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Spatial Preference Heterogeneity for Integrated River Basin Management: The Case of the Shiyang River Basin, China

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Abstract: Integrated river basin management (IRBM) programs have been launched in most parts of China to ease escalating environmental degradation. Meanwhile, little is known about the benefits from and the support for these programs. This paper presents a case study of the preference heterogeneity for IRBM in the Shiyang River Basin, China, as measured by the Willingness to Pay (WTP), for a set of major restoration attributes. A discrete choice analysis of relevant restoration attributes was conducted. The results based on a sample of 1012 households in the whole basin show that, on average, there is significant support for integrated ecological restoration as indicated by significant WTP for all ecological attributes. However, residential location induced preference heterogeneities are prevalent. Generally, compared to upper-basin residents, middle sub-basin residents have lower mean WTP while lower sub-basin residents express higher mean WTP. The disparity in utility is partially explained by the difference in ecological and socio-economic status of the residents. In conclusion, estimating welfare benefit of IRBM projects based on sample responses from a specific sub-section of the basin only may either understate or overstate the welfare estimate.

Keywords: spatial preference heterogeneity; integrated river basin management; discrete choice experiment; willingness to pay; Shiyang River Basin

1. Introduction

Integrated river basin management (IRBM) is expected to play a major role in water and environmental management in many countries, notably developing countries [1,2]. Aimed at restoring ecological conditions at river basin level, it is applied to mitigate human pressures on natural ecosystems and to promote a healthy ecological environment [3–5]. Defined by the Global Water Partnership [1] as "the process of coordinating conservation, management and development of water, land and related resources across sectors within a given river basin in order to maximize the economic and social benefits derived from water resources in an equitable manner while preserving and/or restoring freshwater ecosystems", it is a holistic and unified approach [1]. Since sustainable IRBM necessitates vivacious support from all direct and indirect beneficiaries of the environmental goods and services in the basin [6–8], the strategy aims at balancing water resource exploitation, economic development, and protection of an aquatic environment through co-operation and co-ordination among all relevant sectors at various levels within the basin. However, there are usually distinct environmental and socioeconomic differences across up-stream, middle and down-stream agents in the river basin including natural resources endowments, industry structure, living habits and environmental conditions.

IRBM strategy usually involves policies and protocols with goals and directions set prior to the implementation stage [7]. Most of such strategies focus on mitigating existing problems. The entire population of the basin will be directly or indirectly affected by an intervention. Residential location relative to the improvement site will usually be a determinant of whether one will benefit more or less than others. Generally speaking, the agents in the center, or downstream of the ecological crisis will benefit to a greater extent from restoration than the upstream agents [9,10]. Hence, beneficiaries may have heterogeneous preferences that may or may not align with the objectives of IRBM. For example, Yu et al. [9] provides indirect evidence on this issue based into their research on the perceptions of the Shiyang River Basin residents with respect to the ongoing integrated water management process in their region. They found that the villagers' perspectives are non-uniform in that political trust, experience and expectations with respect to the outcomes of the ongoing projects significantly shape their perception.

River basin restoration valuation is not new [10–15]. However, most of the studies focus on a single or few river basin attributes with water quality improvement as a focal issue [14–18]. Some studies survey sub-basin or single watershed restoration and conservation [19,20]. However, river basin restoration valuation studies based on a limited set of ecological issues, or a sub-basin or single watershed, provide incomplete or inadequate information, especially in the context of IRBM [21,22], and will lead to bias in the WTP estimation [23]. Indeed, including the entire basin in a valuation study fosters public participation in the decision making process which in turn enhances the sustainability and accreditation of the program [24].

Literature on spatial preference heterogeneity have mixed findings [16,17,25–28]. These studies show that ignoring spatial factors may lead to overestimation, underestimation or insignificant welfare impact estimates. For example, Condon et al. [17] investigation of the influence of the local geography on the willingness to pay for land conservation programs in Florida, US, confirmed that residents' local landscapes matter and that ignoring it overstate the welfare impact estimate. On the other hand, Brouwer et al. [16] performed a choice experiment on the changes in water quality in a river basin taking into account the respondents' residential location, and concluded that not accounting for spatial preference heterogeneity resulted in underestimation of the welfare effect. No evidence of spatial preference heterogeneity was found in forest recreation in Abildtrup's study [28].

To the best of our knowledge, there is no previous research that estimated the welfare impacts of IRBM taking into account preference heterogeneity. This paper aims to fill this gap taking the Shiyang River Basin, China, as the case. As in most inland river basins in China, the livelihoods of the people living in different parts of the basin are different. The upper basin residents include an ethnic minority who make their living from animal husbandry and forestry. The middle basin is more economically developed while the lower basin is fertile agricultural land. Similar disparity exists in ecological status where the upper and middle basin residents experience better conditions (e.g., water quality and quantity, forest and grass cover) than the lower sub-basin residents [29,30]. Given this background, the present case study estimates the welfare impacts derived from different ecological attributes of integrated river basin management given the respondents' current local ecological and economic conditions. Furthermore, it assesses if spatial preference heterogeneity significantly affects the total welfare estimates. The results are policy relevant, particularly, in the context of cost–benefit assessment of the management strategy as well as of understanding the public's support for such policy.

The paper is organized as follows. The next section provides details on the study area and the sample. Section 3 presents the methodology, particularly the discrete choice experiment (DCE) design and econometric models. The results are discussed in Section 4 while Section 5 presents the conclusions.

2. Study Area and the Sample

2.1. The Shiyang River Basin

The Shiyang River Basin is an inland river basin located in the western part of Gansu, with typical arid to semi-arid climate. It originates from the Qilian Mountains, and flows about 300 km to the Northeast (Figure 1). Its catchment area covers about 41,600 km^2. The Shiyang River Basin is chosen as a study area because of its critical ecological situation, the familiarity of the people with IRBM and the feasibility to reach the entire basin population for the survey. It has a total population of 2.27 million of which 1.34 million is rural. The basin is the most populated and most developed region in the province and has the highest level of water use [31]. The total renewable water resource of 1.66 billion m^3 is mostly generated from precipitation and snow melt of the mountain ranges surrounding it [32]. On average, agriculture consumes 70% of the water resources, households, industry and ecological functions about 13% while loss due to evaporation accounts for about 17% [30].

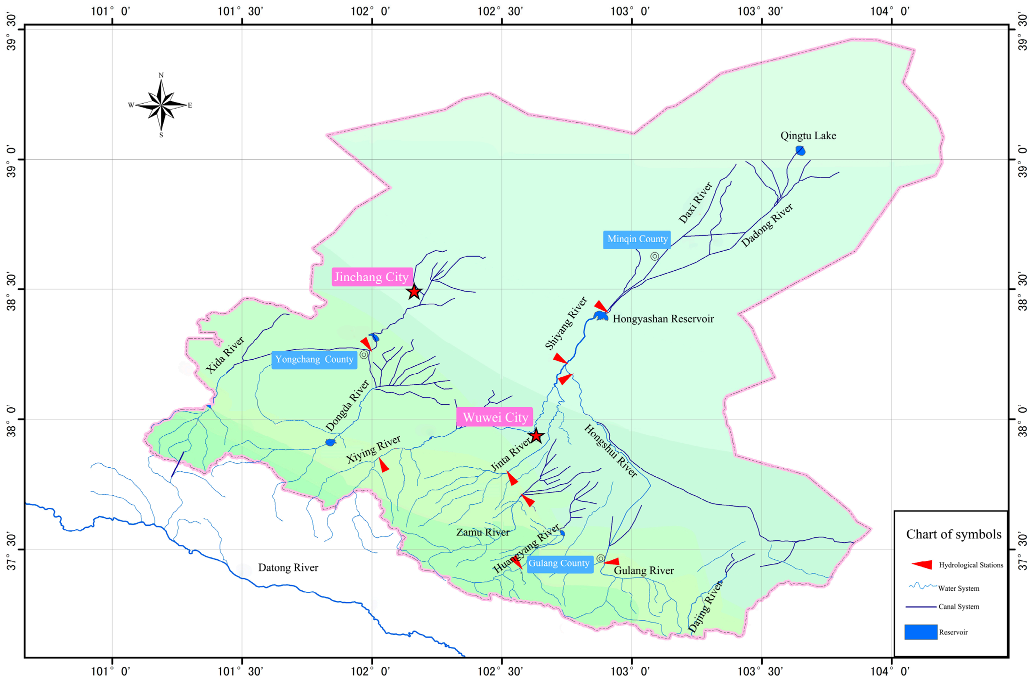

Figure 1. The Shiyang River Basin, Gansu Province.

