Research Article

Public Preference Analysis and Social Benefits Evaluation of River Basin Ecological Restoration: Application of the Choice Experiments for the Shiyang River, China

Tao Xu,1 Qi Ni,2 Liu-yang Yao,3 Dan Qiao,1 and Min-juan Zhao2

1Management School, Hainan University, Haikou 570228, China
2College of Economics and Management, Northwest A&F University, Yangling, Xianning, Shaanxi 712100, China
3School of International Business, Shaanxi Normal University, Xi’an 710119, China

Correspondence should be addressed to Min-juan Zhao; minjuan.zhao@nwsuaf.edu.cn

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Revealing public preferences regarding the ecological restoration of a river basin and evaluating the associated social benefits provide important references for the development of related policies. Taking the Shiyang River Basin as an example, this study quantified and analyzed the difference in public preferences regarding the ecological restoration of the river basin by the choice experiments method and the random parameters logit (RPL) model. It also evaluated the social benefits of river basin ecological restoration. The results showed that (1) The residents all hoped to improve the ecological environment of the Shiyang River Basin and were willing to bear certain restoration costs. (2) There were significant differences in public preferences for ecological restoration of the river basin. These differences existed between the upper, middle, and lower reaches of the river and between urban and rural residents. (3) The average annual cost of ecological restoration that the basin residents were willing to pay was between 505.833 – 948.571 RMB yuan, and the total annual benefits of ecological restoration were 381.2 million RMB yuan. Based on these conclusions, the following recommendations were made. First, future ecological and environmental policies should be further combined with public preferences; and even cross-regional ecological compensation can be introduced to balance the interests of different social groups, to win public support. Second, increased water-saving technology in industries and agriculture, residents’ awareness of water conservation, and the management of water pollution measures should be promoted in order to improve the ecological environment of the river basin. Third, the budget for the ecological restoration of the Shiyang River Basin should be 381.2 million yuan per year. Costs should be controlled while meeting the restoration goals.

1. Introduction

The ecological environment of a river basin is an important material basis for human survival and development. However, with the rapid development of society and the economy, exploitation of human water consumption and water pollution have become increasingly more intense. It has seriously threatened human survival and sustainable social and economic development [1–3]. Using targeted ecological restoration measures to achieve conservation and restoration of the ecological environment of a river basin has become a consensus approach in society [4, 5]. However, because the ecological restoration of a river basin has strong characteristics of public goods, market failure is often considered to be one of the main causes of ecological deterioration. Necessary administrative measures are required to ensure effective supply [6, 7]. Therefore, China has introduced a series of relevant policies and measures for river basin ecological restoration, such as the Action Plan for the Prevention and Control of Water Pollution, the Ecological and Environmental Protection Plan of the Yangtze River Economic Belt, and the Key Management Plan of the Shiyang River Basin. In addition, the Report of the 18th National Congress of the Communist Party of China also made it clear that the development of ecological civilization should be progressively promoted and placed in a prominent position.
At present, however, the implementation of ecological restoration policies by the government encounters two issues. On the one hand, the public, who has a strong demand for ecological restoration, is also a key force in promoting ecological restoration [8, 9]. Policies can achieve restoration goals and remain sustainable only if they are actively supported by the public. Otherwise, it is highly likely that social resources will be wasted without being effective [10–12]. However, in practice, because of the asymmetry of governments’ access to information, their decision-making often has limitations, which can lead to government failure [13, 14]. On the other hand, due to the lack of involvement of market mechanisms, ecological governance can bring social benefits without a specific market price to follow. This leads to the lack of a basis for cost-benefit analysis of governance policies, which leaves the rationality of the input-output ratio of governance policies in question [15, 16]. Therefore, clarifying the public preferences and social benefits of ecological restoration in a river basin and incorporating them into relevant policy development can help compensate for the information asymmetry between policy makers and the public and improve the efficiency of fund allocation for ecological restoration. Doing so also helps correct biases in policy design and enhances its scientific basis, effectiveness and sustainability [17–19].

