basin.

The assessment of transfer errors argued that the heterogeneity in mean transfer error values across basins are usually related to the differences in sites and corresponding residents of the area. It is apparent from the estimated results that the transfer errors estimates for particular attribute or group of attributes are comparatively lesser in RPL model to that of calculated through CL model. For example, the estimated transfer errors calculated through CL model for Forest cover ratio from middle to upper basin were 40.41% whereas for the same sites and attribute the mean transfer errors estimated through RPL model were 8.51%. Likewise, for Water quality level the estimated transfer errors were 68.91% in CL model while for the similar attribute and sites the estimated transfer errors were 52.97% in RPL model.

The transfer errors for a combination of Forest cover ratio (FCR) +Natural landscape (NL) from middle to upper basin were 32.36% in CL model, while for the same combination and site the estimated transfer errors calculated through RPL model were 13.40%. Similarly, transfer errors for combination of Water quality level (WQL) +Soil & water erosion area (SWA) from lower to upper basin were 65.44% estimated through CL model while they were 50.59% in RPL model for the identical combination and sites. The lesser mean transfer error in RPL model are because of reflection of spatial preference heterogeneity in RPL model (Martin-Ortega et al., 2012), since spatial preference heterogeneity is a significant element in benefit transfer assessment (Heiss, 2016; King et al., 2016). Which approves that consideration and addition of taste heterogeneity make transfer errors to be reduced (Brouwer and Bateman, 2005; Colombo et al., 2007; Martin-Ortega et al., 2012). The study of Brouwer et al. (2015) also established that the models (e.g. RPL models) that accounts for taste heterogeneity would result in reduced transfer errors.

The adequate range for accepting transfer errors values was discussed in earlier studies, for example in the study of Blamey et al. (2002) argued that the adequate and suitable range of transfer errors is 4%–191%. While Colombo and Hanley (2008) established the acceptable range of transfer error from 15% to 95%. Rozan (2004) and Hanley et al. (2007) found the mean transfer error values of 25% and 66% respectively in their studies. The estimates of transfer errors for wetlands assessed through met analysis were measured to be greater than 40% (Brouwer, 2009). Kristofersson and Navrud (2005) stated that the suitable range for accepting transfer errors regarding economic valuation of environmental quality assessment could be smaller than 20%. Kaul et al. (2013) and VandenBerg et al. (1995) found that the absolute benefit transfer errors extended between 0 and 172% and 1–239% respectively. Similarly, Colombo

Table 4
Estimated transfer errors of willingness to pay for attributes and scenarios and mean transfer error (CL model).

Attributes	To Upper basin		To Middle basin		To Lower basin	
	From Middle	From Lower	From Upper	From Lower	From Upper	From Middle
Forest cover ratio (FCR)	40.41%	17.47%	28.78%	16.34%	14.87%	19.53%
Water quality level (WQL)	3.56%	68.91%	3.44%	63.10%	40.80%	38.69%
Water quantity per capita (WPC)	NA	NA	NA	41.36%	NA	70.54%
Soil & water erosion area (SWA)	4.28%	2.83%	4.47%	1.51%	2.91%	1.49%
Water loss & soil erosion intensity (WSI)	NA	58.74%	NA	NA	37.00%	NA
Natural landscape (NL)	5.73%	53.87%	5.42%	45.53%	35.01%	31.28%
Eco-tourism & parks (ETP)	8.10%	41.76%	8.82%	54.26%	29.46%	35.17%
FCR + WQL	7.25%	63.76%	6.76%	52.69%	38.94%	34.51%
FCR + WPC	NA	NA	NA	29.03%	NA	40.90%
FCR + SWA	26.40%	11.10%	20.89%	12.10%	9.99%	13.77%
FCR + WSI	NA	47.39%	NA	NA	32.15%	NA
FCR + NL	32.36%	25.93%	24.45%	4.86%	20.59%	5.11%
FCR + ETP	25.73%	24.82%	20.46%	0.72%	19.88%	0.73%
WQL + WPC	NA	NA	NA	49.07%	NA	32.92%
WQL + SWA	3.18%	65.44%	3.08%	60.34%	39.56%	37.63%
WQL + WSI	NA	66.61%	NA	NA	39.98%	NA
WQL + NL	3.63%	68.42%	3.51%	62.52%	40.63%	38.47%
WQL + ETP	3.02%	67.66%	2.94%	62.74%	40.36%	38.55%
WPC + SWA	NA	NA	NA	31.40%	NA	45.77%
WPC + WSI	NA	NA	NA	NA	NA	NA
WPC + NL	NA	NA	NA	25.60%	NA	34.41%
WPC + ETP	NA	NA	NA	20.67%	NA	26.06%
SWA + WSI	NA	49.64%	NA	NA	33.17%	NA
SWA + NL	0.29%	19.76%	0.29%	20.11%	16.50%	16.74%
SWA + ETP	6.14%	18.89%	6.54%	26.67%	15.89%	21.06%
WSI + NL	NA	58.23%	NA	NA	36.80%	NA
WSI + ETP	NA	56.34%	NA	NA	36.03%	NA
NL + ETP	2.42%	46.73%	2.48%	50.37%	31.85%	33.50%
Mean Transfer error	11.50%	44.49%	9.49%	34.81%	29.16%	29.37%