Currently, the region is under critical ecological conditions because of excessive water demand due to rapid population growth and economic development. Consequently, some of the tributaries have dried up which has shortened the river's estuary and degraded the ecological environment. The SRB is one of the most overexploited and ecologically degraded inland river basins in northwest China. Water shortage is not the only critical ecological issue; others include deforestation and escalated desertification which are related to water shortage [33].

The escalating ecological crisis is worsening due to the existing unfair water distribution between the upper, middle and lower basins [32], upstream household and industrial sewage discharge and non-point source pollution [30], and over-exploitation of surface and ground water. Water allocation, particularly in the lower sub-basin is skewed where agricultural, domestic and industrial water use accounts for 97.85%, 1.26% and 0.88% of total water use, respectively, leaving virtually nothing to ecological functions.

To ease water shortage and address ecological deterioration in the basin, the local and regional water resources bureaus and the provincial government have recently proposed several IRBM restoration projects [9,31,34]. Planned investment in ecological restoration amounts to over 4.749 billion RMB in the period 2006–2020 [35]. Given the above background and interdependent ecological and socio-economic functions, the Shiyang River Basin constitutes an adequate case for economic valuation of IRBM.

2.2. The Sample

To evaluate the ongoing Shiyang River Basin IRBM, a survey was held among a sample of the population of the entire basin with sub-samples from all the major cities and counties within each sub-basin. Sample selection involved five stages. First, three integral parts of the basin were identified as upper, middle and lower sub-basin based on the existing administrative division. Second, within each sub-basin, counties were selected based on maximum geographical spread. From the upper sub-basin (USB), including the southern and southeastern mountainous regions, Gulang City, which is the only county in the sub-basin, was selected. Wuwei and Jinchang (part of Yong Chang County) were selected in the middle sub-basin. In the lower basin, the main county of Minqin was selected. Third, reference cities, including their rural surroundings, were selected such that typical ecological and economic characteristics were represented. Next, stratified random sampling of townships and villages was applied following the equal-distance principle from the pre-selected urban center. Three to seven townships per county were selected followed by one to seven villages per township. Finally, 9–29 households were randomly selected from the selected villages proportional to the population size of the village.

The sample consisted of 1012 households. There were 142 incomplete questionnaires (14% of the total distributed). There was no evidence of systematic drop out. In addition, there were 107 protest responses by respondents who stated that they were not willing to pay for improvement because they considered themselves not responsible for the environmental degradation or not guilt of carelessness (for further details, see Section 4.1). The total number of questionnaires available for analysis was 763.

Interviews were face-to-face because of the complexity of the questionnaire was complicated and. This method was applied because the sample included rural, less educated people who could fail to understand the questionnaire. Interviewers could assist them by giving clarifications and thus reduced the cognitive problems. Interviews were mostly held at the respondents' homes, during July and August 2012. The survey was carried out by trained graduate students who received a week-long training before going out for the data collection. The interviewee was the head of household while open discussion among the household members were common. If the head of the household (husband) was absent, the wife was interviewed; if both husband and wife were absent because of employment outside the home village, the elder child of 18 years or older, or if, present, the grandparents were interviewed.

The means of the socio-economic characteristics in Table 1 are in line with the means reported in other studies (e.g., [36]). We conducted equality test between the means of the socio-economic variables using [37] method in the three sub-basins and found insignificant differences only. Therefore, only the descriptive statistics of the pooled samples are reported in Table 1. The sub-basin descriptive statistics are given in the Appendix A, Table A1.

Table 1. Descriptive statistics of the pooled sample.

Variables	Min	Max	Mean	St.dev
Sex (male = 1)	0	1	0.65	0.48
Age	24	81	41.7	11.86
Family size	1	9	3.94	1.3
Dependent child or elderly (yes = 1; no = 0)	0	1	0.85	0.35
Have cadre family member (yes = 1; no = 0)	0	1	0.26	0.33

Table 1. *Cont.*

Variables		Min		Max	Mean	St.dev	
Education Level	%	Head of Household Occupation	%	Household Gross Income (in Yuan per Year)	%	Farm Size (Mean = 14.9 mu)	%
Elementary school	14.91	farmer	52.2	≤10,000	6.65	Large (40–200 mu)	7.4
Junior school	30.28	officer	6.54	10,000–30,000	27.18	Medium (39–15 mu)	27.2
High school or college	20.99	organ or unit	28.1	30,000–50,000	28.67	Small (14.9–0.5 mu)	65.4
Bachelor degree	14.11	businessman	2.52	50,000–70,000	19.84		
above Bachelor	19.72	student	0.11	70,000–90,000	10.55		
		no occupation	4.59	90,000–110,000	4.70		
		other	5.96	>110,000	2.41		

Notes: Other occupations include retired, freelance, driver, cleaner, salesman, and security agents; 15 mu = 1 hectare; Cadre (as indicator of social or political influence): 1 if any family member works as village official as an indicator of their social and political influence, 0 otherwise.

3. Methodology

3.1. Choice Experiment

Environmental and ecological valuation measure the social value of environmental goods and services [38]. The techniques basically involve computing individuals' willingness to pay (WTP) for environmental attributes based on revealed and/or stated preference data [39–41]. In river basin ecological restoration, but also in other areas, discrete choice experiments (DCE) are increasingly being applied.

DCE comes down to the choice (choice task) of a preferred combination of multiple attributes of the environmental good and their levels and implied costs ((choice) alternative) out of a choice set usually made up of three choice alternatives. The respondent is usually invited to perform multiple choice tasks (see below for further details). DEC is considered more informative, reliable and cost effective than open ended and dichotomous elicitation techniques [42,43]. It has also been found to decrease the tendency of strategic bias and protest responses since it limits the respondents' choices from the entire choice set [42].

The environmental and ecological attributes of the hypothetical IRBM in this case study were identified based on a comprehensive literature review of the ecological conditions in the area, discussion with scientists and researchers at universities, administrative bodies and local residents. The Shiyang River Basin ecological crisis is complex. Competing demands for the scarce water resources and free rider behavior (e.g., excessive extraction of water and discharging untreated industrial waste water in the river in the middle basin) are currently pressing issues in the basin, as in most Northwest China basins. Water reservoirs are built at each catchment of the eight river tributaries of the Shiyang River in the upper basin, which limits water flows to the downstream sections of the basin. Water extraction and wastewater discharges in the middle section are endangering water quantity and quality in the lower sub-basin. The limited water resources in the lower basin are virtually all allocated to households and economic activities leaving no water for ecological functions, which leads to ecological degradation, in particular desertification and sandstorms, both within and beyond the sub-basin. To mitigate the crisis, integrated water resources management programs have been running in the Basin, though expectations of benefits from them and support for them among the local residents are still low [9]. The core objective of the programs is to find a sustainable solution to the overwhelming ecological crisis, which is encroaching from the lower basin to the middle and upper sub-basins. Restoring the natural environment in the lower basin requires restoring the vegetation cover, which in turn requires sufficient water inflow from the upper and middle sub-basins.