In terms of quantifying the public preferences and social benefits of ecological restoration, a choice experiment (CE) among the stated preference methods has gradually gained the attention of researchers [20, 21]. The theoretical basis of CE is a random utility approach. The basic assumption is that respondents make choices based on maximizing their utility, thus turning choice problems into utility comparison problems [22, 23]. By combining representative restoration indicators into a clear plan and giving respondents the opportunity to make a trade-off between different restoration indicators, CE provides access to more information on preferences as well as the possibility of a flexible calculation of the social benefits of different levels of restoration. Therefore, it has been considered one of the most promising research methods in the field [24–27].

The current CE studies on river basin ecological restoration include the following. Weber and Stewart [28] calculated the fact that the Albuquerque river basin restoration under the Middle Rio Grande project could bring more than $150 USD per household per year of social benefits for the local residents. Zander et al. [29] estimated the benefits of ecological restoration of the Daly River at approximately 6 million USD. Minjuan et al. [30] analyzed the preferences of the residents of the Shiyang River Basin to different restoration indicators. The results showed preference differences among residents of the upper, middle, and lower reaches. Shi et al. [11] took the Shaanxi section of the Wei River Basin as an example and showed that there were preference differences between urban and rural residents for ecological restoration of the river basin. Chen et al. [31] explored the differences in public preferences regarding ecological restoration in the Zenne River Basin and their sources. The results showed that urban residents had a strong preference for protecting the biodiversity of the river basin. Tao et al. [32] used the Heihe River Basin as an example and showed that including the differences between urban and rural residents in ecological restoration could improve the accuracy of social benefit evaluations. Research by Da Costa and Hernandez [33] showed that improving the ecosystem services of the Taravo River could result in a benefit increase of 128 Euros per year for the local residents. The existing studies lend a rich reference value to this article, but two shortcomings exist. First, due to the differences in natural geography in the upper, middle, and lower reaches of a river and different levels of socioeconomic development in urban and rural areas, public preferences regarding ecological restoration in a river basin tend to show large differences [11, 30]. Currently, there is a lack of consideration of the river basin section and urban versus rural factors in the relevant research. Therefore, it is difficult to provide more effective information on relevant policy development. Second, in the process of social benefits evaluation, the differences in public preference regarding river basin ecological restoration were not paid enough attention, which affected the accuracy and effectiveness of the benefits evaluation results.

In summary, this article used CE to build a hypothetical market. By simulating market trading behavior, the public’s WTP for ecological improvement was evaluated [34]. Through econometric analysis, the differences in public preferences were revealed, and the corresponding social benefits were calculated on this basis. The innovative points of this article included (1) focusing on public preference regarding river basin ecological restoration and the group differences, which helped to enhance the scientific basis of policy development and obtain wide public support, (2) incorporating the differences in public preferences into the social benefits evaluation of river basin ecological restoration, which improved the accuracy of the evaluation results and (3) improving the implementation process of CE and the effectiveness of data collection from index system development, questionnaire optimization, and error control.

2. Research Methods

Based on the implementation steps proposed by Hensher et al. [23], the research outline of this article was as follows. (1) Historical and present information about the ecological environment of the river basin was collected. (2) The relationship between the ecological environment of the river basin and the productivity and life of the residents was clarified. (3) Based on a pilot survey, focus group interviews, and expert consultations in related fields, an index system was developed to describe the state of the ecological environment of the river basin. (4) Restoration plans using orthogonal experimental design were designed and optimized. (5) A CE questionnaire was generated and further improved through a second round of pilot survey application. (6) A CE survey was conducted through one-to-one interviews on-site to obtain the interviewees’ WTP. (7) The utility function of the respondents was estimated, and public preferences and corresponding social benefits were quantitatively analyzed using an econometric model.
The econometric model used in this article was the random parameters logit (RPL) model, which was used to estimate the residents’ utility function. In this model, respondents’ preferences for a certain indicator (variable) can be assumed to be heterogeneous, and their coefficient can be specified as random. If a coefficient is specified as random, we can estimate not only its location parameter (mean) but also its scale parameter (standard deviation), and the significance of the scale parameter was used to test for heterogeneity. The preference parameter was set as a distribution and not limited to a set value, which better reflected the reality [35]. Here, respondent distribution and not limited to a set value, which better significance of the scale parameter was used to test for het-