Note: Where FCR indicates Forest cover ratio, WQL indicates Water quality level, WPC indicates Water quantity per capita, SWA indicates Soil & water erosion area, WSI indicates Water loss & soil erosion intensity, NL indicates Natural landscape and ETP indicates Eco-tourism & parks.

Table 5
Estimated transfer errors of willingness to pay for attributes and scenarios and mean transfer error (RPL model).

Attributes	To Upper basin		To Middle basin		To Lower basin	
	From Middle	From Lower	From Upper	From Lower	From Upper	From Middle
Forest cover ratio (FCR)	8.51%	41.75%	7.84%	46.32%	71.68%	86.28%
Water quality level (WQL)	14.18%	52.97%	12.42%	33.97%	34.63%	25.36%
Water quantity per capita (WPC)	1.01%	11.81%	1.00%	12.69%	13.39%	14.54%
Soil & water erosion area (SWA)	12.30%	3.47%	10.96%	7.87%	3.35%	8.54%
Water loss & soil erosion intensity (WSI)	NA	65.46%	NA	NA	39.56%	NA
Natural landscape (NL)	36.41%	53.03%	26.69%	12.19%	34.65%	10.86%
Eco-tourism & parks (ETP)	8.51%	26.70%	9.31%	38.50%	21.08%	27.80%
FCR + WQL	13.32%	38.64%	11.76%	22.34%	27.87%	18.26%
FCR + WPC	4.65%	26.36%	4.44%	29.63%	35.79%	42.11%
FCR + SWA	9.35%	31.74%	8.55%	37.57%	46.49%	60.18%
FCR + WSI	NA	25.85%	NA	NA	20.54%	NA
FCR + NL	13.40%	25.13%	11.82%	33.97%	33.56%	51.45%
FCR + ETP	4.70%	26.46%	4.49%	29.76%	35.97%	42.37%
WQL + WPC	12.09%	42.69%	10.79%	27.30%	29.92%	21.45%
WQL + SWA	14.09%	50.59%	12.35%	31.98%	33.59%	24.23%
WQL + WSI	NA	55.89%	NA	NA	35.85%	NA
WQL + NL	15.00%	52.98%	13.04%	33.03%	34.63%	24.83%
WQL + ETP	13.08%	51.69%	11.56%	34.15%	34.08%	25.46%
WPC + SWA	3.40%	8.57%	3.29%	11.58%	9.38%	13.10%
WPC + WSI	NA	35.89%	NA	NA	26.41%	NA
WPC + NL	6.93%	0.96%	6.48%	7.38%	0.97%	7.97%
WPC + ETP	1.03%	3.58%	1.04%	2.58%	3.71%	2.64%
SWA + WSI	NA	56.60%	NA	NA	36.14%	NA
SWA + NL	22.62%	24.67%	18.45%	1.68%	19.79%	1.65%
SWA + ETP	1.84%	15.15%	1.80%	13.08%	13.16%	11.56%
WSI + NL	NA	64.08%	NA	NA	39.05%	NA
WSI + ETP	NA	59.87%	NA	NA	37.45%	NA
NL + ETP	10.58%	37.90%	9.57%	24.70%	27.48%	19.81%
Mean Transfer error	8.11%	35.37%	7.06%	17.58%	28.58%	19.30%

Note: Where FCR indicates Forest cover ratio, WQL indicates Water quality level, WPC indicates Water quantity per capita, SWA indicates Soil & water erosion area, WSI indicates Water loss & soil erosion intensity, NL indicates Natural landscape and ETP indicates Eco-tourism & parks.

et al. (2007) in his study regarding valuation of soil erosion using choice experiment also found the mean transfer error values of 66%. Hence, it can be concluded that the acceptable range of transfer errors can be considerably different, depends significantly from policy to policy and study to study as well the techniques used for its measurement. Moreover, results of this study demonstrates that slightly reduced mean transfer errors were found in RPL model to that estimated through CL model and their ranges (i.e. 7.06–35.37% in RPL model and 9.49–44.49% in CL) varies accordingly.