The hypothetical IRBM program in this choice experiment survey focuses on the above issues and the solutions suggested by the different administrative and advisory bodies. Water quality, water quantity and xerophytes plantations were identified as important restoration attributes in the lower basin. Improving these attributes is generally expected to play a role in mitigating desertification and sandstorms. Availability and quality of water allow the rehabilitation of the lower basin ecosystem and lessen the adverse desertification. In turn, a stable ecosystem in the lower basin prevents the expansion of desertification and decreases sandstorm frequencies in the entire basin. Increasing grass cover and forest cover, which are crucial for water purification, erosion control and habitat functioning in and beyond their sites, have been attributes to be restored in the middle and upper basins, respectively. Landscape and tourism amenities improvement and sandstorm reduction in the entire basin have been additional restoration attributes. The restoration attributes, their functions and levels including the status quo level are presented in Table 2.

Table 2. The Shiyang River Basin restoration attributes, their functions, and levels.

Attributes	Functions	Intended Restoration	Level
Landscape (%)	Enjoy the scenery	The watershed's natural landscape in the whole basin	10; 15; 20; 25; 30
Tourist amenity (%)	Leisure and recreation	The wetland and forest park tourism conditions in the whole basin	30; 35; 40; 45; 50
Sandstorm reduction (days)	Prevent weathering and erosion	Dust or sandstorm frequency (number of days with sandstorm per year in whole basin)	139; 55; 40; 35; 20
Forest (%)	Habitat, water quality purification, erosion control	Forest coverage in the upper sub-basin	46.30; 50; 57; 63; 67
Grassland (%)	Water purification and erosion control	Grass coverage in middle sub-basin	55; 60; 70; 75
Xerophytes (ten thousand mu)	Increase vegetation cover to prevent erosion and sandstorm	Suitable area for xerophytes, e.g., *angustifolia*, *Populus*, etc. in LSB	0; 7.5; 10.5; 12
Water quantity (100 million m^3)	Agricultural, industrial and habitat water supply	Annual inflow into the Hongyashan reservoir in the lower sub-basin	2.5; 2.6; 2.7; 2.8
Water quality (grade)	Improve water quality for domestic, agriculture, industry and habitat for flora and fauna	Water quality of Hongyashan reservoir and underground water in the lower sub-basin	V; IV; III; II
Cost/household/year (Yuan)	Annual cost per household	The annual cost that a household pays for restoration	0; 50; 100; 150; 200; 250; 300; 350; 400; 450; 500

Notes: 1. "Level" in column 4 indicates the percentage, number, grade, cost or volume of improvement. The numbers in bold in column 4 indicate the status-quo levels; 2. Water quality levels: II—clean can be used for drinking with conventional purification; III—suitable for fishing and swimming; requires advanced purification for drinking; IV—suitable for industrial and agricultural uses, but not for drinking, swimming, fishery; V—is not suitable for any use without purification.

The ecological conditions of the Shiyang River Basin and the complexity of the restoration attributes, in particular their meanings; functioning and importance were explained in detail in the first part of the questionnaire. The respondents' opinions on the existing environmental conditions and the water resources issues were also assessed in that part. The second, core, part of the questionnaire was the choice section where interviewees were to choose their preferred alternative from a choice set of three alternatives. Brief descriptions of the restoration attributes together with explanatory footnotes were included in the choice set (see first column of Table 3 for an example). The complicated choice tasks were put in the second part to reduce misreporting or careless responses due to weariness. Questions about socio-economic characteristics, which were easier (less likely to miss the answer), were put in the last section.

For the nine attributes in Table 2 with levels ranging from 4 (water quality) to 10 (cost), there were far too many alternatives for the respondents to evaluate. We applied the experimental design approach in Sándor and Wedel [44] to reduce the number of alternatives. The D-optimality criterion [45] was used for this purpose which resulted in 128 unique choice sets (combinations of three alternatives). Unrealistic alternatives (e.g., unrealistically low costs for ambitious restoration alternatives) were eliminated from the 128 choice sets, which resulted in 32 choice sets. The choice sets were divided over 60 different questionnaires (booklets) versions with three different choice sets in each booklet. The 60 different booklets gave approximately 12 respondents per booklet, which gave sufficient numbers of observations per choice set [46].

A typical example of a choice set is given in Table 3. Alternatives are presented side-by-side. Respondents were asked to elicit their choice between three alternatives (one status quo and two policy alternatives) in each choice set (choice task). The first column of the choice set presents the restoration attributes; the corresponding rows show the attribute levels. The second column is the status quo, which refers to the future (10 years later) condition of the basin, if no restoration policy is implemented. The third and the fourth columns are the policy alternatives, which depict improved ecological conditions but are associated with annual household charges. The alternatives differ in terms attribute levels which enables estimation of the parameters of the utility function [47]. Each person faced three choice tasks consisting of selecting the preferred alternative from each of the three choice sets presented.

Table 3. Example of a choice set for the Shiyang River Basin restoration plan.

Attributes	Status Quo	Alternative 1	Alternative 2
Natural landscape in the basin	10%	10%	30%
Eco-tourism and forest parks in the basin	30%	45%	40%
Sandstorm frequency (per year) in the basin	139 sandstorm days	40 sandstorm days	55 sandstorm days
Upper sub-basin forest coverage	46.3%	50%	63%
Mid sub-basin grass coverage	55%	60%	55%
Xerophytes (angustifolia, Populus, etc.) area in in low sub-basin	0 mu	0 mu	93 thousands mu
Average annual water inflow to Hongyashan Reservoir (Cai Qi area) in low sub-basin	250 million m^3	260 million m^3	250 million m^3
Low sub-basin water quality (Hongyashan reservoirs, and underground water quality)	Cannot be used for irrigation and is non-drinkable (level V)	Fit for irrigation, but non-drinking (level IV)	Fit for irrigation, and is potable (level II)
Household payment (Yuan per year)	0	50	350
Please check the box corresponding to your choice	☐	☐	☐

The preliminary questionnaire was tested in a pilot interview with 80 local representatives with different occupations. Important modifications were rewording the attributes and adding description for each attribute, as given in Table 2. Each household was to evaluate three choice sets. About four respondents in each sub-basin faced the same questionnaire and choice tasks giving a total of approximately 12 for the entire sample.