In formula (1), $V_{ns}$ represents the measureable portion of the respondent’s utility. $\epsilon_{ns}$ represents the unobservable portion of the respondent’s utility. It is generally assumed that the error term of the utility function follows the extreme value type I distribution (i.e., the Gumbel distribution) and the independent and identical distribution. The alternative specific constant (ASC) is associated with the status quo is 1 when the respondent chooses the alternative of not taking ecological restoration measures and 0 otherwise, reflecting the baseline utility that maintaining the current ecological environment can bring to the respondent. $X_{ns}$ indicates the value of the restoration indicator $i$ when respondent $n$ selects scenario $s$. $WTP_{ns}$ indicates respondent $n$’s WTP for scenario $s$. $\alpha_n$, $\beta_{ni}$, and $\gamma_n$ are the coefficients that reflect respondent $n$’s preference level, and $\varphi_n = (\alpha_n, \beta_n, \gamma_n)$. Therefore, the probability of respondent $n$ selecting scenario $s$ only among $T$ ecological restoration scenarios is

$$P_n = \frac{\exp(\alpha_n ASC_{ns} + \sum_{i=1}^{K} \beta_{ni} X_{ni} + \gamma_n WTP_{ns})}{\sum_{i=1}^{T} \exp(\alpha_n ASC_{ns} + \sum_{i=1}^{K} \beta_{ni} X_{ni} + \gamma_n WTP_{ns})} = \int e^{V_{ni}(\varphi_n)}/\sum_{T} e^{V_{ni}(\varphi_n)} f(\varphi_n)d\varphi_n.$$ 

### 3. Research Area and Experimental Design

#### 3.1. Overview of the Study Area. The area studied in this article was the Shiyang River Basin located in Gansu Province. It is one of the four inland rivers in the arid and semiarid areas of northwest China (see Figure 1). In the past few decades, the rapid decline in water quality and the excessive amount of water allocation for human production and living have caused excessive drainage of the ecological water distribution. As a result, the Shiyang River Basin has faced a series of ecological and environmental issues, such as a decline in the groundwater level and intensification of land desertification [30, 39]. Furthermore, due to untreated industrial and domestic sewage discharge, the water quality in some areas in the basin once dropped to “class V” (the poorest level). In addition, the east, west, and north sides of Minqin County in the lower reach of the Shiyang River Basin are surrounded by two major deserts, the Tengri and Badain Jaran deserts. The average annual precipitation is only approximately 100 mm, and annual evaporation is more than 2600 mm. It is one of the areas with the most serious water shortage in China.

#### 3.2. Experimental Design

##### 3.2.1. Indicators. High-quality and sufficient water resources are key for ensuring the function of a river basin ecosystem and an important determining factor for ensuring the effectiveness of the ecological restoration of a river basin. Especially for dry inland river basins, increasing ecological water allocation and improving water quality in the river basin are direct and effective approaches
to protect and restore the ecological environment. Therefore, in this study, ecological water allocation and river basin water quality were selected as the restoration indicators. The specific meaning of the indicators and their level settings are as follows.

The first aspect is the ecological water allocation indicator. There are different degrees of water shortage in the upper, middle, and lower reaches of the Shiyang River Basin and significant differences between the basic amount and actual needs of water in different segments of the river [40, 41]. Therefore, in this paper, the ecological water allocation was further divided into three indicators for each region: upper, middle, and lower reach ecological water allocation. Of course, the increase in ecological water allocation is not generated out of thin air. It is obtained through the conservation of industrial, agricultural, and domestic water (e.g., adoption of water conservation technology and increased awareness of water conservation among residents) as well as improvements in water resource management in the river basin (e.g., scientific allocation, clarifying water rights, and water price regulation) while ensuring the basic water supply of various sectors. The ecological water allocation of different sections was determined based on the historical and current water consumption of the Shiyang River Basin. The total water consumption and potential water savings of each sector in the river basin were estimated. Combined with the opinions of the local administrative departments and experts in related fields, the maximum amount of ecological water allocation was calculated. Finally, the total amount was allocated according to the existing ecological water allocation in each section (shown in Table 1). To ensure that the ecological water allocation indicator was easy to understand for the respondents, the general ecological effects associated with the increase in ecological water allocation were described during the survey. Based on the irrigation quota of 215 m³/Mu for artificial shelterbelt forests, an increase of 10 million m³ water allocation could irrigate an additional 465,000 Mu of shelterbelt forests each year.