The welfare estimates i.e. Mean, standard deviation and standard error for each basin with combinations of selected ecological attributes calculated from CL and RPL logit models are discussed in Table 6. Due to availability and consumption of ES at various spatial scales, the economic valuation of ecosystem services needs a careful measurement that can specify how inhabitants could be affected by specific course of services at numerous spatial scales (Escobedo et al., 2011; Turner et al., 2000). What is more essential for planning personnel and policy makers is that they should encourage the benefit transfer in inter-basin and reassure for accounting in income disparities while considering value transfers (Andreopoulos and Damigos, 2017).

4. Conclusion, limitations and recommendations

In the current study, we came up with conclusive empirical outcomes and achieved two main objectives. Primarily, the inhabitants of Wei River basin demonstrates rather a strong potential to pay for the restoration of river ecosystem services. Secondly, there exists the transfer of benefits within the different basins of Wei River. The welfare estimates in the context of environmental improvements were positive but different significantly throughout the upper, middle and lower basins. In terms of willingness to pay for restoration, there exist a significant spatial preference heterogeneity among households of the Wei River basin. The inhabitants cared more about improvements in the current water quality level and were willing to pay quite greater amounts for its improvement. For instance, 109.3 Yuan/annum was the mean willingness to pay for improvement in water quality level in lower, 81.57 Yuan/annum in middle and 71.43 Yuan/annum in upper basin. The sequence of ranking ecological attributes in terms of willingness to pay in upper basin was water quality level followed by Water and Soil Erosion intensity 21.73 Yuan/annum, amount of water per capita 13.47 Yuan/annum, and forest cover ratio (12.73 Yuan/annum). While in middle basin after improvements in water quality level, the ecological attributes in terms of willingness to pay were ranked as, Forest cover ratio (13.82 Yuan/annum), amount of water per capita (13.61 Yuan/annum) and Water and Soil Erosion intensity (8.26 Yuan/annum). Similarly, in lower basin following water quality level the maximum willingness to pay was estimated for Water and Soil Erosion intensity, i.e. 35.95 Yuan/annum followed by 11.88 Yuan/annum for amount of water per capita and 7.42 Yuan/annum for improvements in forest cover ratio. A significant but lowest valued ecological attribute was Natural landscape in all the three basins of Wei River. Based on spatially explicit choice experiment, there also exist heterogeneity in the estimated benefits in all three basins. Relatively reduced mean transfer errors were estimated in RPL model and varying between the ranges of 7.06%–35.07%, while in CL model the estimated mean transfer errors were within the limits of 9.49%–44.49%. Location specific characteristics i.e. greater the resemblance between study and policy site and consideration of taste heterogeneity in RPL model caused the smaller values of mean transfer errors. The RPL model has proved more favored model in the estimation of benefit transfer with the reason of concerning taste heterogeneity and ultimately produces reduced transfer errors. The results hence demonstrated the transfer of all scenarios among all three basins.

To the end, it is worth to note couple of limitations of the current study. The first limitation is that, as benefit transfer technique is susceptible to the error subsequent from deficiency of correspondence among study and policy sites. Since, it is based on the hypothesis of having similar socio-economic features of the beneficiaries, environmental quality and location, the absence of correspondence has a negative impact on the benefit transfer validity. Although, the current study mainly taken into account the

Table 6
Measurement of welfare estimates (CL and RPL).