3.2. Econometric Analysis

DCE is based on the random utility theory (RUT) and is consistent with choice behavior theory [47]. It decomposes the determinants of the latent utility that a respondent assigns to the choice alternative into a deterministic component and a stochastic error component. That is, in utility framework individual i's (i = 1, ... , N) utility associated with alternative j (j = 1, ... , J) in choice set m (m = 1, ... , M) is given by

$$U_{ijm} = \mathbf{b}\mathbf{s}_{ijm} + \boldsymbol{\gamma}\mathbf{z}_i + v_{ijm} \quad (1)$$

$$d_{ijm} = \begin{cases} 1, & \text{if } U_{ijm} \geq U_{ikm}\ j,k \in \mathbf{c}_m \\ 0, & \text{otherwise} \end{cases} \quad (2)$$

where, for respondent i, $\mathbf{s}_{ijm}$ is an ($s \times 1$) attribute vector of alternative j, $\mathbf{z}_i$ is a ($g \times 1$) vector of observable socio-demographic characteristics (e.g., age, family size, etc.), ν_{ijm} an error term that follows an extreme-value (Weibull) distribution. $\mathbf{b}$ and $\boldsymbol{\gamma}$ are ($1 \times s$) and ($1 \times g$) row vectors of unknown coefficients of $\mathbf{s}_{ijm}$, and $\mathbf{z}_i$ respectively. Equation (2) indicates that respondent i chooses alternative j from choice set m containing $\mathbf{c}_m$ alternatives if and only if the alternative j yields maximum utility.

To estimate Equation (1), it is assumed that the error terms ν_{ijm} are distributed independently from each other, i.e., the Independence of Irrelevant Alternatives (IIA) assumption [42,48]. Specifically, the IIA implies that the ratio of choice probabilities between two alternatives in a choice set is unaffected by changes in that choice set. This strong assumption is likely to be violated in practice. The problem can be resolved by applying the Random Parameters Logit model (RPL), also denoted Mixed Logit model (MXL) below. It allows the parameters associated with alternative-specific attributes to vary randomly across individuals [49]. Specifically:

$$\mathbf{b} = \boldsymbol{\beta} + \boldsymbol{\omega}_i \tag{3}$$

Combining Equations (1) and (3) gives:

$$U_{ijm} = (\boldsymbol{\beta} + \boldsymbol{\omega}_i)\,\mathbf{s}_{ijm} + \boldsymbol{\gamma}\mathbf{z}_i + \nu_{ijm} = \boldsymbol{\beta}\mathbf{s}_{ijm} + \boldsymbol{\gamma}\mathbf{z}_i + \boldsymbol{\omega}_i\mathbf{s}_{ijm} + \nu_{ijm} \tag{4}$$

where $\boldsymbol{\beta}$ is the population mean, and $\boldsymbol{\omega}_i$ the stochastic deviation that represents individual taste relative to the average taste in the population. From Equation (4), it follows that the error term $\boldsymbol{\omega}_i \mathrm{s}_{ijm} + \nu_{ijm}$ is correlated over the attributes of the alternative because of the presence of $\boldsymbol{\omega}_i$. Note that the model without the term $\boldsymbol{\omega}_i \mathrm{s}_{ijm}$ is denoted conditional logit model. The conditional logit model assumes that respondents have the same preferences (or that their preferences depend on observable characteristics) and perceives equal proportional substitution between the alternatives. On the other hand, the MXL or random parameter logit model assumes that utility is also affected by unobserved characteristics as well. MXL is flexible and allows for preference taste variation, substitution, and correlation in unobserved factors. The mixed logit model overcomes limitations of Conditional logit model by allowing the coefficients in the model to vary across decision makers. Allowing the coefficients to vary implies that we allow for the fact that different decision makers may have different preferences.

4. Result and Discussion

4.1. Data Screening for Inconsistent Responses

Before estimating the model, the dataset was screened for protest responses, strategic bias, choice task simplification, and attribute non-attendance (ANA) issues. ANA refers to ignoring the information contained in one or more attributes when making a choice [50]. Additional information from the survey was utilized in this process. In the introductory part of the questionnaire, respondents were asked to rank ecological and environmental issues (water availability and quality, health care service, education facilities, economic growth and employment, infrastructure, and poverty reduction) to identify protest and task simplification responses. This was done as follows. If a respondent ranked ecological, environmental and water issues as top three priorities but chose the status-quo alternative throughout the three choice sets, then this response was considered a protest response. A response was also considered as a protest or a choice task simplification if the respondent ranked ecological, environmental and water issues as the least two concerns but chose the highest payment alternatives throughout the three choice sets. Altogether, 87 of the 117 zero WTP responses (straight status-quo choosers) and 20 of the 75 straight highest payment alternatives choosers, were excluded from the analysis. It should be noted that the inclusion/exclusion of those respondents had insignificant impacts on the mean WTP estimate. Since there was weak and conflicting evidence of ANA, the data set without ANA treatment was analyzed.

The next section presents the model results estimated using STATA version 12.1 (StataCorp, College Station, TX, USA). First the MXL model fitness is compared with the standard conditional logit model for a preliminary glance to determine if preference heterogeneity is a genuine issue [51]. Then, detailed spatial based preference heterogeneity is assessed by running separate MXL for the sub-basin dataset. The marginal willingness to pay (MWTP) is computed for the sub-groups and equality test is performed.

4.2. Spatial Preference Heterogeneity

For all attributes, we specified random parameters except for the cost attribute. As a first step, we compared the MLX and the conditional logit model by means of the McFadden Pseudo R^2 and likelihood ratio test. In the model fitness comparisons; the McFadden Pseudo R^2 of the conditional logit model was 0.168 versus 0.203 for the MLX model. The likelihood ratio test showed evidence in favor of the MXL ($\chi^2(8) = 273.33$, $p < 0.00001$) indicating the presence of unobservable preference heterogeneity [52]. The sub-basin specific Pseudo R^2 ranged from 0.191 to 0.22 indicating good model fit [53]. The two sub-basins' MXL models have higher McFadden Pseudo R^2 than the pooled data model, showing a better model fitness of the sub-basin specific models.

Table 4 presents the sub-basin and pooled random parameter models. To render the models identified and to investigate individual taste heterogeneity, we interacted attributes and socioeconomics characteristics [40,54]. For the attributes, we considered random parameters. We only present significant interaction terms in Table 4. A table containing the complete set of estimates can be obtained from the first author.

The significant standard deviations (in the columns SD) for most of the attribute coefficients show that the random specifications are appropriate. The cost attribute was taken fixed because model instability and identification problems complexity may result if it is specified as random [49,55,56]. All attributes were assumed normally distributed and 500 Halton draws were applied to all the simulations.

Table 4 shows that all the attributes except tourism have significant mean coefficients in at least three of the four models. The statistically significant coefficients of the ecological attributes indicate that the selected attributes are important indicators of ecological restoration with significant choice effects. The mean coefficients also have the expected signs in all models. The significant negative cost coefficient indicates the positive utility of money. Ceteris paribus, the respondents prefer more improved attributes to less, given the same cost. The negative coefficient of the sandstorm attribute indicates that the fewer the number of sandstorm days, the higher the residents' utility. The positive means of the other attributes signify that the improvements of those attributes are considered desirable. Moreover, the significant standard deviations associated with the random parameters indicate unobserved preference heterogeneity in the sample. Indeed, the magnitude of the standard deviations of the coefficients of most of the ecological attributes is as large as the corresponding mean estimates indicating large preference heterogeneity among the respondents.

The insignificant utility coefficients for tourism and grass attributes in some of the models probably reflect preference heterogeneity. Tourism restoration has a significant mean in only the MSB model only which is probably due to the fact that in, in contrast to the other sub-basins, tourism is a growing sector in the sub-basin and that its residents are on the average richer. Grass cover has an insignificant mean and standard deviation in the LSB model, which may be related to the fact that its residents perceive grass area expansion in the entire basin as detrimental to the water inflow into their region.