The second indicator was water quality. Hongyashan Reservoir is Asia’s largest artificial reservoir in a desert, known as the “pearl of the sea;” it has many functions such as flood control, drought prevention, aquaculture, and tourism. In addition, the reservoir is located in the lower reach of the Shiyang River Basin and can reflect water pollution issues in the whole river basin. Therefore, it has been a social focus point and conducive for CE surveys. According to the Shiyang River Basin Water Resources Bulletin, the water quality for Hongyashan Reservoir decreased to class V in approximately 2004. After restoration, water quality improved to class IV but remained heavily polluted. Combined with the opinions of the Shiyang River Basin management department and experts in related fields, it was determined that an ideal goal was to raise the water quality to class III through further pollution prevention and control; this goal was achievable.
Table 1: Ecological restoration indicators for the Shiyang River Basin.

| Restoration indicators          | Meaning of the indicators                                                                 | Levels                         |
|--------------------------------|-------------------------------------------------------------------------------------------|--------------------------------|
| Upper reach ecological water allocation | The upper reach ecological water allocation included the basic water needs for the forest and grasslands in the upper reach of the Shiyang River within Gulang County and the irrigation of the artificial shelterbelt forests along the desert edges | 7 million m$^3$ (+0)  
11 million m$^3$ (+4)  
15 million m$^3$ (+8) |
| Middle reach ecological water allocation | The middle reach ecological water allocation mainly included the basic water needs and irrigation for the natural grasslands and shrubs along the middle reach of the Shiyang River in Liangzhou District, the irrigation of the artificial shelterbelt forests, and replenishment of groundwater | 95 million m$^3$ (+0)  
115 million m$^3$ (+20)  
135 million m$^3$ (+40) |
| Lower reach ecological water allocation | The lower reach ecological water allocation mainly included the basic water needs of natural dry-land vegetation (Russian olive, salt cedar, and *Haloxylon ammodendron*) in the Minqin Basin, irrigation for the artificial shelterbelt forests of the oasis, groundwater replenishment, and ecological water supplement to Qingtu Lake located near the end of the Shiyang River | 100 million m$^3$ (+0)  
130 million m$^3$ (+40)  
160 million m$^3$ (+60) |
| Hongyashan Reservoir water quality | The water quality of Hongyashan Reservoir refers to the water quality class. Clean water is the basis of human life and the survival of animal and plant populations (fish, waterbirds, plants, etc.). It also serves recreational functions such as swimming and fishing | Class IV; class III |
| WTP                            | To improve the ecological environment of the Shiyang River Basin and regional ecological security level, the annual willingness of each family will be paid in the next 10 years | 0 yuan; 50 yuan; 100 yuan; 200 yuan; 300 yuan |

Another indicator was WTP. Protection and restoration of the ecological environment of the river basin require governance measures, which are associated with costs and require the residents to pay some necessary costs. Of course, these costs are not necessarily in the form of cash. They might be passed on to food prices, taxes, and tickets to recreational sites in various forms, such as rising water prices, increasing pollution control and developing ecological protection areas. They are ultimately reflected in increases in cost of living. The levels of WTP were determined mainly based on a pilot survey using the contingent valuation method (CVM), and we found that most of the residents in the survey were willing to pay less than 300 yuan.

In addition, there are two points to note about the indicator values. First, the levels of the indicators were set considering the “equal-distant principle” and “rounding principle” to avoid causing cognitive barriers for the respondents. The number of levels was randomly generated on the basis of meeting these principles. Second, the ecological water allocation and the water quality were the levels expected to be achieved in 10 years. It was assumed that the change in the indicator values was continuous during the 10 years.