Attributes	Conditional logit (CL) Model									Random Parameter Logit (RPL) Model								
	Upper basin			Middle basin			Lower basin			Upper basin			Middle basin			Lower basin		
	Mean	SD	SE	Mean	SD	SE	Mean	SD	SE	Mean	SD	SE	Mean	SD	SE	Mean	SD	SE
FCR + WQL	92.5	52.3	30.2	99.2	51.8	29.9	151.5	91.7	53.0	84.2	41.5	24.0	95.4	47.9	27.7	116.7	72.0	41.6
FCR + WPC	NA	NA	NA	26.4	42.2	24.3	18.7	75.8	43.8	26.2	33.7	19.4	27.4	39.2	22.6	19.3	57.6	33.2
FCR + SWA	13.5	44.2	25.5	17.1	38.3	22.1	15.0	66.6	38.4	16.4	31.1	17.9	17.9	35.8	20.7	11.2	50.9	29.4
FCR + WSI	33.7	36.3	21.0	NA	NA	NA	49.6	57.7	33.3	34.5	27.0	15.6	NA	NA	NA	43.4	44.1	25.5
FCR + NL	12.1	33.8	19.5	16.0	35.2	20.3	15.2	53.6	31.0	15.4	25.7	14.9	17.5	32.9	19.0	11.6	41.3	23.8
FCR + ETP	13.3	31.4	18.1	16.7	32.5	18.8	16.6	50.2	29.0	16.4	24.4	14.1	17.2	30.6	17.6	12.1	38.7	22.4
WQL + WPC	NA	NA	NA	99.6	51.5	29.7	148.5	93.9	54.2	84.9	41.0	23.7	95.2	48.1	27.7	121.2	68.9	39.8
WQL + SWA	87.5	55.9	32.3	90.3	45.0	26.0	144.7	77.8	44.9	75.1	36.6	21.2	85.6	42.3	24.4	113.0	58.7	33.9
WQL + WSI	107.7	41.1	23.7	NA	NA	NA	179.4	63.8	36.8	93.2	30.2	17.4	NA	NA	NA	145.2	48.0	27.7
WQL + NL	86.1	37.7	21.8	89.2	40.0	23.1	144.9	58.6	33.8	74.1	28.4	16.4	85.3	37.5	21.7	113.4	44.6	25.8
WQL + ETP	87.3	34.5	19.9	89.9	36.1	20.9	146.3	54.1	31.3	75.1	26.6	15.3	84.9	34.0	19.6	113.9	41.6	24.0
WPC + SWA	NA	NA	NA	17.4	6.6	3.8	12.0	2.6	1.5	17.1	7.0	4.0	17.7	6.8	3.9	15.6	5.8	3.3
WPC + WSI	NA	NA	NA	NA	NA	NA	46.6	19.0	11.0	35.2	9.1	5.2	NA	NA	NA	47.8	16.8	9.7
WPC + NL	NA	NA	NA	16.3	5.7	3.3	12.2	16.8	9.7	16.2	9.0	5.2	17.3	5.6	3.2	16.0	15.2	8.8
WPC + ETP	NA	NA	NA	17.1	4.9	2.8	13.5	15.0	8.6	17.1	8.4	4.8	17.0	5.0	2.9	16.5	13.8	8.0
SWA + WSI	28.7	14.3	8.2	NA	NA	NA	42.9	24.5	14.1	25.4	12.8	7.4	NA	NA	NA	39.7	22.8	13.2
SWA + NL	7.0	12.1	7.0	7.0	0.8	0.4	8.4	19.9	11.5	6.3	10.7	6.2	7.8	0.3	0.2	7.9	18.5	10.7
SWA + ETP	8.3	10.4	6.0	7.7	0.6	0.3	9.8	17.0	9.8	7.3	9.2	5.3	7.4	0.4	0.2	8.4	15.9	9.2
WSI + NL	27.2	15.3	8.8	NA	NA	NA	43.1	24.4	14.1	24.4	13.5	7.8	NA	NA	NA	40.1	22.5	13.0
WSI + ETP	28.4	12.1	7.0	NA	NA	NA	44.5	19.5	11.3	25.4	10.7	6.2	NA	NA	NA	40.6	18.2	10.5
NL + ETP	6.8	0.9	0.5	6.7	0.5	0.3	10.0	1.0	0.6	6.4	0.7	0.4	7.1	0.2	0.1	8.8	0.4	0.2

Note: Where FCR indicates Forest cover ratio, WQL indicates Water quality level, WPC indicates Water quantity per capita, SWA indicates Soil & water erosion area, WSI indicates Water loss & soil erosion intensity, NL indicates Natural landscape and ETP indicates Eco-tourism & parks.

economic aspect, while social, cultural, and natural science information are also compulsory in the environmental valuation studies. Consequently, potential contribution of low-income respondents may not be captured as current study applied monetary value for potential contribution. Hence, further research work is necessary for the valuation of ecosystem services in terms of labors as some of the respondents may not be willing to pay in monetary terms.