Taste preference heterogeneity was controlled by including attribute-socio-economic interaction terms in each model. Dummies for age dummy (below mean = 1, above mean = 0), household gross revenue (below mean = 1, above mean = 0), education (completed junior school or below = 1, otherwise zero), job (farmer = 1, other jobs = 0), and sex (male = 1 and female = 0) of respondent were interacted with the attributes. From Table 4 it follows that USB has homogenous taste preference for forest coverage. MSB residents' has also homogenous preference (insignificant socio-economic variables) for grass attribute, their section-specific improvement attribute. This may imply that all residents of the corresponding sub-basins have similar preference regarding their own sub-basin restoration attribute.

In contrast, for the LSB there are several significant interactions terms. In particular, farmers express lower than mean preference for xerophytes. A possible explanation is that the policy may divert their farmland to xerophytes plantation. Similarly, farmers' higher than mean preference for water quality improvement which is probably related to their expectation that continuation of the status quo may disqualify water for agricultural use. Second, presence of spatial related taste heterogeneity was observed among different socio-economic groups. Particularly, below average earners of mid-stream residents were less interested on forest coverage in USB than above average earners. Younger residents of lower-stream have higher utility in grass coverage in MSB than older residents. Farmers in the USB and MSB have lower than average utility on water quality improvement and increased water flow to the LSB, respectively. The pooled dataset based MXL model also reveals that, on average, farmers have lower than average preference for forestation while richer residents have above average preference for water quality. We can conclude that understanding the benefit of IRBM, expected impact of the improvement attribute on one's livelihood, and financial standing affect the likelihood of support to the IRBM strategy.

Table 4. The sub-basins and pooled random parameter models (standard error in parenthesis).

Models	**USB**		**MSB**		**LSB**		**PD**	
Attribute	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**
Cost	−0.0175 *** (0.004)		−0.022 *** (0.003)		−0.018 *** (0.003)		−0.019 *** (0.002)	
Landscape	0.068 *** (0.02)	0.079 ** (0.039)	0.087 *** (0.015)	0.064 ** (0.029)	0.086 *** (0.021)	0.084 *** (0.033)	0.0813 *** (0.01)	0.074 *** (0.019)
Tour	0.024 (0.019)	0.005 (0.04)	0.061 *** (0.015)	0.123*** (0.025)	0.0077 (0.015)	0.093 *** (0.033)	0.036 *** (0.009)	0.089 *** (0.018)
Sandstorm	−0.019 *** (0.005)	0.012 * (0.007)	−0.015 *** (0.002)	0.013 *** (0.004)	−0.021 *** (0.004)	0.016 *** (0.005)	−0.0174 *** (0.002)	0.0127 *** (0.003)
Forest	0.067 *** (0.024)	0.078 * (0.044)	0.122 *** (0.02)	0.086 *** (0.023)	0.071 *** (0.018)	0.06 * (0.03)	0.085 *** (0.015)	0.075 *** (0.016)
Grass	0.07 *** (0.022)	0.078 ** (0.035)	0.075 *** (0.014)	0.074 ** (0.024)	0.024 (0.015)	0.009 (0.06)	0.065 *** (0.009)	0.063 *** (0.017)
Xerophytes	0.153 *** (0.05)	0.289 *** (0.068)	0.156 *** (0.027)	0.17 *** (0.034)	0.259 *** (0.054)	0.17 *** (0.046)	0.199 *** (0.026)	0.198 *** (0.026)
Quantity	3.71 *** (1.17)	4.01 * (2.3)	4.337 *** (0.87)	2.55 ** (1.49)	4.39 *** (1.04)	6.031 *** (1.546)	3.82 *** (0.51)	4.478 *** (0.825)
Quality	0.927 (0.26)	0.91 *** (−0.25)	0.97 *** (0.14)	0.98 *** (0.16)	0.84 *** (0.19)	0.587 *** (0.2)	0.99 *** (0.11)	0.844 *** (0.104)
Age-grass					0.042 * (0.022)			
Job-forest							−0.044 *** (0.015)	
Job-xerophytes					−0.162 *** (0.049)		−0.094PD *** (0.027)	
Job-water quantity			−3.302 *** (1.093)					
Job-water quality	−0.768 ** (0.31)				0.372 ** (0.186)			
Revenue-forest			−0.07 *** (0.022)					

Table 4. *Cont.*

Models	USB		MSB		LSB		PD	
Attribute	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Revenue-water quality					−0.524 ** (0.187)		0.333 *** (0.11)	
McFadden Pseudo R^2	0.224		0.217		0.191		0.208	
likelihood ratio $\chi^2(8)$	68.87		150.74		74.87		274.89	
No. observation	1332		3402		2133		6867	

Note: 1. ***, ** and * represent statistical significance at 99%, 95% and 90% confidence levels, respectively; 2. USB = upper sub-basin; MSB = middle sub-basin; LSB = lower sub-basin; PD = pooled data or the whole basin dataset; SD = standard deviation.

4.3. The Willingness to Pay Estimate

The mean willingness to pay (WTP) or implicit price is calculated using the delta method as the ratio of mean restoration attribute coefficient to the cost coefficient ($\text{WTP} = \beta_{\text{attributex}}/{-\beta_{\text{cost}}}$) [57].

Table 5 presents the mean WTP for the IRBM restoration attributes calculated based on mean coefficients of the restoration attributes in Table 4. The implicit price indicates WTP for each percent increment for the attributes landscape, tour, forest, and grass. It measures WTP for each 10,000 mu (15 mu = 1 hectare) increment for xerophytes, per hundred million m^3 increase for water quantity, one day reduction in sandstorm days for sandstorm attribute and one grade improvement in water quality. For instance, an average respondent in upper-stream, mid-stream and lower-stream are willing to pay about 3.909, 4.004, and 4.89 Yuan/year, respectively, for an additional one percent improvement in landscape scenery; and 1.07, 0.704, 1.18 Yuan/year, respectively, for one day reduction in total sandstorm days per year.

Table 5. Mean willingness to pay for the integrated water basin restoration attributes (in Yuan/year).

Model	USB			MSB			LSB			PD		
Attributes /Coefficient	Mean	95% CI		Mean	95% CI		Mean	95% CI		Mean	95% CI	
landscape	3.909 *** (1.08)	1.791	6.027	4.004 *** (0.53)	2.959	5.049	4.89 *** (0.79)	3.34	6.45	4.221 *** (0.41)	3.416	5.023
tour				2.822 *** (0.60)	1.646	3.999				1.858 *** (0.42)	1.029	2.685
sandstorm	1.073 *** (0.21)	0.659	1.486	0.704 *** (0.1)	0.514	0.895	1.18 *** (0.18)	0.84	1.52	0.902 *** (0.08)	0.711	1.06
forest	3.801 *** (1.02)	1.797	5.804	5.641 *** (0.69)	4.279	7.003	4.047 *** (0.71)	2.65	5.43	4.406 *** (0.71)	3.012	5.8
grass	4.002 *** (0.93)	2.187	5.816	3.454 *** (0.48)	2.52	4.389				3.369 *** (0.35)	2.674	4.07
xerophytes	8.72 *** (2.06)	4.689	12.743	7.191 *** (0.88)	5.464	8.918	14.77 *** (2.00)	10.84	18.69	10.34 *** (0.93)	8.512	12.16
quantity	211.6 *** (56.65)	100.53	322.57	200.1 *** (35.24)	131	269.15	244.1 *** (47.77)	156.26	331.83	201.1 *** (21.84)	142.23	227.87
quality	52.84 *** (9.22)	34.77	70.91	44.56 *** (4.05)	36.63	52.49	47.77 *** (8.3)	31.48	64.06	51.42 *** (4.038)	43.51	59.34

Note: 1. ***, **, and * represent statistical significance at 99%, 95% and 90% levels, respectively; 2. CI refers to confidence interval for the 95% lower limit and upper limit WTP.