3.2.2. Questionnaire Design. Based on prior research, each CE questionnaire provided the respondents with three choice sets (i.e., every three choice sets were an experiment requiring each respondent to make three separate choices). Each choice set included three alternatives [42, 43]. Figure 2 shows one of the choice sets. “Alternative 0” represents no restoration measures. “Alternative 1” and “Alternative 2” represent different levels of management measures.

As shown in Table 1, based on the indicators and their level values, there were 216 possible alternatives ($3 \times 3 \times 3 \times 2 \times 4$) (The level of each indicator corresponding to “0” WTP is a fixed value, that is, the state when no governance measures are taken. Therefore, only four levels of the WTP are entered into the permutation and combination.), 23,220 possible choice sets ($C_2^{23,220}$), and 2,696 * 10*8 possible CE questionnaires ($C_2^{2,696}$). If all the possible CE questionnaires were tested, it would take a massive amount of labor and resources and would be difficult to achieve [44, 45]. Therefore, this article used “Ngene 1.1.1” to carry out an orthogonal experimental design. Some representative CE questionnaires were selected based on orthogonality. Finally, a total of 12 CE questionnaires containing 36 choice sets were generated. The results of the efficiency measure of the orthogonal experiment had a D-error of 0.000504 and an A-error of 0.034161 (Both D-error and A-error are derived from the progressive variance covariance matrix. The D-error takes the determinant of the matrix, and the A-error takes the trace of the matrix. The ideal experimental design can achieve the minimization of the two.).

The following explanations need to be made regarding the CE questionnaires. First, in “Alternative 1” and “Alternative 2,” at least one indicator has been improved compared to “Alternative 0.” Second, there is no difference in terms of priority between the two alternatives with restoration measures. Third, because the focus of restoration measures may be different, the indicator values in the high-payment alternative are not necessarily all higher than the low-payment alternative. Fourth, if the values of the indicators in one restoration alternative are all higher than in the other alternative, the amount of payment for that alternative is also higher than the other (For a normal commodity, if all the indicators of one commodity are better than the other, then its price should also be higher than the other. Therefore, if the choice sets obtained from “Ngene 1.1.1” were not in line with common sense, they had to be adjusted.). Based on
these guidelines, the rationality of each choice set and CE questionnaire was examined.

3.2.3. Experiment Optimization. The accuracy of the respondents' understanding of the questionnaire and access to appropriate information are keys to the success of CE [32, 46]. Therefore, the following measures were taken to optimize the experiment. First, the CE questionnaire was designed with a combination of graphics and text (as shown in Figure 2), making the policy scenarios more visual. Consequently, the experiments were more interesting and easier for the respondents to understand. Second, before the formal survey, combining the results from the pilot survey, the description of indicators was further optimized to make sure that the respondents could accurately understand the questionnaire. Third, at the end of the survey, the respondents were asked to self-evaluate their understanding level and attitude toward completion of the questionnaires. The investigators then evaluated the degree of cooperation, understanding, and rigor of the respondents to provide a basis for distinguishing the effectiveness of the CE. Fourth,
5.1. Results of RPL Model Estimation. In this paper, the RPL model was estimated using Halton draws with 500 simulations in Stata 15.0 [49, 50] (In our study, we estimated the RPL model over a range of draws, respectively (e.g., 50, 100, 200, 300, 400, 500, 800, and 1000 draws), and we found that with 500 times, the results showed stability.). The results are shown in Table 4. For the model estimation, the coefficients of the ecological water allocation and water quality were specified as random, and we could estimate their means and standard deviations. The coefficients of ASC and WTP were specified as fixed, and only their means were estimated. In previous presurveys, we found that most respondents had a strong willingness to pay to improve the local ecological environment, and, in formal surveys, we also found that only 6.79% did not choose alternatives with restoration measures. Therefore, we assumed that respondents had a preference consistency between alternatives with restoration measures and without restoration measures, and the coefficient of ASC was specified as fixed, which is consistent with many studies [37, 46]. The coefficient of WTP was specified as fixed, because we assumed that WTP was inversely proportional to the level of respondents' utility, which means that they were constrained by the budget line when choosing alternatives, a commonly observed phenomenon [23, 51, 52]. From the overall fitting of the model, the likelihood ratios of the six samples all reached a significance level of 1%, indicating that the econometric model was overall statistically significant.