The recommendations based on the findings of the current study formulated with regard to payment for the restoration of river ecosystem services. Particularly, the payment for ecosystem services would be marked as portion of area development program. It is compulsory to expand communication between the administrative authorities and inhabitants of Wei River basin to alleviate the cavity between river restoration & development schemes and the public preferences. The estimated outcomes of attributes corresponding marginal willingness to pay could be consider as a significant indicator and reference while formulating resolutions regarding restoration and management of ecosystem programs. The outcomes also recommend that allocation of funds and investments in restoration programs would be substantial as derived from the household's significant willingness to pay for ecosystem services. The current study claims that benefit transfer of river ecosystem services could be considerately reflected as a substitute way to estimate non-market benefits. However, for future perspective further valuation analytical work in this regard is compulsory to enhance the precision of benefit transfer in Wei River basin.

CRediT authorship contribution statement

Sufyan Ullah Khan: Conceptualization, Data curation, Formal analysis, Investigation, Software, Methodology, Writing - original draft, Writing - review & editing. **Sikandar Hayat:** Writing - original draft, Writing - review & editing. **Xianli Xia:** Investigation, Software, Methodology. **Guobin Liu:** Data curation, Formal analysis, Funding acquisition, Project administration, Supervision, Writing - original draft, Writing - review & editing. **Minjuan Zhao:** Data curation, Formal analysis, Funding acquisition, Investigation, Software, Methodology, Project administration, Supervision.

Declaration of competing interest

I would like to declare on behalf of my co-author that the work described is original research that has not been published previously, and not under consideration for publication elsewhere, in whole or in part. I confirmed that no conflict of interest exists in the submission of this manuscript, and is approved by all authors for publication in your journal.