Equality of the implicit prices between the three sub-basins and the pooled dataset was conducted following [37], commonly known as the Poe independent empirical distribution equality test [58]. It is one-side significant test hypothesizing:

H0: $\text{WTP}_x = \text{WTP}_y$

H1: $\text{WTP}_x - \text{WTP}_y > 0$

where x and y refer to mean WTP for a given attribute in upper, middle, lower sub-basin or the pooled data models, such that the higher WTP value always enters as x.

The three sub-basin residents have similar WTP for most of the attributes with notable differences in few as given in Table 6. MSB respondents have generally lower WTP than the other two groups except for the forest and tourism attributes. They have a significantly lower implicit price for sandstorm, xerophytes and water quantity than lower sub-basin residents and the basin average. The difference in their mean WTP can be attributed to their difference in living style and their disutility from water flow to the lower basin. High water resources development and water utilization in the mid-basin is currently limiting the flow to the lower sub-basin. Their lower than average utility for an increase in water flow into the lower basin reservoir may imply the need for compensation policy if water use in MSB is to be reduced in order to increase supply to LSB. On the contrary, they have significant higher than average WTP for the forest cover and eco-tourism conditions. Their WTP for forest is even higher than the USB (improvement site) residents. This is probably because the USB residents are reluctant to allocate additional land for forestation, as this sub-basin is already rich in forests while the MSB perceives increase in forest cover may resolve the existing ecological degradation.

LSB residents have higher or equal implicit prices for all the attributes than average residents in the basin reflecting their high expectation from the IRBM to mitigate the worst ecological condition they are living on. The lower sub-basin and upper sub-basin residents have very similar WTP for all the attributes. The only significant difference was with regard to xerophytes. In general, the statistically significant difference in WTP for ecological attributes between the sub-basins indicates the existence of spatial preference heterogeneity. Ignoring those spatial heterogeneities in economic cost–benefit assessment can mislead the policy making.

Table 6. Sub-basin residents mean willingness to pay (WTP) equality test.

Pair of Sub-Basins/Attributes	Landscape	Tour	Sandstorm	Forest	Grass	Xerophytes	Quantity	Quality
USB–MSB	0.456		0.217	0.074	0.256	0.228	0.413	0.208
USB–LSB	0.215		0.213	0.430		0.01	0.325	0.336
MSB–LSB	0.186		0.003	0.037		0.000	0.014	0.350
USB–PD	0.393		0.203	0.310	0.709	0.275	0.306	0.421
MSB–PD	0.359	0.083	0.036	0.030	0.427	0.005	0.344	0.426
LSB–PD	0.203		0.059	0.335		0.015	0.108	0.331

Note: 1. The numbers in each cell indicates the p-value for the equality test for the coefficients of the same attribute evaluated by residents of two different sub-basins. Values between 0.1 and 0.05 indicates significant difference at 90% CI, between 0.5 and 0.01 indicate significant difference at 95% CI, and $\leq$0.01 indicates significant difference at 99% CI; 2. The pair, for example USB–MSB, indicates comparison was between mean WTP of the upper sub-basin residents and the mid sub-basin residents for a given attribute.

Compensating surplus (CS) or WTP measures relative to difference policy scenarios can be computed based on:

$$CS = -1/\beta cost \left(V^0 - V^1\right)$$

where V^0 and V^1 refer the indirect utility before and after the change under consideration [59]. We did not aim to compute CS as different hypothetical IRBM scenarios yield different CS. Instead, we computed the present value of implicit price, which is common factor for universal policy scenario and it gives a policy relevant insight. The PV is computed as: ($PV = WTP/\ (1+i)^n$), where present value (PV) is a function of nominal annual payment (i.e., mean WTP), the discount rate (i), and the total years of payment or the projects time span (n). In the case study, n = 10 years (as designed in the choice experiment), and China Central Bank discount rate i = 3% is used.

The mean present value of WTP for the pooled data (in Table 7) reads as follows. An average resident is willing to pay a present value of 36.01, 15.84, 37.58 and 28.74 Yuan for a 1% improvement in landscape, tourism, forest and grass, respectively, in the course of ten years. Similarly, he/she would pay 7.70 Yuan for one day less in total sandstorm days per year; 88.17 Yuan for ten thousand mu xerophytes; 1715.00 Yuan for 100 million m^3 water increase in lower basin; and 438.63 Yuan for one unit upgrade in water quality to be achieved in the coming ten years (2013–2023).

Table 7. Present value implicit price in Yuan.

Model	USB			MSB			LSB			PD		
Coefficient	**Mean**	**95% CI**		**Mean**	**95% CI**		**Mean**	**95% CI**		**Mean**	**95% CI**	
Landscape	33.4	15.3	51.4	34.2	25.3	43.1	41.7	28.5	55	36.0	29.1	42.9
tour				24.1	14.0	34.1				15.9	8.8	22.9
sandstorm	9.2	12.7	5.6	6.0	4.4	7.6	10.1	7.1	13.0	7.7	6.4	9.0
forest	32.4	15.3	49.5	48.1	36.5	59.7	34.5	22.6	46.4	37.6	25.7	49.5
grass	34.1	18.7	49.6	29.5	21.5	37.4				28.7	22.8	34.7
xerophytes	74.4	40	108.7	61.3	46.6	76.1	126	92.5	159.4	88.2	72.6	103.7
quantity	1805	857.5	2752	1707	1118	2296	2082	1333	2831	1715	1213	1942
quality	450.8	296.7	604.9	380.1	312.5	447.8	407.5	268.5	546.4	438.6	371	506.2

Note: 1. Discount rate is 3% (China central bank's average discount rate); CI = confidence interval.

5. Conclusions

It can be concluded that the Shiyang River residents significantly support the IRBM programs because they elicited significant WTP values not only for ecological restoration in their own site but also in the other sub-basins. For example, the entire basin residents have expressed statistically significant positive WTP for restoring water quality, water quantity and xerophytes in the lower basin; forest in the upper sub-basin; and landscape and sandstorm improvements in the entire basin, regardless of their residential location. However, there is a certain degree of variation in the preferences revealed by the in-depth analysis.

Spatial preference heterogeneity was prevalent among the respondents. Assessment of preference heterogeneity by modeling the sub-basin dataset conveys important policy implications. First of all, residents have shown similar environmental concerns for the escalating ecological deterioration in the basin. Statistically, the same WTP for most of the attributes regardless of the improvement site depicts residents' understanding of the benefits of river basin restoration. The upper and lower basin residents (who both share similar livelihood) have statistically equivalent WTP for all (except xerophytes) the restoration attributes assessed. The mid basin residents, however, have lower WTP for some attributes for which their adjacent sub-basin (LSB) is desperately in need. The mid-basin residents are probably suspicious about the impact that improvement on the LSB may have on their water use and economic activity. They might be anticipating that water supply improvement in the lower sub-basin is at the cost of supply reduction in their region. This indicates spatial preference heterogeneity because, in any given sub-basin, no residents expressed significant lower than average implicit price for their own-site restoration attribute. However, they do have lower or insignificant utility for other sub-basin improvement attributes.