From the mean estimates of ecological water allocation, we observed obvious preference differences between the residents of the upper, middle, and lower reaches. However, the common characteristic was that most residents in the survey wanted the ecological water allocation in their section to increase, showing a strong inclination toward “self-interest.” At the same time, it was found that (1) for upper reach urban residents the mean estimation of the ecological water allocation in the upper and middle reaches of the river was not significant, indicating that the increase in ecological water allocation in any section would not increase their utility. (2) Middle reach urban residents hoped to increase the ecological water allocation in not only the middle reach but also the lower reach. The reason might be that changes in the lower reach ecological environment would affect the quality of life of middle reach residents to some extent (e.g., sandstorms mainly originate from the lower reach, etc.). (3) Lower reach urban residents hoped to increase the ecological water allocation in not only the lower reach but also the upper reach. The reason might be that the increase in ecological water allocation in the upper reach would help to restore the upper reach vegetation cover and improve water conservation capacity. In terms of the water quality of Hongyashan Reservoir, the mean values for the six groups of samples were estimated to be negatively significant at a 5% level or above, indicating that the water quality of the reservoir improving from class IV to class III would be beneficial for all residents in the basin.

From the mean estimates of ASC, all results except lower reach urban residents were negatively significant at a 5% level or above. The residents of the Shiyang River Basin had a strong tendency to take ecological restoration measures. In terms of the water quality of Hongyashan Reservoir, the estimated mean values for the six groups of samples were all
negatively significant at a 5% level or above. The payment amount was inversely proportional to the level of utility of residents, indicating that the residents in the survey did not randomly choose the restoration plan without any considerations. It also showed that the CE did well in simulating the consumer behavior of the residents in the survey.

From the standard deviation estimates of the coefficients of the ecological water allocation and the water quality of Hongyashan Reservoir, which were specified as random, we saw that they all passed the 5% significance test in six models. This result indicated that respondents had a preference heterogeneity for each ecological indicator and that the assumption of preference with the RPL model was closer to the real situation.

5.2. IP Measurement. The estimation results of the RPL model above could reflect whether respondents had a preference for certain restoration indicators. Further IP analysis could quantify the marginal willingness of the residents to pay for the unit change in the restoration indicators and reveal the degree of preference. Table 5 shows the IP of the restoration indicators with a significant estimate at the 10% significance level or greater.

| Table 2: Descriptive statistics of the sample. |
|-----------------------------------------------|
| **Project** | **Urban** | **Rural** | **Urban** | **Rural** | **Urban** | **Rural** |
| Gender | 0.495 (0.500) | 0.655 (0.475) | 0.677 (0.468) | 0.730 (0.444) | 0.680 (0.467) | 0.719 (0.449) |
| Age (years) | 35.187 (10.172) | 46.294 (13.034) | 39.126 (12.713) | 43.865 (11.284) | 36.718 (11.412) | 51.281 (10.767) |
| Level of education (years) | 12.000 (3.464) | 7.769 (4.167) | 12.291 (3.561) | 9.021 (3.338) | 12.913 (2.903) | 8.460 (3.283) |
| Labor input | 4.159 (1.298) | 4.765 (1.633) | 4.173 (1.375) | 4.660 (1.298) | 4.088 (1.331) | 3.986 (1.474) |
| Number of samples | 107 | 119 | 127 | 141 | 103 | 139 |

Note: (a) In gender statistics, males are equal to 1, females are equal to 0; (b) data are the mean (standard deviation).