Acknowledgements

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

References

Andreopoulos, D., Damigos, D., 2017. To transfer or not to transfer? Evidence from validity and reliability tests for international transfers of non-market adaptation benefits in river basins. J. Environ. Manag. 185, 44–53.
Aregay, F.A., Minjuan, Z., 2012. Impact of irrigation on fertilizer use decision of farmers in China: a case study in Weihe River Basin. J. Sustain. Dev. 5, 74–82.
Aregay, F.A., Yao, L., Zhao, M., 2016. Spatial preference heterogeneity for integrated river basin management: the case of the Shiyang River Basin, China. Sustainability 8, 970.
Assessment, M.E., 2005. Ecosystems and human well-being: Synthesis. Millennium Ecosyst. Assess. 1–100.
Bhat, C.R., 2001. Quasi-random maximum simulated likelihood estimation of the mixed multinomial logit model. Transp. Res. Part B Methodol. 35, 677–693.
Blamey, R.K., Bennett, J.W., Louviere, J.J., Morrison, M.D., Rolfe, J.C., 2002. Attribute causality in environmental choice modelling. Environ. Resour. Econ. 23, 167–186.
Brazell, J.D., Diener, C.G., Karniouchina, E., Moore, W.L., Séverin, V., Uldry, P.-F., 2006. The no-choice option and dual response choice designs. Market. Lett. 17, 255–268.
Brouwer, R., 2009. Multi-attribute Choice Modelling of Australia's Rivers and Wetlands: a Meta-Analysis of Ten Years of Research, vol. 30. CSIRO Sustainable Ecosystems.
Brouwer, R., Bateman, I.J., 2005. Benefits transfer of willingness to pay estimates and functions for health-risk reductions: a cross-country study. J. Health Econ. 24, 591–611.
Brouwer, R., Bliem, M., Getzner, M., Kerekes, S., Milton, S., Palarie, T., et al., 2016. Valuation and transferability of the non-market benefits of river restoration in the Danube river basin using a choice experiment. Ecol. Eng. 87, 20–29.
Brouwer, R., Martin-Ortega, J., Dekker, T., Sardonini, L., Andreu, J., Kontogianni, A., et al., 2015. Improving value transfer through socio-economic adjustments in a multicountry choice experiment of water conservation alternatives. Aust. J. Agric. Resour. Econ. 59, 458–478.
Cao, S., Suo, X., Xia, C., 2020. Payoff from afforestation under the three-North shelter forest program. J. Clean. Prod., 120461
Carpenter, S.R., Mooney, H.A., Agard, J., Capistrano, D., DeFries, R.S., Díaz, S., et al., 2009. Science for managing ecosystem services: beyond the Millennium Ecosystem Assessment. Proc. Natl. Acad. Sci. Unit. States Am. 106, 1305–1312.
Colombo, S., Calatrava-Requena, J., Conzalex-Roa, M., 2005. Testing Choice Experiment for Benefit Transfer.
Colombo, S., Calatrava-Requena, J., Hanley, N., 2007. Testing choice experiment for benefit transfer with preference heterogeneity. Am. J. Agric. Econ. 89, 135–151.
Colombo, S., Hanley, N., 2008. How can we reduce the errors from benefits transfer? An investigation using the choice experiment method. Land Econ. 84, 128–147.
Costanza, R., d'Arge, R., De Groot, R., Farber, S., Grasso, M., Hannon, B., et al., 1997. The value of the world's ecosystem services and natural capital. Nature 387, 253–260.
Da Costa, P., Hernandez, D., 2019. The Economic Value of Ecosystem Conservation: A Discrete Choice Experiment at the Taravo River Basin in Corsica.
de Groot, R., van der Perk, J., Chiesura, A., Marguliew, S., 2000. Ecological Functions and Socioeconomic Values of Critical Natural Capital as a Measure for Ecological Integrity and Environmental Health. Implementing ecological integrity. Springer, pp. 191–214.
Deng, J., Sun, P., Zhao, F., Han, X., Yang, G., Feng, Y., 2016. Analysis of the ecological conservation behavior of farmers in payment for ecosystem service programs in eco-environmentally fragile areas using social psychology models. Sci. Total Environ. 550, 382–390.
Desvousges, W.H., Naughton, M.C., Parsons, G.R., 1992. Benefit transfer: conceptual problems in estimating water quality benefits using existing studies. Water Resour. Res. 28, 675–683.
Escobedo, F.J., Kroeger, T., Wagner, J.E., 2011. Urban forests and pollution mitigation: analyzing ecosystem services and disservices. Environ. Pollut. 159, 2078–2087.
Follain, J.R., Jimenez, E., 1985. Estimating the demand for housing characteristics: a survey and critique. Reg. Sci. Urban Econ. 15, 77–107.
Gardner, R.C., Barchiesi, S., Beltrame, C., Finlayson, C., Galewski, T., Harrison, I., et al., 2015. State of the world's wetlands and their services to people: a compilation of recent analyses. Soc. Sci. Electr. Publish.
Gigliotti, M., 2018. Reference Module in Earth Systems and Environmental Sciences || the Sustainable Development Goals.
Greene, W.H., Hensher, D.A., 2007. Heteroscedastic control for random coefficients and error components in mixed logit. Transport. Res. E Logist. Transport. Rev. 43, 610–623.
Guofang, Z., Suzuki, T., 2008. Public willingness to pay for environmental management, risk reduction and economic development: evidence from Tianjin, China. China Econ. Rev. 19, 551–566.
Hanley, N., Wright, R.E., Alvarez-Farizo, B., 2007. Estimating the Economic Value of Improvements in River Ecology Using Choice Experiments: an Application to the Water Framework Directive. Environmental value transfer: Issues and methods. Springer, pp. 111–130.
Hauber, A.B., González, J.M., Groothuis-Oudshoorn, C.G.M., Prior, T., Bridges, J.F.P., 2016. Statistical methods for the analysis of discrete choice experiments: a report of the ISPOR conjoint analysis good research practices task force. Value Health 19, 300–315.
Heiss, F., 2016. Discrete Choice Methods with Simulation. Taylor & Francis.
Hensher, D.A., Rose, J.M., Greene, W.H., 2005. Applied Choice Analysis: a Primer. Cambridge University Press.
Jiang, W., 2017. Ecosystem services research in China: a critical review. Ecosyst. Serv. 26, 10–16.
Johnston, R.J., Wainger, L.A., 2015. Benefit Transfer for Ecosystem Service Valuation: an Introduction to Theory and Methods. Springer Netherlands.
Kaul, S., Boyle, K.J., Kuminoff, N.V., Parmeter, C.F., Pope, J.C., 2013. What can we learn from benefit transfer errors? Evidence from 20 years of research on convergent validity. J. Environ. Econ. Manag. 66, 90–104.
Khan, S.U., Khan, I., Zhao, M., Chien, H., Lu, Q., Ali, M.A.S., et al., 2019a. Spatial heterogeneity of ecosystem services: a distance decay approach to quantify willingness to pay for improvements in Heihe River Basin ecosystems. Environ.