This study sheds light on preference heterogeneity as a basic deriving force for residents' utility difference on IRBM. It contributes particularly contributes useful information for China, the country which inland rivers make up one third of the basins. On average, the entire basin residents have generally provided consensus regarding the importance of this strategy. However, socio-economic characteristics and residential location difference induces preference heterogeneity are prevalent on the mean WTP for some of the attributes. Not accounting for spatial variables may understate or overstate welfare estimates depending on the restoration attribute under consideration. In conclusion, a carefully designed IRBM strategy has the capability to enhance the benefit of ecological and environmental restoration of the entire basin residence regardless of their relative location, while residents' economic empowerment and education can foster its sustainability and popularity.

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Appendix A

Table A1. Descriptive statistics by sub-basin.

Variables		Sex (Male = 1)	Age	Gross Income (¥1000)	Education (Below High School = 1)	Job (Farmer = 1)	Family Size	Dependent Child or Elder (Yes = 1)	Cadre (Yes = 1)
USB	Min	0	15	2.39	0	0	1	0	0
	max	1	78	156	1	1	9	1	1
	mean	0.6	40.6	42.5	0.47	0.44	4.0	0.85	0.26
	St.dev	0.48	14.11	26.5	0.49	0.49	1.58	0.36	0.44
MSB	min	0	14	1.1	0	0	1	0	0
	max	1	81	159.2	1	1	8	1	1
	mean	0.64	40.7	46.84	0.46	0.47	3.86	0.85	0.29
	St.dev	0.48	11.78	27.68	0.49	0.49	1.26	0.36	0.45
LSB	min	0	20	1.5	0	0	1	0	0
	max	1	75	150	1	1	8	1	1
	mean	0.7	44.0	47.2	0.42	0.59	3.9	0.87	0.21
	St.dev	0.46	9.8	28.8	0.49	0.49	1.16	0.34	0.42
pooled data (PD)	min	0	24	1.1	0	0	1	0	0
	max	1	81	159.2	1	1	9	1	1
	mean	0.65	41.7	46.12	0.452	0.56	3.94	0.85	0.26
	St.dev	0.48	11.86	27.84	0.49	0.49	1.3	0.35	0.33

References

1. GWP. *Integrated Water Resources Management*, 4th ed; Global Water Partnership: Stockholm, Sweden, 2000; p. 71.
2. Rahaman, M.M.; Varis, O. Integrated water resources management: Evolution, prospects and future challenges. *Sustain. Sci. Pract. Policy* **2005**, *1*, 15–21.
3. Boekhorst, D.G.J.T.; Smits, T.J.M.; Yu, X.B.; Li, L.F.; Lei, G.; Zhang, C. Implementing Integrated River Basin Management in China. *Ecol. Soc.* **2010**, *15*, 23.
4. Song, X.; Ravesteijn, W.; Frostell, B.; Wennersten, R. Managing water resources for sustainable development: The case of integrated river basin management in China. *Water Sci. Technol.* **2010**, *61*, 499–506. [CrossRef] [PubMed]
5. McNally, R.; Tognetti, S. *Tackling Poverty and Promoting Sustainable Development: Key Lessons for Integrated River Basin Management*; WWF: Godalming, UK, 2002; p. 35.
6. Harsha, J. IWRM and IRBM concepts envisioned in Indian water policies. *Curr. Sci.* **2012**, *102*, 986–990.
7. Evers, M. An analysis of the requirements for DSS on integrated river basin management. *Manag. Environ. Qual. Int. J.* **2008**, *19*, 37–53. [CrossRef]
8. Molle, F. River-basin planning and management: The social life of a concept. *Geoforum* **2009**, *40*, 484–494. [CrossRef]
9. Yu, H.; Edmunds, M.; Lora-Wainwright, A.; Thomas, D. From principles to localized implementation: Villagers' experiences of IWRM in the Shiyang River basin, Northwest China. *Int. J. Water Resour. D* **2014**, *30*, 588–604. [CrossRef]
10. Carson, R.T.; Mitchell, R.C. The value of clean water: The public's willingness to pay for boatable, fishable, and swimmable quality water. *Water Resour. Res.* **1993**, *29*, 2445–2454. [CrossRef]

11. Del Saz-Salazar, S.; Hernández-Sancho, F.; Sala-Garrido, R. The social benefits of restoring water quality in the context of the Water Framework Directive: A comparison of willingness to pay and willingness to accept. *Sci. Total Environ.* **2009**, *407*, 4574–4583. [CrossRef] [PubMed]
12. Glenk, K.; Lago, M.; Moran, D. Public preferences for water quality improvements: Implications for the implementation of the EC Water Framework Directive in Scotland. *Water Policy* **2011**, *13*, 645–662. [CrossRef]
13. Hanley, N.; Wright, R.E.; Alvarez-Farizo, B. Estimating the economic value of improvements in river ecology using choice experiments: An application to the water framework directive. *J. Environ. Manag.* **2006**, *78*, 183–193. [CrossRef] [PubMed]
14. Ramajo-Hernández, J.; del Saz-Salazar, S. Estimating the non-market benefits of water quality improvement for a case study in Spain: A contingent valuation approach. *Environ. Sci. Policy* **2012**, *22*, 47–59. [CrossRef]
15. Perni, Á.; Martínez-Paz, J.; Martínez-Carrasco, F. Social preferences and economic valuation for water quality and river restoration: The Segura River, Spain. *Water Environ. J.* **2012**, *26*, 274–284. [CrossRef]
16. Brouwer, R.; Martin-Ortega, J.; Berbel, J. Spatial preference heterogeneity: A choice experiment. *Land Econ.* **2010**, *86*, 552–568. [CrossRef]
17. Condon, B.; Hodges, A.; Matta, R. Public preferences and values for rural land preservation in Florida. In Proceedings of the American Agricultural Economics Association Annual Meeting, Portland, OR, USA, 29 July–1 August 2007.
18. Martin-Ortega, J.; Brouwer, R.; Ojea, E.; Berbel, J. Benefit transfer and spatial heterogeneity of preferences for water quality improvements. *J. Environ. Manag.* **2012**, *106*, 22–29. [CrossRef] [PubMed]
19. Calderon, M.M.; Camacho, L.D.; Carandang, M.G.; Dizon, J.T.; Rebugio, L.L.; Tolentinob, N.L. Willingness to pay for improved watershed management: Evidence from metro manila, Philippines. *For. Sci. Technol.* **2006**, *2*, 42–50. [CrossRef]
20. Amponin, J.A.R.; Bennagen, M.E.C.; Hess, S.; dela Cruz, J.D.S. *Willingness to Pay for Watershed Protection by Domestic Water Users in Tuguegarao City, Philippines*; Institution for Enviromental Studies: Amsterdam, The Netherlands, 2007; p. 51.
21. Cao, S.X.; Chen, L.; Shankman, D.; Wang, C.M.; Wang, X.B.; Zhang, H. Excessive reliance on afforestation in China's arid and semi-arid regions: Lessons in ecological restoration. *Earth Sci. Rev.* **2011**, *104*, 240–245. [CrossRef]
22. Li, W.H. Degradation and restoration of forest ecosystems in China. *For. Ecol. Manag.* **2004**, *201*, 33–41.
23. Wang, X.M.; Zhang, C.X.; Hasi, E.; Dong, Z.B. Has the Three Norths Forest Shelterbelt Program solved the desertification and dust storm problems in arid and semiarid China? *J. Arid Environ.* **2010**, *74*, 13–22. [CrossRef]
24. te Boekhorst, D.; Smits, T.; Xiubo, Y.; Lifeng, L.; Gang, L.; Chen, Z. Implementing integrated river basin management in China. *Ecol. Soc.* **2010**, *15*, 99–119.
25. Schaafsma, M.; Brouwer, R.; Gilbert, A.; van den Bergh, J.; Wagtendonk, A. Estimation of distance-decay functions to account for substitution and spatial heterogeneity in stated preference research. *Land Econ.* **2013**, *89*, 514–537. [CrossRef]
26. Sutherland, R.J.; Walsh, R.G. Effect of distance on the preservation value of water quality. *Land Econ.* **1985**, *61*, 281–291. [CrossRef]
27. Schaafsma, M.; Brouwer, R.; Rose, J. Directional heterogeneity in WTP models for environmental valuation. *Ecol. Econ.* **2012**, *79*, 21–31. [CrossRef]
28. Abildtrup, J.; Garcia, S.; Olsen, S.B.; Stenger, A. Spatial preference heterogeneity in forest recreation. *Ecol. Econ.* **2013**, *92*, 67–77. [CrossRef]
29. Ma, J.; Ding, Z.; Wei, G.; Zhao, H.; Huang, T. Sources of water pollution and evolution of water quality in the Wuwei basin of Shiyang river, Northwest China. *J. Environ. Manag.* **2009**, *90*, 1168–1177. [CrossRef] [PubMed]
30. Li, F.; Zhu, G.; Guo, C. Shiyang River ecosystem problems and Countermeasures. *Agric. Sci.* **2013**, *4*, 7. [CrossRef]
31. Wang, Z.J.; Zheng, H.; Wang, X.F. A Harmonious Water Rights Allocation Model for Shiyang River Basin, Gansu Province, China. *Int. J. Water Resour. D* **2009**, *25*, 355–371.
32. Xie, H.; Burrell, B.C.; Droslte, R. The Shiyang River: A case of water scarcity. *Can. Civ. Eng.* **2011**. Available online: https://csce.ca/wp-content/uploads/2012/04/2011-Summer-issue-vol-28.3.pdf (accessed on 13 August 2013).