| Table 3: Variable descriptive statistics. |
|-------------------------------------------|
| **Variable** | **Upper reach** | **Middle reach** | **Lower reach** |
| Gender | 0.495 (0.500) | 0.655 (0.475) | 0.677 (0.468) | 0.730 (0.444) | 0.680 (0.467) | 0.719 (0.449) |
| Age (years) | 35.187 (10.172) | 46.294 (13.034) | 39.126 (12.713) | 43.865 (11.284) | 36.718 (11.412) | 51.281 (10.767) |
| Level of education (years) | 12.000 (3.464) | 7.769 (4.167) | 12.291 (3.561) | 9.021 (3.338) | 12.913 (2.903) | 8.460 (3.283) |
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| Number of samples | 107 | 119 | 127 | 141 | 103 | 139 |

Note: (a) Unit of ecological water allocation is million m³; (b) class IV water quality is equal to 4, class III water quality is equal to 3; (c) the unit for WTP is the yuan; (d) data are the mean (standard deviation).

| Table 4: Results of RPL model estimation. |
|-------------------------------------------|
| **Variable** | **Upper reach** | **Middle reach** | **Lower reach** |
| Gender | 0.495 (0.500) | 0.655 (0.475) | 0.677 (0.468) | 0.730 (0.444) | 0.680 (0.467) | 0.719 (0.449) |
| Age (years) | 35.187 (10.172) | 46.294 (13.034) | 39.126 (12.713) | 43.865 (11.284) | 36.718 (11.412) | 51.281 (10.767) |
| Level of education (years) | 12.000 (3.464) | 7.769 (4.167) | 12.291 (3.561) | 9.021 (3.338) | 12.913 (2.903) | 8.460 (3.283) |
| Labor input | 4.159 (1.298) | 4.765 (1.633) | 4.173 (1.375) | 4.660 (1.298) | 4.088 (1.331) | 3.986 (1.474) |
| Number of samples | 107 | 119 | 127 | 141 | 103 | 139 |

Note: (a) In gender statistics, males are equal to 1, females are equal to 0; (b) data are the mean (standard deviation).
In detail, (1) the IP of upper reach ecological water allocation was relatively high. For the increase of 1 million m³ ecological water allocation, upper and lower reach urban residents were willing to pay 14.917 yuan and 16.122 yuan, respectively. The reason might be that the quality of ecological water in the upper reach was relatively small, and the total amount of payment was low, resulting in respondents being insensitive to the price of ecological water allocation in the upper reach. (2) For every 1 million m³ increase in the ecological water allocation in the middle reach, the middle reach urban residents were willing to pay 2.932 yuan, which was lower than the 5.031 yuan the rural residents were willing to pay. The reason might be that the middle reach rural residents were relatively far away from the river. In comparison, the urban residents were closer to the desert and had a stronger sense of ecological crisis. (3) For every 1 million m³ increase in ecological water allocation in the lower reach, the middle reach urban residents, lower reach urban, and rural residents were willing to pay 1.948, 8.631 and 2.773 yuan, respectively. The marginal WTP of lower reach urban residents was higher than that of rural residents. The reason might be that, on the one hand, the environmental deterioration caused by water shortages in the lower reach areas had been very prominent, and the urban and rural residents had a strong sense of ecological crisis (which was different from the middle reach areas). On the other hand, compared to the rural residents, urban residents had a higher ecological awareness and ability to pay. (4) For the water quality of Hongyashan Reservoir improving from class IV to class III, the marginal WTP of the residents in the survey showed a large difference. The marginal WTP of the upper reach residents was higher than that of the middle and lower reaches. The reason might be that upper reach residents were less concerned about ecological water allocation and more willing to pay for improved water quality. The residents in the middle and lower reaches paid attention to the increase in ecological water allocation and water quality improvement. They needed to balance between the two based on their limited ability to pay. The marginal WTP of the lower reach residents was higher than that of the middle reach residents. The reason might be that Hongyashan Reservoir is located in the lower reach area, and its water quality has a greater impact on the productivity and life of the lower reach residents. Therefore, lower reach residents’ marginal WTP was also higher.