Sci. Pollut. Control Ser. 26, 25247–25261.
Khan, S.U., Khan, I., Zhao, M., Khan, A.A., Ali, M.A.S., 2019b. Valuation of ecosystem services using choice experiment with preference heterogeneity: a benefit transfer analysis across inland river basin. Sci. Total Environ. 679, 126–135.
Khan, S.U., Liu, G., Zhao, M., Chien, H., Lu, Q., Khan, A.A., et al., 2019c. Spatial prioritization of willingness to pay for ecosystem services. A novel notion of distance from origin's impression. Environ. Sci. Pollut. Control Ser. 1–13.
King, S., Fraser, I., O'Hanley, J.R., 2016. Benefits transfer and the aquatic environment: an investigation into the context of fish passage improvement. J. Environ. Manag. 183, 1079–1087.
Krinsky, I., Robb, A.L., 1990. On approximating the statistical properties of elasticities: a correction. Rev. Econ. Stat. 72, 189–190.
Kristofersson, D., Navrud, S., 2005. Validity tests of benefit transfer–are we performing the wrong tests? Environ. Resour. Econ. 30, 279–286.
Kumar, A., Yang, T., Sharma, M., 2019. Greenhouse gas measurement from Chinese freshwater bodies: a review. J. Clean. Prod. 233, 368–378.
Lagarde, M., 2013. Investigating attribute Non ‖ ttendance and its consequences in choice experiments with latent class models. Health Econ. 22, 554–567.
Lancsar, E., Louviere, J., 2006. Deleting 'irrational' responses from discrete choice experiments: a case of investigating or imposing preferences? Health Econ. 15, 797–811.
Ledoux, L., Turner, R., 2002. Valuing ocean and coastal resources: a review of practical examples and issues for further action. Ocean Coast Manag. 45, 583–616.
Li, J., Ren, L., Sun, M., 2020. Is there a spatial heterogeneous effect of willingness to pay for ecological consumption? An environmental cognitive perspective. J. Clean. Prod. 245, 118259.
Li, S., Zhang, Y., Zhang, Y., Zhang, L., Wang, L., 2014. Willingness to pay for the urban river ecosystem restoration in Hangzhou and Nanjing, China. World Rev. Sci. Technol. Sustain. Dev. 11, 14–25.
Li, S.Y., Tao, J.H., Yu, L., 2013. Study on water environmental integrated management modeling platform in Zhangweinan Basin, China. Adv. Mater. Res. 726, 3506–3512. Trans Tech Publ.
Logar, I., Brouwer, R., 2018. Substitution effects and spatial preference heterogeneity in single-and multiple-site choice experiments. Land Econ. 94, 302–322.
Ma, J., Ding, Z., Wei, G., Zhao, H., Huang, T., 2009. Sources of water pollution and evolution of water quality in the Wuwei basin of Shiyang river, Northwest China. J. Environ. Manag. 90, 1168–1177.
Mace, G.M., 2008. Millennium Ecosystem Assessment. John Wiley & Sons, Ltd.
Martin-Ortega, J., Brouwer, R., Ojea, E., Berbel, J., 2012. Benefit transfer and spatial heterogeneity of preferences for water quality improvements. J. Environ. Manag. 106, 22–29.
Mcfadden, D., Train, K., 2000. Mixed MNL Models for Discrete Response, vol. 15, pp. 447–470.
MEa, M.E.A., 2005. Ecosystems and Human Well-Being: Synthesis. Island, Washington, DC.
Millington, P., Olson, D., McMillan, S., 2006. An Introduction to Integrated River Basin Management. Integrated river basin management briefing note.
Morrison, M., Bennett, J., Blamey, R., Louviere, J., 2002. Choice modeling and tests of benefit transfer. Am. J. Agric. Econ. 84, 161–170.
Mu, L., Wang, C., Xue, B., Wang, H., Li, S., 2019. Assessing the impact of water price reform on farmers' willingness to pay for agricultural water in northwest China. J. Clean. Prod. 234, 1072–1081.
Muthke, T., Holm-Mueller, K., 2004a. National and international benefit transfer testing with a rigorous test procedure. Environ. Resour. Econ. 29, 323–336.
Muthke, T., Holm-Mueller, K., 2004b. National and international benefit transfer testing with a rigorous test procedure. Environ. Resour. Econ. 29, 323–336.
Nicosia, K., Daaram, S., Edelman, B., Gedrich, L., He, E., McNeilly, S., et al., 2014. Determining the willingness to pay for ecosystem service restoration in a degraded coastal watershed: a ninth grade investigation. Ecol. Econ. 104, 145–151.
Nielsen, A.B., Olsen, S.B., Lundhede, T., 2007. An economic valuation of the recreational benefits associated with nature-based forest management practices. Landsc. Urban Plann. 80, 63–71.