33. Danfeng, S.; Dawson, R.; Baoguo, L. Agricultural causes of desertification risk in Minqin, China. *J. Environ. Manag.* **2006**, *79*, 348–356. [CrossRef] [PubMed]
34. Wei, Y.; Zheng, H. Enforcing the science and policy interface—Experiences from ACEDP Inland River Basin Project. In Proceedings ot the 14th International River Symposium, Brisbane, Australia, 26–29 September 2011.
35. Zhao, M.; Yao, L.; Tao, X. What restoration do the public expect? Quantifying Economic value, preferences heterogeneity and regional decision support. In Proceedings of the 2014 CAER_IFPRI Annual International Conference, Yangling, China, 16–17 October 2014; China Agricultural University Press: Yangling, China, 2014; p. 619.
36. Tang, Z.; Nan, Z.; Liu, J. The Willingness to Pay for Irrigation Water: A Case Study in Northwest China. *Glob. Nest J.* **2013**, *15*, 76–84.
37. Aizaki, H. Package 'mded': Measuring the Difference between Two Empirical Distributions. 2015. Available online: https://cran.r-project.org/web/packages/mded/mded.pdf (accessed on 15 June 2015).
38. Hanley, N.; Spash, C.L. *Cost-Benefit Analysis and the Enviroment*; Edward Elgar: Aldershot, UK, 1993; p. 288.
39. Hensher, D.; Shore, N.; Train, K. Households' willingness to pay for water service attributes. *Environ. Resour. Econ.* **2005**, *32*, 509–531. [CrossRef]
40. Kosenius, A.K. Heterogeneous preferences for water quality attributes: The Case of eutrophication in the Gulf of Finland, the Baltic Sea. *Ecol. Econ.* **2010**, *69*, 528–538. [CrossRef]
41. Jianjun, J.; Chong, J.; Thuy, T.D.; Lun, L. Public preferences for cultivated land protection in Wenling City, China: A choice experiment study. *Land Use Policy* **2013**, *30*, 337–343. [CrossRef]
42. Hanley, N.; Mourato, S.; Wright, R.E. Choice modelling approaches: A superior alternative for environmental valuation? *J. Econ. Surv.* **2001**, *15*, 435–462. [CrossRef]
43. Carson, R.; Czajkowski, M. The discrete choice experiment approach to environmental contingent valuation. In *Handbook of Choice Modelling*; Daly, S.H.a.A., Ed.; Edward Elgar Publishing: Cheltenham, UK, 2014.
44. Sándor, Z.; Wedel, M. Profile construction in experimental choice designs for mixed logit models. *Mark. Sci.* **2002**, *21*, 455–475. [CrossRef]
45. Scarpa, R.; Rose, J.M. Design efficiency for non-market valuation with choice modelling: How to measure it, what to report and why. *Aust. J. Agric. Resour. Econ.* **2008**, *52*, 253–282. [CrossRef]
46. Lancsar, E.; Louviere, J. Conducting discrete choice experiments to inform healthcare decision making. *Pharmacoeconomics* **2008**, *26*, 661–677. [CrossRef] [PubMed]
47. Carson, R.T.; Louviere, J.J.; Wei, E. Alternative Australian climate change plans: The public's views. *Energy Policy* **2010**, *38*, 902–911. [CrossRef]
48. McFadden, D. Conditional Logit Analysis of Qualitative Choice Behavior. In *Frontiers in Economics*; Zimmermann, K.F., Ed.; Academic Press: New York, NY, USA, 1973.
49. Revelt, D.; Train, K. Mixed logit with repeated choices: Households' choices of appliance efficiency level. *Rev. Econ. Stat.* **1998**, *80*, 647–657. [CrossRef]
50. Lagarde, M. Investigating Attribute Non-Attendance And Its Consequences In Choice Experiments with Latent Class Models. *Health Econ.* **2013**, *22*, 554–567. [CrossRef] [PubMed]
51. Hensher, D.A.; Greene, W.H. The Mixed Logit model: The state of practice. *Transportation* **2003**, *30*, 133–176. [CrossRef]
52. Hensher, D.A.; Rose, J.; Greene, W.H. *Applied Choice Analysis: A Primer*; Cambridge University Press: Cambridge, UK, 2005; p. 744.
53. Louviere, J.J.; Hensher, D.A.; Swait, J.D. *Stated Choice Methods: Analysis and Applications*; Cambridge University Press: Cambridge, UK, 2000.
54. Kragt, M.E.; Bennett, J.W. Using choice experiments to value catchment and estuary health in Tasmania with individual preference heterogeneity. *Aust. J. Agric. Resour. Econ.* **2011**, *55*, 159–179. [CrossRef]
55. Train, K. Halton Sequences for Mixed Logit. Department of Economics, UCB, 2000. Available online: https://escholarship.org/uc/item/6zs694tp (accessed on 10 December 2013).
56. Lusk, J.L.; Schroeder, T.C. Are choice experiments incentive compatible? A test with quality differentiated beef steaks. *Am. J. Agric. Econ.* **2004**, *86*, 467–482. [CrossRef]
57. Hanemann, W.M. Welfare evaluations in contingent valuation information with discrete responses. *Am. J. Agric. Econ.* **1984**, *66*, 20. [CrossRef]

58. Poe, G.L.; Giraud, K.L.; Loomis, J.B. Computational methods for measuring the difference of empirical distributions. *Am. J. Agric. Econ.* **2005**, *87*, 353–365. [CrossRef]
59. Morrison, M.; Bennett, J.; Blamey, R. Valuing improved wetland quality using choice modeling. *Water Resour. Res.* **1999**, *35*, 2805–2814. [CrossRef]