5.3. CS Calculation. The CS reflected annual fees that the households in the survey were willing to pay for the increase in ecological water allocation and improvement in water quality of Hongyashan Reservoir. In this study, it was assumed that the restoration indicators could improve the optimal level design; the results of the CS calculation are shown in Table 6. It can be seen that there are some differences in the CS of the residents in the survey. The reason might be that their ecological consciousness and ability to pay were different. Further, according to the number of urban and rural households in the Shiyang River Basin from the 2017 Gansu Statistical Yearbook (data at the end of 2016), the total CS of the urban and rural residents in each basin section was calculated. Summing the CS of each section indicated that the total benefits of the ecological restoration of the Shiyang River Basin each year were 381.2 million yuan.

6. Conclusion and Discussion

This article used the inland river basin of the Shiyang River as an example. Using a CE questionnaire design, field survey, and RPL model estimation, the social benefits of the ecological restoration of the river basin were analyzed. The main conclusions are as follows. (1) The residents in the survey hoped to improve the ecological environment of the Shiyang River Basin by increasing ecological water allocation and improving the water quality of Hongyashan Reservoir and were willing to bear certain restoration costs. (2) There were clear differences in public preferences for ecological restoration of the river basin. These differences occurred not only between the urban and rural residents but also among the upper, middle, and lower reaches, providing strong evidence for building a cross-regional ecological compensation mechanism. (3) The annual expenses that the

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**Table 5: Implicit prices for restoration indicators.**

| Implicit price                  | Upper reaches | Middle reaches | Lower reaches |
|--------------------------------|---------------|----------------|---------------|
|                                | Urban | Rural | Urban | Rural | Urban | Rural |
| Upper reach ecological water allocation | —        | 14.917 | — | —     | 16.122 | —     |
| Middle reach ecological water allocation | — | — | 2.932 | 5.031 | — | —     |
| Lower reach ecological water allocation | — | — | 1.948 | — | 8.631 | 2.773 |
| Hongyashan Reservoir water quality | 278.047 | 329.475 | 257.432 | 178.207 | 309.197 | 228.664 |

**Table 6: Compensating surplus and benefits of ecological restoration.**

| Items                               | Upper reaches | Middle reaches | Lower reaches |
|-------------------------------------|---------------|----------------|---------------|
|                                    | Urban | Rural | Urban | Rural | Urban | Rural |
| Compensating surplus calculation    | 677.500 | 600.903 | 725.583 | 568.438 | 948.571 | 505.833 |
| Number of households (10,000 households) | 6.686 | 12.060 | 15.199 | 17.890 | 2.459 | 5.560 |
| Total benefits (10,000 yuan)        | 4529.765 | 7246.893 | 11028.141 | 10169.347 | 2332.537 | 2812.433 |
Residents in the survey were willing to pay for ecological restoration of the basin were roughly distributed between 505.833 and 948.571 yuan. Based on these numbers, the total annual social benefits of ecological restoration were 381.2 million yuan.

Based on the analysis and conclusions above, the following recommendations should be considered. First, the design of ecological restoration policies in the river basin should consider more public preferences, taking into account the interests of urban and rural residents in the upper, middle, and lower reaches. When necessary, cross-regional ecological compensation can be introduced to balance the interests of different social groups to gain more public support. Second, efforts to introduce advanced industrial water-saving technology, promote agricultural water-saving irrigation technology, improve water-saving awareness of river basin residents and strictly control agricultural nonpoint source pollution and urban sewage discharge should be further increased. Through the joint action of various management measures, the ecological water allocation in the Shiyang River Basin should be increased and the water quality of Hongyashan Reservoir should be improved. Third, ecological management measures in the Shiyang River Basin should be implemented. If the annual investment of up to 381.2 million yuan can be made, ecological water allocation in the upper, middle and lower reaches will increase by 8 million $m^3$, 40 million $m^3$, and 60 million $m^3$, respectively, in 10 years. At the same time, the water quality will improve to class III. These measures are reasonable and effective.

Data Availability

The (respondents’ WTP and characteristics) data used to support the findings of this study are currently under embargo while the research project was completed. Requests for data (18 months) after publication of this article should be made to Xu Tao (xutao_2013@outlook.com).

Conflicts of Interest

The authors declare that there are no conflicts of interest regarding the publication of this paper.

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