Organization, W.H., 2005. Ecosystems and Human Well-Being: Health Synthesis: a Report of the Millennium Ecosystem Assessment.
Park, C., Song, H., 2018. Visitors' perceived place value and the willingness to pay in an urban lake park. Int. J. Environ. Res. Publ. Health 15, 2518.
Perni, Á., Martínez-Paz, J.M., 2017. Measuring conflicts in the management of anthropized ecosystems: evidence from a choice experiment in a human-created Mediterranean wetland. J. Environ. Manag. 203, 40–50.
Poder, T.G., Dupras, J., Ndefo, F.F., He, J., 2016. The economic value of the greater Montreal blue network (Quebec, Canada): a contingent choice study using real projects to estimate non-market aquatic ecosystem services benefits. PloS One 11.
Poff, L.R., Brinson, M.M., 2002. Aquatic Ecosystems & Global Climate Change.
Ready, R., Navrud, S., Day, B., Dubourg, R., Machado, F., Mourato, S., et al., 2004. Benefit transfer in Europe: how reliable are transfers between countries? Environ. Resour. Econ. 29, 67–82.
Reid, W.V., Mooney, H.A., Cropper, A., Capistrano, D., Carpenter, S.R., Chopra, K., et al., 2005. Ecosystems and Human Well-Being-Synthesis: A Report of the Millennium Ecosystem Assessment. Island Press.
Richardson, L., Loomis, J., Kroeger, T., Casey, F., 2015. The role of benefit transfer in ecosystem service valuation. Ecol. Econ. 115, 51–58.
Rozan, A., 2004. Benefit transfer: a comparison of WTP for air quality between France and Germany. Environ. Resour. Econ. 29, 295–306.
Scarpa, R., Willis, K.G., Acutt, M., 2007. Valuing externalities from water supply: status quo, choice complexity and individual random effects in panel kernel logit analysis of choice experiments. J. Environ. Plann. Manag. 50, 449–466.
Shang, Z., Che, Y., Yang, K., Jiang, Y., 2012. Assessing local communities' willingness to pay for river network protection: a contingent valuation study of Shanghai, China. Int. J. Environ. Res. Publ. Health 9, 3866–3882.
Shi, H., Zhao, M., Aregay, F.A., Zhao, K., Jiang, Z., 2016. Residential environment induced preference heterogeneity for river ecosystem service improvements: a comparison between urban and rural households in the Wei River basin, China. Discrete Dynam Nat. Soc. 2016.
Shrestha, R.K., Loomis, J.B., 2003. Meta-analytic benefit transfer of outdoor recreation economic values: testing out-of-sample convergent validity. Environ. Resour. Econ. 25, 79–100.
Tait, P., Baskaran, R., Cullen, R., Bicknell, K., 2012. Nonmarket valuation of water quality: addressing spatially heterogeneous preferences using GIS and a random parameter logit model. Ecol. Econ. 75, 15–21.
Train, K.E., 2009. Discrete Choice Methods with Simulation. Cambridge university press.
Turner, R.K., Van Den Bergh, J.C., Söderqvist, T., Barendregt, A., Van Der Straaten, J., Maltby, E., et al., 2000. Ecological-economic analysis of wetlands: scientific integration for management and policy. Ecol. Econ. 35, 7–23.
VandenBerg, T.P., Poe, G.L., Powell, J.R., 1995. Assessing the Accuracy of Benefits Transfers: Evidence from a Multi-Site Contingent Valuation Study of Ground-water Quality. Working paper (USA).
Wang, J.-F., Zhang, T.-L., Fu, B.-J., 2016. A measure of spatial stratified heterogeneity. Ecol. Indicat. 67, 250–256.
Yao, R.T., Scarpa, R., Rose, J.M., Turner, J.A., 2015. Experimental design criteria and their behavioural efficiency: an evaluation in the field. Environ. Resour. Econ. 62, 433–455.
Zhang, X., 2012. Study on willingness to pay based on choice experiment method a case study of Xiangjiang river water pollution. Resour. Dev. Mark 28, 600–603.
Zhao, A., Zhu, X., Liu, X., Pan, Y., Zuo, D., 2016. Impacts of land use change and climate variability on green and blue water resources in the Weihe River Basin of northwest China. Catena 137, 318–327.
Zhou, Z., Huang, Y., Zhao, L., Jia, A., 2015. An analysis of the spatial heterogeneity of the functioning of ecosystem services related to land-and-water resources. Nat. Environ. Pollut. Technol. 14.
Ziegel, Eric R., 1991. Analysis of binary data. Technometrics 33, 242–243 second ed.